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mobility and access

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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	orders@bts.gov
statistics by phone	800.853.1351
fax-on-demand	800.671.8012

Acknowledgments

US Department of Transportation

Rodney E. Slater
Secretary

Mortimer L. Downey
Deputy Secretary

Bureau of Transportation Statistics

T.R. Lakshmanan
Director

Robert A. Knisely
Deputy Director

Rolf R. Schmitt
Associate Director for Transportation Studies

Philip N. Fulton
Associate Director for Statistical Programs and Services

Project Manager
Wendell Fletcher

Assistant Project Manager
Joanne Sedor

Editor
Marsha Fenn

Major Contributors

Part I
Audrey Buyrn
Bingsong Fang
John Fuller
Robert Gibson
David Greene
Xiaoli Han
William Mallett
Don Pickrell
Michael Rossetti
Rolf Schmitt
Basav Sen

Part II
Felix Ammah-Tagoe
William Anderson
Audrey Buyrn
John Fuller
John Hopkins
Donald Jones
T.R. Lakshmanan
William Mallett
Kirsten Oldenburg
Lisa Randall
Frank Southworth

Other Contributors
Nat Bottigheimer
Kathleen Bradley
Lillian Chapman
Shih-Miao Chin
Paula Coupe
Alan Crane
Stacy Davis
Selena Giesecke
Madeline Gross
Marilyn Gross
Janet Hopson
Stephen Lewis
Bruce Spear
Demin Xiong

Cover and Report Design
Susan Hoffmeyer

Report Layout and Production
OmniDigital, Inc.
Gardner Smith

Photo Credits
Chapter 2 *Maritime Administration, U.S. Department of Transportation*
Chapter 3 *Paula Coupe*
Chapter 7 *Brandon Hensley*
Chapter 11 *Elliott Linder*
All other photos *Marsha Fenn*

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PART I THE STATE OF THE TRANSPORTATION SYSTEM

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Statement of the Director

This document is the fourth *Transportation Statistics Annual Report* (TSAR) prepared by the Bureau of Transportation Statistics (BTS) for the President and Congress. As in previous years, it reports on the state of U.S. transportation system at two levels. First, in Part I, it provides a statistical and interpretive survey of the system—its physical characteristics, its economic attributes, aspects of its use and performance, and the scale and severity of unintended consequences of transportation, such as fatalities and injuries, oil import dependency, and environment impacts. Part I also explores the state of transportation statistics, and new needs of the rapidly changing world of transportation.

Second, Part II of the report, as in prior years, explores in detail the performance of the U.S. transportation system from the perspective of desired social outcomes or strategic goals. This year, the performance aspect of transportation chosen for thematic treatment is "Mobility and Access," which complements past TSAR theme sections on "The Economic Performance of Transportation" (1995) and "Transportation and the Environment" (1996).

Mobility and access are at the heart of the transportation system's performance from the user's perspective. In what ways and to what extent does the geographic freedom provided by transportation enhance personal fulfillment of the nation's residents and contribute to economic advancement of people and businesses?

This broad question underlies many of the topics examined in Part II: What is the current level of personal mobility in the United States, and how does it vary by sex, age, income level, urban or rural location, and over time? What factors explain variations? Has transportation helped improve people's access to work, shopping, recreational facilities, and medical services, and in what ways and in what locations? How have barriers, such as age, disabilities, or lack of an automobile, affected these accessibility patterns? How are commodity flows and transportation services responding to global competition, deregulation, economic restructuring, and new information technologies? How do U.S. patterns of personal mobility and freight movement compare with other advanced industrialized countries, formerly centrally planned economies, and major newly industrializing countries? Finally, how is the rapid adoption of new information technologies influencing the patterns of transportation demand and the supply of new transportation services? Indeed, how are information technologies affecting the nature and organization of transportation services used by individuals and firms?

PART I: THE STATE OF THE TRANSPORTATION SYSTEM

Extent, Condition, and Performance of the System

The United States has the world's most extensive transportation system, serving the 265 million people and 6 million business establishments that occupy the fourth largest country by land area. (Table 1-1 in chapter 1 provides a detailed summary by mode.)

Use of the transportation system grew rapidly between 1970 and 1995. Passenger-miles traveled (pmt) grew 95 percent, at an annual rate of 2.7 percent, while intercity freight activity measured in ton-miles increased by 65 percent. Average pmt increased during this time from 11,000 to 16,500 miles per person (excluding miles traveled by heavy trucks). Air activity grew at the fastest rates, while, in absolute terms, the highway modes accounted for the largest increases in miles traveled and ton-miles.

Highway and bridge conditions have generally improved in recent years. Although new measurement techniques complicate trend analysis, recent data published by the Federal Highway Administration (FHWA) suggest improvement in roads between 1994 and 1995. Congestion in many metropolitan areas has worsened. As for air passenger service, on-time arrivals for major carriers declined between 1994 and 1995. The freight rail industry is showing improved physical condition, despite less track and increased traffic and revenue. By contrast, Amtrak, the nation's passenger rail carrier, has experienced a fall in patronage. While the average age of its locomotives has declined, the average age of its passenger car fleet has increased. Capital expenditures in public ports were about 5 percent higher in 1994 than in 1993 (not including a major land purchase in 1994). There is little public information available to allow tracking of the performance and condition of pipelines.

Although the analysis in chapter 1 covers all modes, urban transit is given more detailed treatment in this year's report. The condition of urban transit equipment showed a mixed picture between 1985 to 1995. Although the fleet of large and mid-size buses has become older, many smaller buses were added for paratransit services over the past few years, stabilizing the age of the total fleet. Rail transit, power systems, stations, bridges and tunnels, and maintenance improved between 1984 and 1992. The average age of light-rail transit vehicles declined somewhat between 1985 and 1995, but the average age of heavy-rail vehicles increased. The age of commuter railcars also increased: for example, powered cars averaged 12.3 years in age in 1985 and 19.8 years in age in 1995.

Over the 1985 to 1995 period, the number of cities served by rail transit increased and there was continued expansion of bus service into outlying suburban areas of large metropolitan regions and into smaller urbanized areas. Rail transit service frequency increased. By contrast, bus service frequency declined with the expansion of systems into outlying suburbs and smaller urban areas.

Despite expansion of service, urban transit pmt was about the same in 1995 as in 1985, and ridership declined by about 11 percent. This decline masks a complex pattern of transit patronage. There has been growth in newer heavy-rail, light-rail, and commuter rail systems and level or declining patronage in older rail systems and buses. Some of the growth in ridership on newer rail systems has been at the expense of bus ridership.

The occasion of an annual report offers an opportunity to review a few key events that either caused major dislocations in transportation or highlight important features of the transportation system. The report discusses three 1996 events: a blizzard in the eastern United States at the beginning of the year; another blizzard in the Northwest at the end of the year; and the provision of transportation for the Atlanta Olympic Games.

The two snowstorms made travel very difficult for several days, pointing out the vulnerability of the transportation system to extreme weather events. The disruption also focused public attention on the importance of the transportation system, which many people take for granted when operations are troublefree. As for the Olympic Games, the expanded transportation system put in place by various public agencies at all levels was considered a success. Over the 17 days of the event, the transportation system moved approximately 18 million passengers, twice its normal load.

Transportation and the Economy

Although transportation touches every facet of our economic life, current economic indicators do not fully capture the rich interplay between transportation and the larger economy, or fully measure the ways transportation supports economic activity. A number of indicators are discussed below, such as the share of transportation-related final demand in gross domestic product (GDP),[1] household and government expenditures, returns on public investment, and transportation-related employment, in an attempt to describe these economic relationships.

Transportation-related final demand as a share of GDP has remained slightly under 11 percent since 1989, contributing $777 billion to a $7.25 trillion GDP in 1995. Transportation-related final demand is the broadest measure of transportation's economic importance, as it includes the value of outputs from many non-transportation industries (e.g., cars produced by the automobile industry and gasoline produced by the petroleum industry).

A narrower measure is the value-added by the for-hire transportation industry, defined here as those establishments that provide transportation services to the public for a fee. The share of GDP of the for-hire transportation industry was $223 billion in 1994, or about 3.2 percent of total GDP in current dollars. This does not include the value of in-house transportation services taking

[1] Transportation-related final demand is defined as the value of all transportation-related goods and services (regardless of industry of origin) delivered to the final customer; this includes consumer and government expenditures, investments, and net exports.

place within firms that are not primarily engaged in providing transportation services to the public (e.g., a manufacturing plant or a grocery store chain). Although in-house providers of transportation are very important, current information is insufficient to estimate their contribution. BTS and the Bureau of Economic Analysis of the U.S. Department of Commerce are conducting a joint project, called the Transportation Satellite Account, to develop a more complete picture of the transportation industry, including in-house transportation services.

Household and government expenditures also indicate transportation's economic importance. Transportation's share of household expenditures was 19 percent in 1994. The largest share of household expenditures was housing, followed by transportation, and then food. Household expenditures on transportation vary significantly by income. In 1994, transportation's share of household expenditures ranged from 14.1 percent for the $5,000 to $10,000 income category to 22.1 percent for those in the $40,000 to $50,000 income category.

Total government expenditures for transportation were $116 billion in 1993. State and local governments contribute the lion's share of public expenditures for transportation. From 1983 to 1993, their share (excluding federal grants) rose by 38 percent in real terms; federal spending on transportation during that period only increased by 15 percent, resulting in a decline in the federal share of government transportation expenditures from 37 to 32 percent. In 1993, about 60 percent of government expenditures were for highways, followed by transit (19 percent), air (15 percent), and water transportation (5 percent). Rail and pipelines together accounted for less than 1 percent.

In 1993, government revenues from gasoline taxes and other transportation-related taxes and fees totaled $85 billion, and covered 73 percent of government transportation expenditures. State governments collected about half of these revenues, the federal government about one-third, and local governments about one-fifth. By mode, highways generated about 70 percent of these revenues, followed by air (15 percent), transit (10 percent), and water transportation (4 percent).

From 1977 to 1994, federal transportation-related budget receipts, including revenue from trust funds (taxes and user fees dedicated to a specific mode), rose from $16 billion to $19.7 billion (in constant 1987 dollars). The two largest sources are the Highway Trust Fund (HTF)—which has highway and transit accounts—and the Airport and Airway Trust Fund. Of these, the aviation trust fund revenues increased the most, while HTF transit account revenues grew more slowly and HTF highway account revenues declined slightly. Together, the trust fund balances (unspent money in these accounts at the end of the year) grew substantially from the mid-1980s to the early 1990s, but have declined from the 1992 high point.

In 1993, governments at all levels invested $52.5 billion in transportation infrastructure and equipment. Most of the investment was for highways, followed by airports and transit.

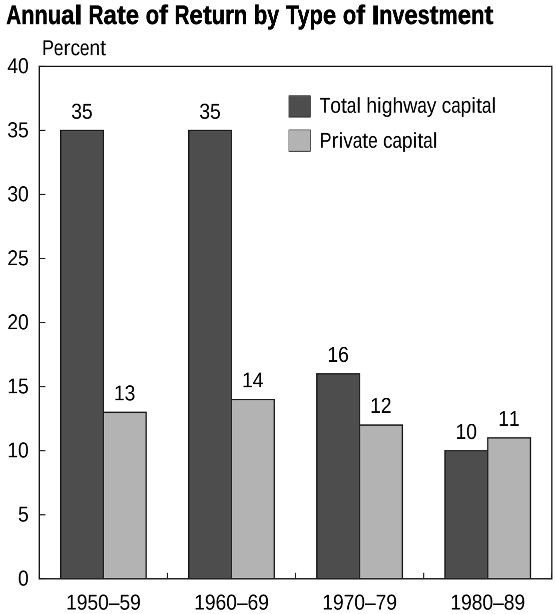
In recent years, a good deal of research has been devoted to assessing the economic returns from government investment in public infrastructure, including transportation infrastructure.[2] A recent study prepared for FHWA by Nadiri and Mamuneas offers strong evidence on the many ways highway capital in the United States contributes to the productivity of 35 different industries and the overall economy. In particular, it suggests that in the first two decades or more while the Interstate highway network was expanding the overall economic benefits were high—with the return on the investment of a dol-

[2] See *Transportation Statistics Annual Report 1995* for an indepth discussion of public investment in transportation.

lar in highway infrastructure greater than the return on a dollar of private capital investment. As the Interstate Highway System neared completion in the 1980s, the rate of return on highways fell gradually to just under the return on private capital investment in the economy.

Transportation is also a major source of employment. Employment in the for-hire transportation industry (3.9 million people) could be added to employment in transportation occupations within nontransportation industries to estimate the number of people employed in transportation functions. The resulting figure of 5.8 million employees, however, is a low-end estimate. For example, it excludes people who are not in transportation occupations who nonetheless work full time in transportation activities in nontransportation industries. Nor does it include most employees in such transportation-related functions as transportation equipment manufacture or in government. If all of these jobs are counted, employment in transportation and related industries has fluctuated around 9.9 million since 1990.

Annual Rate of Return by Type of Investment



SOURCE: M.I. Nadiri and T.P. Mamuenas. 1996. Contribution of Highway Capital to Industry and National Productivity Growth, prepared for the U.S. Department of Transportation, Federal Highway Administration, Office of Policy Development. September.

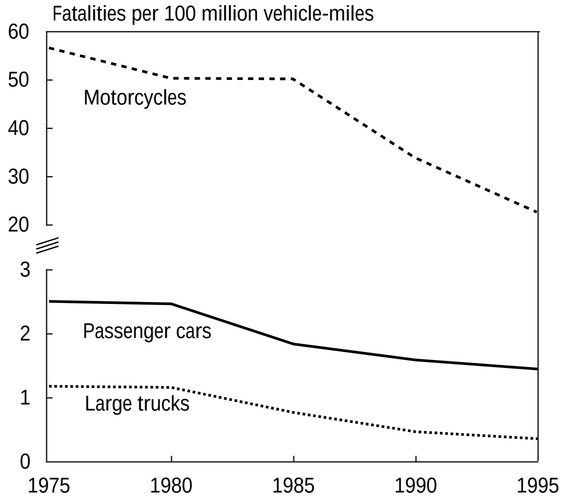
Transportation and Safety

In the United States, transportation has accounted for roughly half of accidental deaths for many years. Transportation fatality trends show that commercial airlines, buses, and railroads are the safer passenger modes. Travel by private vehicle—whether a car or light truck, a recreational boat, or personal use aircraft—is less safe. In 1995, more people died in recreational boating and general aviation crashes than were killed as passengers on trains, buses, or planes in commercial aviation combined.

Crashes involving motor vehicles accounted for 41,798 fatalities in 1995—some 94 percent of the transportation deaths that year. An estimated 3.5 million people were injured in crashes involving motor vehicles. Motor vehicle crashes are the leading cause of death for Americans until their mid-thirties, except for the very youngest children. The National Highway Traffic Safety Administration (NHTSA) estimates that the costs to the economy over the lifetimes of those injured or killed in motor vehicle crashes in 1994 will be $150.5 billion. This amount does not attempt to estimate the dollar value of the loss of quality of life.

Despite the huge toll—115 people died and over 9,500 people were injured in highway crashes each day in 1995—remarkable improvement in highway safety has occurred in the last three decades. The greatest number of deaths occurred in 1972, when 54,589 people were killed in crashes involving motor vehicles. Had the 1969 death rate of 5.0 fatalities for every 100 million vehicle-miles traveled (vmt) persisted, more than 120,000 people would have died from motor vehicle crashes in 1995, compared with the actual figure of 41,798 fatalities (about

Occupant Fatalities



SOURCE: See figure 3-1 in chapter 3.

1.7 fatalities for each 100 million vmt). The improvement was evident in most categories of vehicles, even though the rates vary greatly. Many factors, including installation and use of safety innovations, better highway design, safety standards and regulations, education efforts, and improved emergency and medical care, have helped reduce the fatality rate.

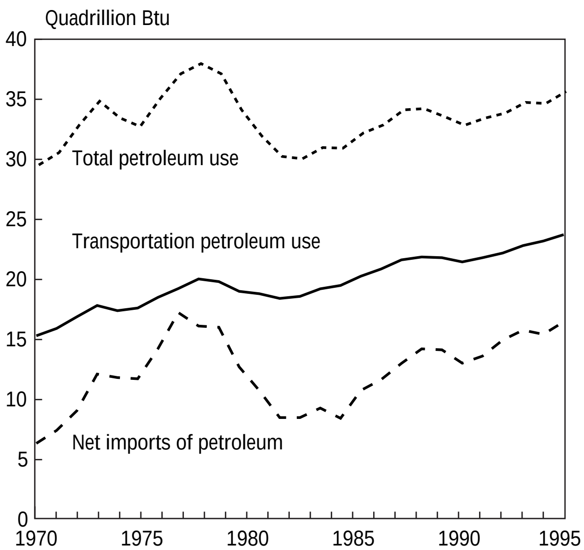
Since 1992, however, the fatality rate has been stable, portending an increase in the number of fatalities if vmt continues to increase. Many fatalities could be avoided if more drivers, occupants, and pedestrians followed well-known safety precautions. In 1995, 17,274 people died in alcohol-related crashes— 41 percent of all people killed in highway crashes. Excessive speed or driving too fast for conditions was a contributing factor in 31 percent of fatal crashes. (Often, fatal crashes involve speeding and drinking). While safety belt use has increased over the years, nearly one-third of passengers still do not buckle up. NHTSA estimates that there would be 9,835 fewer fatalities if everyone used safety restraints.

Although they involve far fewer fatalities in total than private vehicles, fatal crashes involving commercial vehicles—especially airplanes, trains, and buses—receive great scrutiny from safety organizations, the press, and the public, in part because a single crash can involve dozens or, in some cases, hundreds of deaths. Two plane crashes in 1996—the crash of ValuJet Flight 592 into the Florida Everglades and the crash of TWA Flight 800 off Long Island Sound—have been the subject of extensive investigation by safety authorities, and received prime time coverage from the media for many weeks, putting a spotlight on aviation safety. With air travel growing in popularity, aviation safety will continue to be a prominent concern of the traveling public.

Travel by commercial airline is much safer today than it was three decades ago, when about 10 people died for every 100,000 plane departures on U.S. air carriers. Since 1992, the rate has fluctuated between 1 and 2 fatalities per 100,000 departures. (Because crashes are infrequent, this rate is expressed as a 5-year moving average to even out large year-to-year variations.) The most robust improvement (as shown in the moving average) occurred in the 1960s and the 1970s; since then, the improvement has slowed.

Safety data are collected separately for each individual mode. There is, however, increasing interest in examining safety trends on a cross-modal or systemwide basis. This year's safety chapter addresses four cross-modal issues: the safety of children in the transportation system; safety of workers in transportation occupations or occupations that require frequent use of transportation; transportation of hazardous materials; and efforts to develop common measures of safety across the modes.

U.S. Petroleum Use and Imports



SOURCE: See figure 4-7 in chapter 4.

Energy and the Environment

For nearly half a century, transportation has accounted for about one-quarter of total U.S. energy use. Between 1994 and 1995, transportation energy use grew by 1.7 percent—a rate of growth similar to that which has occurred since 1985. In contrast, transportation energy use grew by only 0.6 percent annually between 1973 and 1985, when oil supply shocks and higher prices dampened demand and inspired major improvements in energy efficiency.

Petroleum-based fuels are used to satisfy almost all (95 to 97 percent) of U.S. transportation energy demand. Transportation accounts for about two-thirds of the nation's demand for oil. Despite recent gains in the number of alternative fuel vehicles and the greatly increased use of alcohols and ethers in gasoline to satisfy mandated cleaner fuel requirements, nonpetroleum fuels still supply a small share.

Approximately half of the petroleum consumed in the United States must be imported. Petroleum dependence is of concern because the world's oil reserves are increasingly concentrated in relatively few countries. The Organization of Petroleum Exporting Countries (OPEC) holds two-thirds to three-quarters of the world's proven reserves and more than half of the world's estimated resources. In the past three years, however, increased production in the North Sea and other nontraditional producing areas stabilized the market influence of OPEC and kept prices low. As these relatively small reserves are depleted, OPEC market share and influence likely will grow. World dependence on OPEC oil is expected to rise from today's 40 percent to 52 percent in 2010 and 56 percent by 2015, levels similar to those of the early 1970s.

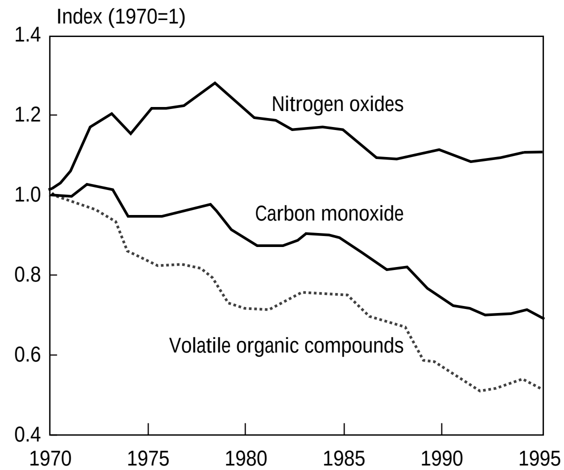
Concentration of production can lead to price volatility and upward pressure on prices, even if no supply disruption occurs. The potential for volatility in petroleum markets was illustrated in the spring of 1996, when a confluence of factors, including higher crude prices, low inventories, and a surge in demand, caused a greater than normal seasonal increase in gasoline prices. Average gasoline prices rose almost 22¢ per gallon, in contrast to a typical seasonal increase of 5¢ per gallon. This jump renewed public concern about the operation of petroleum markets and the nation's dependence on petroleum.

It appears that the transportation sector has reached the end of a 20-year period of steadily improving energy efficiency. Although some modes, such as air passenger travel and rail freight, continue to show efficiency gains, this is offset by a decline in the energy efficiency of highway travel. (Accounting for the vast majority of all passenger-miles, the highway mode dominates U.S. passenger travel and energy use trends.) Bus and rail transit modes also showed higher energy intensity.

BTS's analysis shows that cumulative energy savings from changes in transportation energy efficiency declined between 1993 and 1994—the first time since 1985. Average miles per gallon of light-duty vehicles, now 24.6, has not changed significantly since 1979. Technological improvements were largely offset by increasing vehicle weight and power and decreasing vehicle occupancy rates.

The energy efficiency of air travel has continued an unbroken 22-year trend of improvement. The biggest factor was an increase in load, but improved aircraft efficiency accounted for about one-third of the improvement. Like air travel, rail freight energy efficiency has made steady gains for two decades. Many factors have contributed to efficiency gains, including improved operating practices that have greatly reduced engine idling and improved train pacing, lighter weight cars, and new locomotive technologies.

Selected Air Emissions from Transportation



NOTE: Transportation emissions include all onroad mobile sources and the following nonroad mobile sources: recreational vehicles, recreational marine vessels, airport service equipment, aircraft, marine vessels, and railroads.

SOURCE: See figure 4-10 in chapter 4.

► Environmental Impacts

Because of its enormous size and activity, the U.S. transportation system inevitably has undesirable environmental impacts.[3] Air pollution is the most studied environmental impact and has been the subject of extensive remedial action, air quality monitoring, and data collection. Transportation accounts for two-thirds of carbon monoxide (CO), 42 percent of nitrogen oxides, and nearly one-third of the hydrocarbons produced.

Despite a doubling in highway vehicle-miles, most highway vehicle emissions are far lower today than in 1970, reflecting emissions controls adopted under federal clean air requirements. The record of success has not been uniform, however. There were increases in some transportation emissions in 1992, 1993, and 1994 compared with previous years. According to the latest U.S. Environmental Protection Agency estimates, progress was made in 1995, with, among other things, a major reduction in CO emissions and the first drop since 1992 in volatile organic compounds emissions. Reductions in onroad vehicle emissions accounted for the lion's share of the recent reductions; emissions from aircraft and airport services vehicles also decreased. (Lead emissions from transportation have been all but eliminated for several years.)

Transportation-related greenhouse gas emissions continue to follow trends prevalent over the past several years. Carbon dioxide emissions by transportation continue to rise due to increased energy use. Since 1990, transportation has accounted for nearly 40 percent of the national increase in carbon dioxide emissions from end-use sectors, with potentially serious implications for global climate change.

Strides have been made in understanding, quantifying, and reducing some other environmental impacts of transportation. For example, federal noise standards have reduced exposure to unacceptable levels of aircraft noise, and the government continues to monitor underground storage tank releases and cleanup efforts. Other impacts, such as land use and habitat fragmenta-

[3] See Part II of *Transportation Statistics Annual Report 1996* for a comprehensive discussion of transportation-related environmental issues.

tion, are less well understood, and thus more difficult to assess or quantify.

The State of Transportation Statistics

When Congress, through the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), created the Bureau of Transportation Statistics, the purpose was to enhance the transportation knowledge base and to inform the public about transportation and its consequences. To that end, Congress called on BTS to document the methods used to obtain information and to ensure the quality of statistics used in this annual report, and to include in the report "recommendations for improving transportation statistical information." Because ISTEA's authorization for federal spending ends with fiscal year 1997, Congress is now evaluating alternative authorization options for these programs in the future. Thus, this 1997 annual report comes at an opportune time to review the path followed by BTS and other information-producing agencies, and examine whether that path is appropriate for the start of the next century. Chapter 5, summarized below, discusses progress and challenges in meeting ISTEA information needs, suggests ways in which the world of information may change, and indicates some future directions that decisionmakers might consider for transportation statistics programs.

BTS has taken many actions to fill data and knowledge gaps and needs identified in the ISTEA. Among other things, the Bureau has:

- published four transportation statistics annual reports, as well as annual compendiums of national transportation statistics;
- completed national surveys of commodity and passenger flows by all modes and intermodal combinations;
- initiated efforts with Canada and Mexico to produce a continental view of North American transportation;
- established a standard classification of transportable goods;
- become a leader in developing geographic information systems databases; and
- actively disseminated information, using printed and newer electronic means.

The ISTEA provided a good start toward meeting critical information needs, but several topics remain for which more or better information are needed. These include: 1) domestic transportation of international trade; 2) timeliness and reliability of transit, highway travel, and freight modes; 3) costs of transportation services; 4) more reliable information on the number of motor vehicles by vehicle class, and distances they are driven; 5) fuller information on the location, connectivity, capacity, and condition of railroad lines; and 6) interactions among transportation, economic development, and land use.

Needs for information and technologies for meeting these needs continue to evolve rapidly. Statistics on cost and service quality, involving timeliness and reliability, and not just forecasts of traffic volume and capacity are needed. Involvement by metropolitan planning organizations, private sector interests, and citizen organizations, as well as federal and state agencies, has increased the number and range of customers demanding data and the tools to use the data.

The Government Performance and Results Act of 1993 (GPRA) is also affecting the need for statistical information. GPRA requires all federal agencies to begin measuring their outcomes, and not just their inputs and outputs. GPRA is to be the basis of budget decisions by the Office of Management and Budget and will be monitored by Congress. GPRA's focus is prompting many agencies to become aware of the conditions being measured by BTS and other statistical agencies. Most state departments of transportation and some local agencies also are undertaking performance measurement efforts.

Decentralization of decisionmaking, either from the public sector to the private sector through deregulation or from the federal government to state and local governments, is potentially the biggest change in transportation policy to be informed by statistics. Although decentralization could reduce the federal role in many areas, the need for publicly available transportation statistics may grow. The free flow of information is often a prerequisite to properly functioning private markets, and state and local officials need to relate conditions within their jurisdictions to national and international trends.

In response to customer demands, BTS proposes to build on its initial products and services with three major initiatives. These initiatives are part of the Administration's proposed National Economic Crossroads Transportation Efficiency Act (NEXTEA). They include: expanded programs of data collection, and the development of a knowledge base involving international transportation in a globalized economy; expanded services and grants to state, local, and private decisionmakers to enhance data collection and sharing throughout the transportation community; and a program of research, technical assistance, and data-quality enhancement to improve performance measurement. These proposals are discussed in detail in chapter 5.

PART II: MOBILITY AND ACCESS

Part II explores mobility's importance in the American society and economy, and the transportation system's facilitating role in providing access to opportunities. Mobility, as used here, refers to the *potential for movement*. It expands the geographic choices available to people and businesses. Today's level of personal mobility (as reflected in miles traveled per capita) is unparalleled in U.S. history. Mobility can enhance the ability of people to participate in economic and social life, expanding personal freedom and choice. Mobility helps businesses serve new markets, provides more choices for locating facilities, broadens their range of suppliers, and increases the available pool of workers.

Accessibility refers to the *potential for spatial interaction with various desired social and economic opportunities*. Accessibility varies for individuals and across regions. Part II describes such variations in accessibility in the context of barriers to movement, such as age, location, disbility, and the lack of availability of vehicles or transportation services.

Part II also examines advances in information technologies (IT), and their ramifications for transportation. Transportation firms and their customers are adopting a number of generic information technologies made possible by advances in telecommunications and computers. IT is transforming the way these firms do business in a manner reminiscent of the change wrought on transportation and the broader economy in the 19th century by the telegraph and the railroad. This IT transformation is discussed in terms of changes in the nature of transportation demand and the supply of new transportation services, and in the emerging pattern of activities, management structures, and competition both among transportation producers and among their customers.

Part II discusses six topics:

- concepts of mobility and access,
- personal mobility in the United States,
- access to opportunity,
- freight,
- the international context, and
- mobility and access in the information age.

Concepts of Mobility and Accessibility

Mobility is measured by the movement of people and materials on the transportation system. Accessibility is measured by the ease of reaching the location of a desired activity from another place.

Measurements of mobility and accessibility can be helpful in evaluating the performance of transportation. A number of methodological difficulties, however, limit their use. Of the two concepts, accessibility is the more difficult to measure, but measuring mobility is not especially easy. Because of data gaps, there is often little alternative to using indirect measures.

Analysts have employed the concept of *revealed mobility* (defined as the number of miles traveled or trips taken over some unit of time such as a day, week, or a year) as an imperfect proxy for mobility. The assumption in using revealed mobility is that, all else being equal, people taking many trips or traveling many miles have a higher level of mobility. This assumption is not always borne out, however. For example, revealed mobility data would register a mobility decline if a commuter moves to a residence closer to work. Yet, having to travel fewer miles to work or spend less time commuting is not in any meaningful sense a decline in mobility. Despite such problems, revealed mobility can be a useful analytical tool, and helps explain a great deal about travel behavior and shipping activities.

Accessibility measures can be useful in evaluating transportation access to locations where desired activities (e.g., employment, shopping, health care, and recreation) take place. They also can help identify access problems of people with limited transportation options. Several accessibility measures have been developed, including *relative accessibility* (measuring one location relative to another) and *integral accessibility* (integrating information about locations of several activities). Accessibility also encompasses a time element. While there may be several shops located a short distance from a person's home, they will not be accessible if they close for business before the person can get there from work, or do not open until after the commuter leaves home.

The concept of accessibility applies to firms as well. Manufacturing firms benefit if their suppliers and markets for their products are easily accessible, and if a large pool of workers is within commuting range. Retail stores and other service firms have an advantage if their location is highly accessible to a large number of potential customers. Firms that produce or use bulky materials need access to low cost transportation (e.g., railroads or waterways). If transportation time is more critical than cost, proximity to an airport may be needed for accessibility.

On a broad scale, accessibility can critically affect the economic prospects of entire regions. In the 19th century, Chicago's location as the main hub of a network of railroads gave it unmatched accessibility among midwestern cities. More recently, accessibility to Pacific Rim markets has been an impetus to growth in west coast port cities.

Measurement of accessibility requires information not only about travel but about the location of destinations. This task has become more complicated, reflecting multiple locations of facilities and activities in most urban regions. While once travel time to the central business district from a residential area may have sufficed as an indication of relative accessibility, today, relative accessibility measures might include average travel time or cost to the nearest shopping mall, hospital, or park.

Because of the variety of opportunities available in most urban areas, integral accessibility measures provide a better picture of the ability to reach many desired destinations. These measures are harder to construct, however, as they must combine information about many routes and destinations.

Developing appropriate accessibility indicators at different geographic scales is an important challenge. It is possible to develop accessibility measures for a zone or region—by taking an average of a number of points within a zone. It is also possible to map patterns on a broader geographic scale by calculating accessibility at different points.

Personal Mobility in the United States

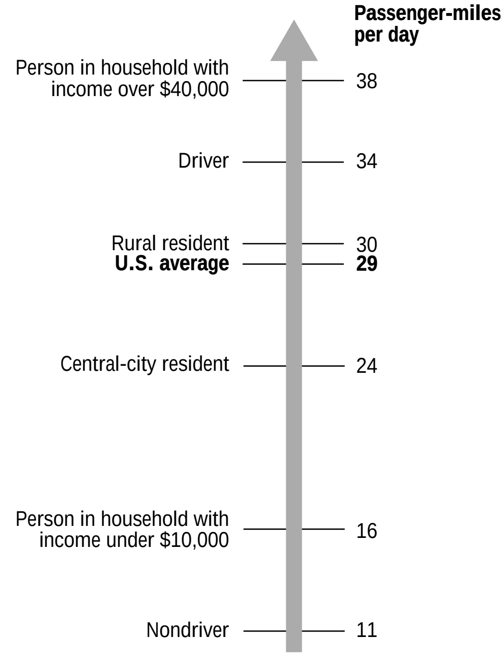
Americans travel more than ever, and continue to increase their use of the transportation system. Growth in passenger travel reflects many different factors, including population and labor force growth, a decline in household size, income growth, and dispersion of development and employment centers within metropolitan areas.

Four Nationwide Personal Transportation Surveys (NPTS) conducted between 1969 and 1990 provide detailed information about travel behavior of specific groups. (Results from the 1995 NPTS and BTS's American Travel Survey (ATS), also conducted in 1995, are not yet available. The ATS focuses on travel of more than 75 miles from home, while NPTS emphasizes daily trips.)

On average, most groups—men and women, young and old, rich and poor, city and rural residents—traveled more each day in 1990 than in 1969. Pronounced differences abound, reflecting both travel needs and the ability to travel. For example, suburban residents travel about 32 miles per day, slightly more than rural residents, and 30 percent more than central-city residents (just over 24 miles per day). People with higher incomes travel farther than those with lower incomes. People in the 40- to 49-year-old age group travel more than their younger or older age cohorts. Men travel further than women, on average, although women make slightly more daily trips. Whites travel further than blacks or Hispanics.

The availability of a passenger car or vehicle makes a critical difference. People relied on cars and other privately owned vehicles for 87 percent of their daily trips in 1990. Transit accounted for 2 percent of trips. All other modes (including airplanes, Amtrak, taxi, walking,

Average Daily Miles of Travel



SOURCE: See figure 7-1 in chapter 7.

bicycling, and school buses) accounted for the remaining 11 percent.

The number of households without a car or other passenger vehicle declined from 21 percent in 1960 to 11.5 percent in 1990; still, 10.6 million households did not have a car in 1990. The ability to drive a passenger car has had an enormous impact on mobility. In 1990, people with drivers licenses took nearly twice as many daily trips, traveled three times as far, and took longer trips than people without licenses.

More than one-third of the travel by the average person involved social and recreational purposes; another third involved family and personal business (e.g., shopping and doctor's appointments). About one-quarter of the travel miles and 22 percent of trips are to and from the workplace. Work trips, however, are more important than the figure suggests. Many people shop and conduct other personal business during their commute to and from work. If such trip chaining is added to simple work trips, then people structure 30 percent of their daily trips around their work schedule. While trip chaining during the work commute increases peak hour travel, it also may allow people to choose to make fewer trips and to travel fewer miles overall.

Access to Opportunities

On a nationwide basis, access has increased since the end of World War II reflecting the effects of further urbanization, the development of transportation facilities (particularly the completion of the Interstate Highway System and the expansion of the air transportation industry), and economic development. Despite these improvements, some areas of the country, experienced a decline in some types of transportation services. Fewer places are served today by passenger rail and intercity buses, in part because carriers have given up unprofitable or sparsely used services. Rural areas have been especially affected by such changes.

In urban areas, access has generally increased, although much of that access depends on the automobile. Transit service, too, is accessible to many urban residents. In 1990, half of the households in urban areas were located within one-quarter mile of a transit route, close enough for most people to walk. Transit, however, has had a hard time keeping up with the changing spatial distribution of opportunities, particularly job sites. Many poor people in central cities have very limited access to employment opportunities in the distant suburbs, the location of much new employment growth, including entry-level jobs. Insufficient transportation options are part of the explanation, as many urban poor people do not have cars and public transit stops are often lacking near suburban job locations. This will present a transportation challenge for many welfare recipients in central-city areas who will soon need employment due to changes in federal and state welfare programs.

Access to transportation is increasing for persons with disabilities, although challenges remain. Under the Americans with Disabilities Act of 1990, fixed-route service is to be made increasingly available to the disabled, with paratransit the recourse when fixed-route transit does not meet a customer's needs or is inappropriate to the situation. Paratransit accounted for 37 million trips in 1995. The evolving relationship between fixed-route transit and paratransit has several implications. For example, fixed-route service needs to be designed so as to be accessible to persons with disabilities (e.g., lifts on buses, and elevators and raised platforms at key train stations), and drivers need training on proper use of equipment. Fixed-route and paratransit services will now need to be coordinated and developed together, taking advantage of newly available information technologies. With greater accessibility, transit demand by the disabled has increased and will likely increase in the near future.

Mobility from the Freight Perspective

Because of the widespread availability of transportation and advances in information technologies, U.S. businesses are able to transport raw materials, finished goods, and people quickly, cheaply, and reliably, often across great distances. On a typical day in 1993, about 33 million tons of commodities, valued at about $17 billion, moved an average distance of nearly 300 miles on the U.S. transportation network. These estimates are based on data from the Commodity Flow Survey (CFS),[4] the most extensive survey of domestic freight movements undertaken since 1977, and supplemental data on waterborne and pipeline shipments. Even this large figure underestimates total freight movements,

[4] BTS calculated the daily total from final CFS data plus additional data on waterborne and pipeline shipments not fully covered by the CFS.

as it does not include most imports and some other flows.

In 1993, domestic establishments in the sectors covered by the CFS shipped materials and finished goods weighing 12.2 billion tons, generating 3.6 trillion ton-miles within the United States. The goods shipped were valued at more than $6.1 trillion. The food and kindred products sector accounted for the highest dollar amount of shipments identified in 1993, followed by transportation equipment. The major commodities by weight were petroleum and coal products, nonmetallic minerals, and coal. Food and kindred products ranked fourth by weight.

The major commodities vary greatly when ranked by the value per ton of shipment. On average in 1993, high-value commodities (e.g., worth over $5,000 per ton) accounted for 41 percent of the total shipments but only 2 percent of the tons and 5 percent of the ton-miles. Low-value commodity categories (e.g., those that averaged less than $1,000 per ton) accounted for less than half of the value, yet accounted for most of the tons and ton-miles, 96 percent and 91 percent, respectively.

A large portion of the shipments by value originate in states with a major manufacturing base, such as California, New York, Michigan, Texas and Illinois. These states were also the destinations for a large portion of shipments. Manufacturing, however, is an important activity in most states. Partly because firms are able to cheaply and reliably transport materials, parts, and merchandise from one part of the country to another, industrial production is dispersed throughout the United States.

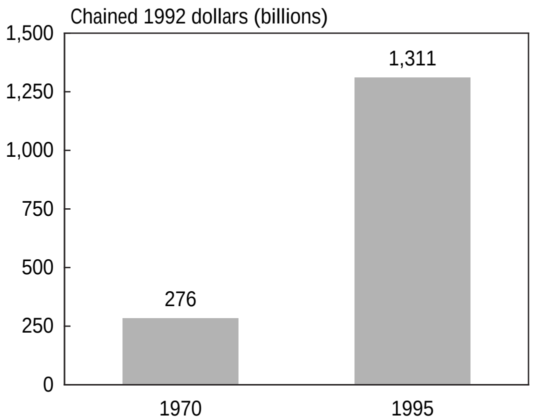
Raw materials and processed goods are shipped to all parts of the nation. For example, enormous amounts of farm products travel from north to south on the Mississippi River for export from Gulf coast ports. During the past three decades, the pattern of coal movement has significantly changed. Before the 1970s, about 95 percent of domestically produced coal was mined east of the Mississippi River. By 1995, more than 47 percent of U.S. coal was produced in the western states. This growth is partly due to increased demand for low-sulfur coal mined in Montana and Wyoming.

Trucking was the most dominant mode for freight transportation in 1993, moving about 72 percent by value and 53 percent by weight of shipments, and producing 24 percent of ton-miles. Rail freight produced slightly more ton-miles, 26 percent of the total, and accounted for 13 percent of the weight of shipments but just 4 percent of the value. Waterborne transportation accounted for over 17 percent of tons and 24 percent of ton-miles. The classic intermodal combination of truck and rail moved over 40 million tons of commodities worth over $83 billion. Parcel, postal, and courier services were used to move over 9 percent of the value of shipments valued at over $560 billion.

The distribution of freight carried by the different modes in part reflects changes occurring in the economy. Today, high value-adding businesses often require quick, reliable, and high-quality transportation to assure faster product deliveries, on time, with little product loss or damage. For example, parcel, postal, and courier services were used to transport nearly one-quarter of the shipments of electrical equipment, machinery, and supplies in 1993. Business uses of more expensive truck and air transport fit a pattern of dynamic, globalized economic activity moving toward lower overall costs of production and product distribution.

The transportation system also is used to provide other essential services to the economy. About 16 million households moved in 1994. Over 200 million tons of solid waste were collected by municipalities for recycling, incineration, or disposal in 1994. Most was transported

Sum of Imports and Exports of Goods



SOURCE: See figure 9-10 in chapter 9.

a few miles, but some was shipped as much as 2,000 miles for disposal.

The nation's transportation network facilitates an interconnected economy both nationally and internationally. Imports and exports of goods and services have grown rapidly. Since 1970, international waterborne freight moving to and from U.S. ports has nearly doubled by weight. As businesses transport enormous amounts of goods within and among states, the nation's economy becomes more connected. Nationally, about 62 percent of the value and 35 percent of the weight of shipments by all modes were interstate. These estimates from the CFS show the national dimensions of freight movement within the United States.

International Trends in Passenger Mobility and Freight Activity

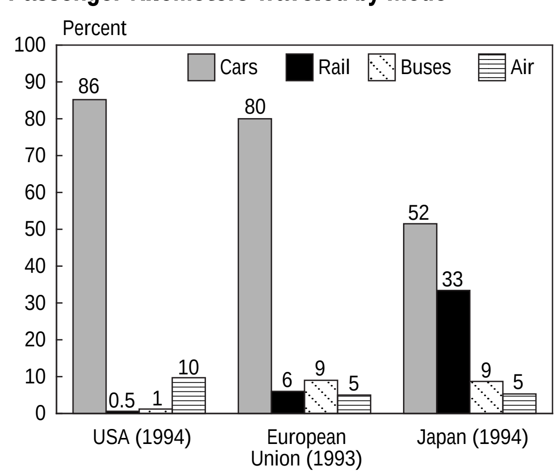
Americans traveled more than 24,000 passenger-kilometers (pkm) per capita in 1991, surpassing Europeans at 12,000 pkm and Japanese at 11,000 pkm. The United States also leads all countries in freight intensity with almost 20,000 metric ton-kilometers per capita in 1994 compared with 10,000 in Canada and about 4,500 in Japan.

As national economies and real personal income increase in most parts of the world, passenger cars and trucks are replacing rail and bus service and nonmotorized transportation for both passenger travel and freight activity. Air transportation is generally the fastest growing mode (but it holds a small overall modal share). Although changes in passenger travel and freight movement are evident in all regions of the developing world except some parts of Africa, the pace and extent of change varies greatly.

In the United States, cars and light trucks dominate passenger travel, accounting for 86 percent of passenger-miles traveled in 1994. Passenger cars account for about 80 percent of pkm in Western Europe. In Japan, by contrast, only about half of travel takes place in passenger cars, in part reflecting the importance of intercity and urban rail services in the high-population-density corridor between Tokyo and Osaka.

The number of passenger cars in use has been growing faster than the population in the developed countries. Automobile growth, however, is the highest in some developing countries, especially the rapidly growing economies in Asia.

Passenger-Kilometers Traveled by Mode



SOURCE: See figure 10-1 in chapter 10.

The United States still has the greatest number of cars, both absolutely and per capita.

Increasing income is a key factor influencing the shift toward cars. Other important factors include household formation, women's participation in the workforce, population age distribution, and shifts taking place in workplace locations. In developed countries, people tend to be moving out of urban areas to the suburbs. In developing countries, people tend to be moving from rural to urban areas, concentrating in the urban periphery.

The increased use of motor vehicles has resulted in greater personal mobility and freight activity, as well as in congestion, pollution, and higher energy consumption. Due in large part to increasing automobile use, cities such as Bangkok and Mexico City are facing urgent air pollution and congestion problems. Because of these problems, some countries have focused attention on how to stem the rise of personal automobile use, while enhancing public forms of transportation.

A nation's domestic freight activity generally increases in step with economic growth. Annual growth in freight activity in OECD countries has been between 1 percent and 4 percent during the last two decades, but over 7 percent in such rapidly growing countries as China. While U.S. freight activity has been growing at just 2 percent annually, per-capita U.S. freight activity is 10 times the 2,000 metric ton-kilometers generated per capita in China. Freight activity has been relatively constant in countries of the former East Bloc, where economies have been stagnant.

Trucks have been moving a greater share of freight, while the rail share has been declining, but with a worldwide average of 7.5 percent growth per year, air freight has been the fastest growing mode. Still, in most countries, air has a significantly smaller share of freight activity than either truck or rail.

The general shift from rail to motor vehicles and, now, air transportation for freight reflects structural, business production, and technology changes. For example, road and air transportation are more viable in countries where manufacturing and services are major economic sectors compared with agriculture or mining. Compared with rail, trucking provides more flexibility for just-in-time manufacturing.

Nonetheless, there are notable differences among countries in freight modal trends. In the United States, all freight modes increased their ton-miles of transportation between 1970 and 1994 (see chapter 9). In western Europe as a whole, by contrast, rail freight activity (measured in metric ton-kilometers) declined an average of 0.4 percent annually over the period. Concern about the growing dominance of road transportation has prompted some European countries and the European Union to seek ways to promote rail, inland watercarriage, and intermodalism.

Mobility and Access in the Information Age

Information technologies have become an important element of transportation. As a motivator and enabler of innovation, IT may ultimately have an impact on the performance and use of the transportation system comparable to the impacts of earlier advances in propulsion systems. IT applications not only can be used to improve operation, control, and management of the physical elements of transportation, but also can improve organizational processes used in transportation.

Information technologies are being adopted throughout the economy in ways that are fundamentally affecting not only the supply of new services, but also the nature of society's needs and desires for mobility and access. Today, people in many places around the world can choose among fax, electronic mail, and overnight express for the movement of documents, or avoid intercity trips through conference calls. Such options are affecting commercial operations and daily life.

Transportation-related enterprises, like most businesses, are being changed by IT. The "bottom line" in transportation applications of IT is determined by the balance between cost and service. IT can affect both strongly. The acquisition and processing of operational, financial, and related data directly support higher system capacity, greater labor and capital productivity, improved efficiency, more effective resource allocation, and better integration of the many processes and activities that cumulatively produce transportation services.

Detailed understanding of system operations enables the design and implementation of innovative operational concepts and practices. The overnight package delivery service, for example, could hardly exist on its present scale without a myriad of computers, digital tags on each item, and extensive communications links. Similarly, computerized reservation systems are critical to the operation of the commercial aviation system, which fills well over 1 million airline seats each day for several thousand origin-destination pairs at market-driven prices.

Information technologies are beginning to transform the interface between the service provider and the customer or user. The implementation of intelligent transportation systems (ITS) includes as a basic component the provision of real-time status information for local highways and transit systems, potentially with guidance as to optimal choices for particular trips. An individual sending a package for next-day delivery can use the Internet to track its progress. With a highly controlled and visible transportation system, manufacturers can safely integrate their suppliers into just-in-time production systems and tailor their outputs to short-term customer needs.

Information technologies also can alter the need to travel, or the type of transportation consumed. Personal purchases may be made by traveling to a store, or by ordering (using the telephone or the Internet) and relying on a delivery service. Aided by modem-equipped computers, fax machines, and online services, some people find it feasible—and often preferable—to work from home, either as a telecommuting employee or as an independent business or contractor.

Most transportation uses of IT depend on the integration of many specific technologies and capabilities. Improvements in one technical area may make new applications or services available. The full impact of the IT evolution for transportation is likely to emerge slowly in the coming decades, and often will not be separable from the effects of other societal changes.

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BTS has published a companion volume to this report, *National Transportation Statistics 1997* (NTS), which covers the 1960 through 1995 time period. NTS provides modal profiles and statistics on the state of transportation, the economic importance of transportation, safety trends, and energy and environmental aspects of transportation. Most of the NTS tables, as well as many other BTS products, are available on the BTS Internet homepage. Information about contacting BTS is on the back cover of this report.

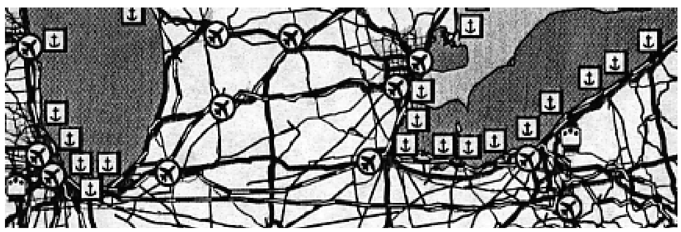
T.R. Lakshmanan
Director

Part I

The State of the Transportation System

chapter one

The Transportation System



The United States has the world's largest transportation system, serving the 265 million people and 6 million business establishments that occupy the fourth largest nation by land area. The interlocking elements of the transportation system include not only the physical links among places—highways, transit systems, railroads, airports, waterways and ports, and pipelines—but the firms that provide transportation services, the many industries that produce and maintain vehicles, and agencies with transportation responsibilities at all government levels. Americans are highly mobile and American businesses ship more freight per capita than any other country. Passenger-miles per person averaged 16,500 miles in 1995 (not including miles traveled in heavy trucks), while 12,600 ton-miles of freight were generated per capita. The transportation facilities that made this possible included, among other things, 3.9 million miles of public roads, 170,000 miles of railroad track operated by freight carriers, 44,000 transit buses, 40,000 U.S.-flag vessels, and 200,000 miles of oil pipelines (see table 1-1). These transportation facilities supported 4.3 trillion miles of passenger travel and 3.6 trillion ton-miles of goods movement. (USDOT BTS 1996, 15, 20)

This chapter provides an overview of the extent, use, condition, and physical performance of the transportation system, updating the discussion in earlier editions of the *Transportation Statistics Annual Report*. For 1997, one mode, urban

Table 1-1.
Major Elements of the Transportation System: 1995

Mode	Major defining elements	Components
Highways[1]	Public roads and streets; automobiles, vans, trucks, motorcycles, taxis, and buses (except local transit buses) operated by transportation companies, other businesses, governments, and households; garages, truck terminals, and other facilities for motor vehicles	*Public roads* 45,744 miles of Interstate highway 111,237 miles of other National Highway System roads 3,755,245 miles of other roads *Vehicles and use* 136 million cars, driven 1.5 trillion miles 58 million light trucks, driven 0.7 trillion miles 6.9 million freight trucks, driven 0.2 trillion miles 686,000 buses, driven 6.4 billion miles
Air	Airways and airports; airplanes, helicopters, and other flying craft for carrying passengers and cargo	*Public use airports* 5,415 airports *Airports serving large certificated carriers*[2] 29 large hubs (67 airports), 393 million enplaned passengers 33 medium hubs (59 airports), 86 million enplaned passengers 58 small hubs (73 airports), 34 million enplaned passengers 561 nonhubs (593 airports), 14 million enplaned passengers *Aircraft* 5,567 certificated air carrier aircraft, 4.6 billion miles flown[3] *Passenger and freight companies* 86 carriers, 506 million domestic revenue passenger enplanements, 12.5 billion domestic ton-miles of freight[3] *General aviation* 181,000 aircraft, 2.9 billion miles flown[4]
Rail[5]	Freight railroads and Amtrak	*Railroads*[6] 125,072 miles of major (Class I)[7] 18,815 miles of regional 26,546 miles of local 24,500 miles of Amtrak *Equipment* 1.2 million freight cars 18,812 freight locomotives *Freight railroad firms* Class I: 10 companies, 185,782 employees, 1.3 trillion ton-miles of freight carried Regional: 30 companies, 10,647 employees Local: 500 companies, 13,269 employees *Passenger (Amtrak)* 23,646 employees, 1,722 passenger cars,[8] 313 locomotives,[8] 20.7 million passengers carried[9]

Table 1-1.
Major Elements of the Transportation System: 1995 ***(continued)***

Mode	Major defining elements	Components
Transit[10]	Commuter trains, heavy-rail (rapid-rail) and light-rail (streetcar) transit systems, local transit buses, vans and other demand response vehicles, and ferry boats	*Vehicles* 43,577 buses, 17.0 billion passenger-miles 8,725 rapid rail and light rail, 11.4 billion passenger-miles 4,413 commuter rail, 8.2 billion passenger-miles 68 ferries, 243 million passenger-miles 12,825 demand response, 397 million passenger-miles
Water	Navigable rivers, canals, the Great Lakes, the St. Lawrence Seaway, Intracoastal Waterway, and ocean shipping channels; ports; commercial ships and barges, fishing vessels, and recreational boats	*U.S.-flag domestic fleet*[11] Great Lakes: 698 vessels, 60 billion ton-miles Inland: 31,910 vessels, 306 billion ton-miles Ocean: 7,033 vessels, 440 billion ton-miles Recreational boats[12]: 11.7 million *Ports*[13] Great Lakes: 362 terminals, 507 berths Inland: 1,811 terminals Ocean: 1,578 terminals, 2,672 berths
Pipeline[14]	Crude oil, petroleum product, and natural gas lines	*Oil* Crude lines: 114,000 miles of pipe, 323 billion ton-miles transported Product lines: 86,500 miles of pipe, 269 billion ton-miles transported 161 companies, 14,900 employees *Gas* Transmission: 276,000 miles of pipe Distribution: 919,000 miles of pipe 19.7 trillion cubic feet, 150 companies, 187,200 employees

[1] U.S. Department of Transportation, Federal Highway Administration. 1995. *Highway Statistics*. Washington, DC.
[2] U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information. 1996. *Airport Activity Statistics of Certificated Air Carriers, 12 Months Ending December 31, 1995*. Washington DC.
[3] Preliminary data.
[4] U.S. Department of Transportation, Federal Aviation Administration. 1997. *General Aviation and Air Taxi and Avionics Survey, Calendar Year 1995.* Washington, DC.
[5] Except where noted, figures are from Association of American Railroads. 1996. *Railroad Facts.* Washington, DC.
[6] Miles of track operated.
[7] Includes 891 miles of road operated by Class I railroads in Canada.
[8] Amtrak. 1997. *Twenty-Fifth Annual Report, 1996.* Washington, DC.
[9] Excludes commuter service.
[10] U.S. Department of Transportation, Federal Transit Administration. 1997. *National Transit Database, 1995.* [cited as of 5 August 1997] Available at www.fta.dot.gov/library/reference/sec15/1995/index.html.
[11] Excludes fishing and excursion vessels, general ferries and dredges, derricks, and so forth used in construction work. Vessel data from U.S. Army Corps of Engineers. 1996. *Transportation Lines of the United States.* New Orleans, LA. Ton-miles data from U.S. Army Corps of Engineers. 1996. *Waterborne Commerce of the United States,1995*. New Orleans, LA.
[12] U.S. Department of Transportation, United States Coast Guard. 1996. *Boating Statistics*. Washington, DC.
[13] Ports data from U.S. Department of Transportation, Maritime Administration. 1996. *A Report to Congress on the Status of the Public Ports of the United States, 1994–1995.* Washington, DC. October.
[14] Data are for 1994.

SOURCE: Unless otherwise noted, U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997*. Washington, DC. December.

transit, is profiled in detail. The chapter concludes with a discussion of selected transportation events that occurred in 1996. Other aspects of the system's performance, its economic role and its unintended consequences for safety, energy import dependency, and the environment, are discussed in subsequent chapters of Part I of this report, which concludes with an analysis of data and information needs in the rapidly changing world of transportation.

Passenger Transportation

Passenger transportation, measured by passenger-miles traveled (pmt), continues to grow, and per capita travel growth appears to have accelerated during the last 25 years. Overall, pmt, excluding miles traveled by heavy trucks, grew from approximately 2.2 trillion in 1970 to 4.3 trillion in 1995, a 2.7 percent average annual increase. Again, excluding miles traveled by heavy trucks, per capita miles traveled in 1995 were 16,500, up from 11,000 in 1970, which was an annual rate of 1.6 percent over the 25 year period—1.1 percent annually from 1970 to 1980, 1.8 percent annually from 1980 to 1990, and 2.3 percent annually from 1990 to 1995. (USDOT BTS 1996)

As discussed in more detail in chapter 7, many factors contribute to the increase in pmt. The resident population increased by nearly 59 million, a rise of 29 percent between 1970 and 1995. The number of people in the labor force, most of whom commute to work, grew twice as fast as the population over the same period (from 83 million to 132 million, a 59 percent increase). The number of working women and women looking for work increased from 32 million in 1970 to 61 million in 1995. People also have more money to spend on transportation, particularly automobiles and air travel. Disposable personal income per capita rose from $12,000 in 1970 to $18,800 in 1995 (in chained 1992 dollars), a 56 percent increase. (USDOC 1996)

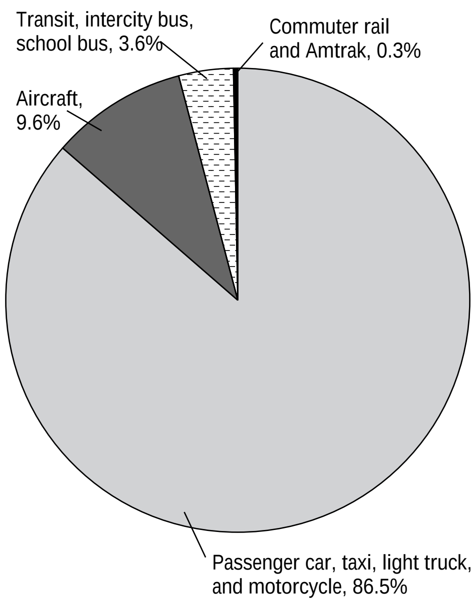
The vast majority of pmt, 87 percent in 1995, took place in personal vehicles (including cars, light trucks, taxis, and motorcycles) (see figure 1-1). Despite enormous growth in pmt by personal vehicles, their percentage of total pmt declined from 90 percent in 1970 because of the more rapid growth of air travel. Nearly 10 percent of pmt was by air, 4 percent by transit, intercity bus, and school bus, and 0.3 percent by rail (both Amtrak and commuter rail). Passenger-miles traveled in light trucks (including pickups, minivans, and sport utility vehicles) rose from 9 percent of all pmt in 1970 to 21 percent in 1995. (USDOT BTS 1996)

Despite the increase in motorized transportation, nonmotorized forms of transportation remain an important way to travel. In 1990, about 8 percent of all trips were made by nonmotorized transportation (7.2 percent on foot and 0.7 percent by bicycle), a drop from 9.3 percent in 1983. (USDOT FHWA 1993, 4-58; USDOT FHWA 1986, 6-5) As pedestrian and bicycle trips are short, averaging 0.6 miles and 2 miles, respectively, they accounted for less than 1 percent of all person-miles in 1990. Because of their low cost, minimal impact on the natural environment, and positive impact on public health, the U.S. Department of Transportation carried out research to seek new ways to encourage walking and bicycling to fulfill people's mobility needs. (See USDOT FHWA 1994) Trends in personal mobility are discussed in much greater detail in chapter 7.

Freight Transportation

The transportation of freight reached 3.65 trillion ton-miles in 1995, about 3.5 percent more than in 1994. From 1970 to 1995, freight ton-

Figure 1-1.
Passenger-Miles Traveled, by Mode: 1995



SOURCE: Various sources as cited in U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.

miles rose 2 percent annually.[1] There are several reasons for this trend other than growth in the general population and economy. These include the increasingly complex logistics of production, more international trade, technological improvements allowing more trading of perishable goods, and the implementation of information technologies allowing just-in-time delivery systems.

According to the 1993 Commodity Flow Survey (CFS—conducted by the Bureau of Transportation Statistics (BTS) and the Census Bureau), for-hire and private trucking is the most dominant mode of freight transportation in the United States. Trucks moved 72 percent of freight by value and 53 percent by tonnage. About 26 percent of ton-miles moved by rail and 24 percent by water.[2] These modes of transportation are particularly important for the movement of bulk commodities, like coal, grain, mineral ores, and oil. Although air freight moves a minute proportion of total ton-miles (less than 1 percent), the value of freight moved and the price paid for such movement are high; air freight ton-miles have grown nearly sixfold since 1970. Freight movement and the CFS are discussed in greater detail in chapter 9.

System Extent and Use

Overall, the U.S. transportation system continues to change and expand in response to a variety of factors, especially increased demand from travelers and freight shippers. This section outlines the changes and trends that have occurred in the system from 1994 to 1995, and, in some instances, since 1980. Urban transit trends are discussed in a separate section of this chapter.

Railroads

The rail system at the end of 1995 included 10 major freight carriers, known as Class I railroads, which dominated the industry, and 530 regional and local railroads. Information about Class I railroads is quite extensive and informs most of the discussion here. More limited information is available for smaller railroads, and some is presented here (see ASLRA 1995 for more details).

In the Class I railroad industry, track is decreasing while rail stock, both locomotives and railcars, is increasing. In 1995, there were 180,000 miles of track owned, about 2 percent less than in 1994, continuing a trend evident for much of this century.[3] (Between 1980 and 1995, miles of track declined by about one-third, from 271,000 miles.) Conversely, the 18,800 freight

[1] These figures do not include local truck freight movements or non-Class I rail.

[2] These estimates were calculated by BTS from final datasets in the 1993 CFS, plus additional data on waterborne and pipeline shipments not fully covered in the CFS (see USDOT BTS 1997).

[3] The term *miles of track* adds up all railroad multiple main tracks, yard tracks, and sidings. In contrast, *miles of road* counts only the total length of the roadway operated, excluding yard tracks and sidings, and any multiple mainline tracks. (AAR 1996, 44)

locomotives in service in 1995 was nearly 2 percent more than in 1994. The number of freight railcars also increased by 2 percent between 1994 and 1995, to 1.2 million. (AAR 1996, 50) Despite less track, revenue ton-miles grew from 1.20 trillion in 1994 to 1.31 trillion in 1995, and since 1980 have increased by 42 percent. (AAR 1996, 27)

Capital expenditures on equipment and roadway and structures in the freight rail industry have been increasing. Total spending was $6.0 billion in 1995, up from $4.9 billion one year earlier (unadjusted for inflation). At the same time, the number of employees in the Class I, regional, and local freight railroads fell from 213,000 at the end of 1994 to 210,000 at the end of 1995. The year-end number of people working for Class I railroads fell from 189,000 in 1994 to 186,000 in 1995. (AAR 1995 and 1996, 3)

The 10 Class I railroad companies operating at the end of 1995 were two fewer than at the end of 1994.[4] (AAR 1995 and 1996) Another recent development of note was the creation of the Surface Transportation Board (STB), which took over the regulatory functions of the Interstate Commerce Commission. STB began operating on January 1, 1996, and in 1996 approved the Union Pacific acquisition of Southern Pacific. In 1997, STB was examining a proposed acquisition of Conrail by Norfolk Southern and CSX Transportation.

At the end of 1995, there were 30 regional and 500 local railroad companies. The regionals operated nearly 19,000 miles of road, employed 10,600 people, and had revenue of $1.5 billion. Local railroads operated 26,500 miles of road, employed 13,000 people, and had revenue of $1.4 billion. (AAR 1996, 3)

[4] During 1995, the Chicago and North Western Transportation Company was acquired by the Union Pacific Company, and the Burlington Northern Railroad Company merged with the Atchison, Topeka, and Santa Fe Company.

Intercity rail passenger service is provided primarily by Amtrak (the National Railroad Passenger Corporation). Amtrak operated nearly 24,500 miles of road in 1995, but owned only 750 miles. (AAR 1996) The number of passenger locomotives and passenger cars in service declined between fiscal year (FY) 1994 and FY 1995. (Amtrak 1997)

Capital expenditures by Amtrak amounted to $617 million in FY 1995, up from $323 million in FY 1994 (unadjusted for inflation). During 1995, Amtrak raised fares, cut routes, and reduced its losses. Average employment during the year was nearly 24,000, down about 1,000 from the previous year. (AAR 1995 and 1996)

The number of Amtrak passengers decreased from 21.2 million in FY 1994 to 20.7 million in FY 1995. Passenger-miles traveled over the same period fell from 5.9 billion to 5.5 billion, but this is still higher than the 4.5 billion in 1980. (USDOT BTS 1996)

Highways

The public road system continues to expand, although much more slowly than the growth in the number of vehicles. Urban and rural roads totaled 3.91 million miles in 1995, up from 3.86 million in 1980, a 1 percent increase.[5] Lane mileage (including lanes added due to road widening) has increased faster. Between 1985 and 1995, lane mileage on nonlocal roads increased by 3 percent, from 2.70 million miles to 2.78 million miles. The number of highway vehicles (excluding transit vehicles), however, has increased much faster than road length, going from 161 million in 1980 to 205 million in 1995, a 27 percent increase. (USDOT FHWA Various years)

Highway vehicle-miles traveled (vmt) by all vehicles in 1995 was 2.42 trillion, up from 2.36 trillion in 1994 and 1.53 trillion in 1980.

[5] These figures are for length of public roads only, and do not include private roads.

(USDOT FHWA Various years) Vehicle-miles traveled by automobiles and light trucks accounted for 92 percent of the vmt in 1995, with most of the rest traveled by trucks.

In September 1996, the first roads designated as "All-American Roads" and "Scenic Byways" (under the National Scenic Byways program created by the Intermodal Surface Transportation Efficiency Act of 1991—ISTEA) were announced by then-Secretary of Transportation Frederico Peña. The All-American Roads are: the Selma to Montgomery March Byway in Alabama; the Route 1, Pacific Coast Highway in California; the San Juan Skyway and Trail Ridge Road/ Beaver Meadow Road in Colorado; the Natchez Trace Parkway in Mississippi, Tennessee, and Alabama; and the Blue Ridge Parkway in North Carolina. Fourteen national scenic byways were designated in 12 states. The program is designed to recognize and enhance already existing special highway corridors, and grants totaling $62.4 million have been awarded for the development of programs and related services (in fiscal years 1992 through 1996). Designated roads will receive priority for funding under the program. A second set of roadway designations is expected to be made in 1997. (USDOT 1996)

Air Transportation

After many years of growth, the total number of airports (including civil and joint civil-military airports, heliports, STOLports, and seaplane bases) declined slightly between 1994 and 1995, from 18,343 to 18,224, still well above the 15,161 operated in 1980. (USDOT BTS 1996, 6) This change was due primarily to the variation in the number of general aviation (GA) airports. Private-use airports constitute 70 percent of these airports, and 96 percent of all airports are used by GA aircraft. General aviation airports are usually rudimentary facilities; only about half have paved runways and about one-quarter have lighted runways. The number of civil certificated airports (serving air carrier operations with aircraft seating more than 30 passengers) has declined somewhat. Between 1994 and 1995, the number of these airports declined from 577 to 572. There has been an increase in the number of airports with Federal Aviation Administration (FAA) towers or FAA-contracted towers from 434 in 1994 to 447 in 1995.[6] (USDOT FAA 1997a) Since 1980, the number of heliports doubled, reaching 4,617 in 1994. (USDOT FAA Various years).

In 1995, there were 5,567 aircraft available for service by U.S.-flag certificated air carriers, an increase of 7 percent from the previous year. (USDOT BTS 1996, 33) Since 1980, the number of such aircraft almost doubled. The available seat-miles as a result increased from 427 billion in 1980 to 803 billion in 1994. (Aviation Week Group 1997) By contrast, the number of GA aircraft in 1995 was 181,000, a significant drop since 1980 when there were over 200,000. (USDOT FAA 1997b)

The number of air carriers rose slightly from 82 in 1994 to 86 in 1995. (USDOT BTS 1996, 209) There were 72 air carriers in 1980. The number of air carrier employees increased from 586,000 in 1994 to 609,000 in 1995, up from 354,000 in 1980. (USDOT BTS 1996, 209)

The number of enplanements (including international passengers) on certificated carriers at U.S. airports grew to 559 million in 1995, up from 541 million in 1994 and 303 million in 1980. (USDOT BTS 1996)

Water Transportation

The U.S. oceangoing merchant fleet over 1,000 gross tons consisted of 512 vessels in 1995, totaling 19 million deadweight tons. Of these, 322 were owned privately and the rest (190) were

[6] Preliminary data.

owned by the Maritime Administration (MARAD). All but 12 of the MARAD-owned ships were inactive, either in reserve or pending disposal. By contrast, most of the privately owned ships (292) were in the active fleet. The private U.S. oceangoing fleet ranked 23rd in number of ships and 11th by deadweight tons in the world. Of the 512 public and private vessels in 1995, 182 were tankers, 171 were intermodal vessels, 125 were general cargo ships, 21 were bulk carriers, and 13 were passenger carriers. (USDOT MARAD 1996a)

The domestic fleet, including the inland waterways, Great Lakes, and oceangoing vessels (vessels of all sizes, self-propelled and nonself-propelled), totaled nearly 40,000 in 1995, with a cargo capacity of 67 million short tons and a passenger capacity of 377,000. (US Army Corps of Engineers 1996c) Vessels using the inland waterways made up 80 percent of the entire fleet (a large proportion of these being nonself-propelled barges for dry cargo). Ships on the Atlantic, Gulf, and Pacific coasts made up another 18 percent, and the remaining 2 percent worked the Great Lakes.

In 1995, there were 1,940 public and private deep-draft terminals at ocean and Great Lakes ports, with 3,179 berths. Approximately 75 percent of these terminals were privately owned. General cargo berths made up 38 percent of all berths, 22 percent were dry bulk berths (e.g., for coal, grain, or ore), liquid bulk berths made up 20 percent (e.g., for crude and refined petroleum), and passengers berths accounted for 3 percent. The remaining 18 percent were classified as "other" (e.g., berths for barges, for mooring, or inactive berths). (USDOT MARAD 1996b, 20)

Inland waterway ports and terminals generally have shallow water depths (14 feet or less), and can be located in many places on the 25,000 miles of navigable inland rivers and intracoastal waterways, providing more flexibility than coastal ports. In 1995, there were about 1,800 river terminals in 21 states, of which about 89 percent were privately owned. Of these terminals, approximately 4 percent were for general cargo, 58 percent were for dry bulk cargo, 27 percent were for liquid bulk cargo, and 11 percent were multipurpose. (USDOT MARAD 1996b, 24)

Capital expenditures in 1994 on public ports amounted to $930 million, a 42 percent increase over 1993. The increase reflects the purchase of a large tract of land for current and future development of a port in the South Pacific (California) Region of the United States. Even excluding the money spent to hold this land for future development ($243 million), twice as much was spent on public ports in the South Pacific Region as in any other. The next largest expenditures were in the South Atlantic Region, including ports in Virginia, Georgia, North and South Carolina, and Florida. Analysis of public port expenditures in 1994 reveals that the industry spent most heavily on specialized cargo facilities (35 percent of the total) and conventional general cargo facilities (23 percent) (see table 1-2). (USDOT MARAD 1996b, 27)

Total freight moved by water increased by 12 percent between 1980 and 1995. Imports and exports grew much faster than domestic shipments, increasing by 25 percent between 1980 and 1995, while domestic shipments increased by 1 percent. (US Army Corps of Engineers 1996d) Fifty-five percent of domestic shipments by water take place along the coasts, totaling 440 billion ton-miles. Shipments by inland waterways make up another 38 percent and lakewise transport constitutes the remaining 7 percent. Inland waterways shipments are the only form of domestic water transportation that increased over the past 15 years. Between 1980 and 1995, inland waterways movement increased by 35 percent, while coastwise move-

Table 1-2.
U.S. Port Capital Expenditures: 1994

Type of expenditure	Amount (thousands)	Percent
Total	$686,620	100.0
Specialized cargo	239,236	34.8
General cargo	156,213	22.8
Dry bulk	38,240	5.6
Passenger	32,536	4.7
Liquid bulk	2,169	0.3
Other	49,790	7.3
Infrastructure	144,664	21.1
Off terminal	103,641	15.1
On terminal	41,023	6.0
Dredging	23,772	3.5

NOTE: Excludes $243 million land purchase in the South Pacific Region (California).

SOURCE: U.S. Department of Transportation, Maritime Administration. 1996. *A Report to Congress on the Status of the Public Ports of the United States, 1994–1995.* Washington, DC.

ment decreased by 30 percent, and lakewise movement declined by 3 percent. (USDOT BTS 1996, 20) Tonnage handled by major U.S. ports in 1995 is shown in figure 1-2.

Pipelines

Oil pipeline mileage increased slightly between 1993 and 1994 (from 199,000 miles to 201,000 miles), but is still below the 218,000 miles that existed in 1980. Pipelines for crude oil movement decreased from 130,000 miles in 1980 to 114,000 in 1994, while oil product lines fell slightly from 89,000 miles to 87,000 miles over the same period. The number of Federal Energy Regulatory Commission-regulated pipeline companies increased from 130 in 1980 to 161 in 1995, while the number of oil pipeline employees decreased from 21,300 to 14,900 over the same period. (USDOT BTS 1996)

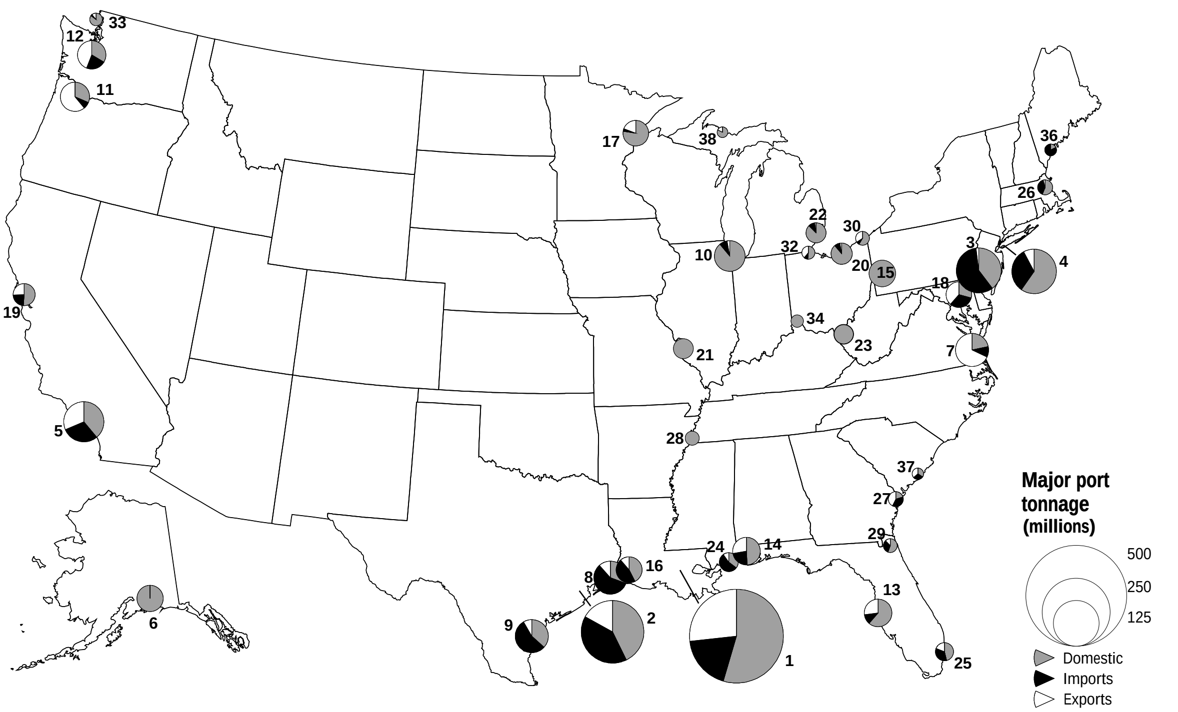
Natural gas pipelines totaled 1.2 million miles in 1994 (up slightly from 1993). Distribution lines are three-quarters of this total mileage; transmission, field, and gathering lines make up the other quarter. Since 1980, the length of pipeline has increased by 24 percent, mostly on the distribution side. Transmission pipeline increased by only 3 percent over this period. In 1994, there were 150 interstate natural gas pipeline companies (an increase of 15 from 1993) employing about 187,000 people, 28,000 fewer than in 1980 when there were 91 companies in the industry. (USDOT BTS 1996, 246)

Since 1980, the annual pipeline throughput of natural gas has been around 20 trillion cubic feet. In 1994, throughput was 19.7 trillion, up from 19.0 trillion in 1993. Ton-miles of crude oil and petroleum products were 599 billion in 1995, roughly the same as 1994, but up slightly from 1980 (588 billion ton-miles). (USDOT BTS 1996)

Condition and Performance of the Transportation System

Accurate information about the physical condition and performance of the transportation system can provide the basis for informed decisions about future investments. This section discusses the condition and performance of each transportation mode (except urban transit, which is profiled separately). It updates the detailed discussion in the 1996 *Transportation Statistics Annual Report*, which summarized the Department of Transportation's (DOT) biennial report to Congress on the condition and performance of the nation's surface transportation system, and also examined air transportation. While there is some new information to report this year, the data are scattered and not comparable across modes.

Figure 1-2.
Tonnage Handled by Major U.S. Ports: 1995



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

NOTE: Major ports were defined as having at least one port with over 10 million tons shipped in 1995, 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 in 1995.

SOURCE: U.S. Army Corps of Engineers. 1996. *Waterborne Commerce of the United States: Calendar Year 1995.* New Orleans, LA.

Highway Transportation

One of the most important aspects of highway systems is the condition of the roads. Table 1-3 shows the condition of the Interstate Highway System and other heavily used roads, measured by pavement roughness. The data show: 1) rural Interstates are in better condition than urban Interstates, although there has been some improvement in the condition of urban Interstates; 2) improvement between 1994 and 1995 in almost all road categories.

The condition of roads, and trends in their condition, are difficult to establish because of a

Table 1-3.
Highway Pavement Conditions: 1994 and 1995
(In percent)

Type of road	Year	Poor	Mediocre	Fair	Good	Very good	Total miles reported
Urban							
Interstates	1994	13.0	29.9	24.2	26.7	6.2	12,338
	1995	10.4	26.8	23.8	27.5	11.4	12,307
Other freeways and	1994	5.3	12.7	58.1	20.9	2.9	7,618
expressways	1995	4.8	9.8	54.7	20.4	10.3	7,804
Other principal arterials	1994	12.5	16.3	50.8	16.6	3.8	38,598
	1995	12.4	14.7	47.2	15.9	9.7	41,444
Rural							
Interstates	1994	6.5	26.5	23.9	33.2	9.9	31,502
	1995	6.3	20.7	22.3	36.9	13.9	31,254
Other principal arterials	1994	2.4	8.2	57.4	26.6	5.4	89,506
	1995	4.4	7.6	51.1	27.9	9.0	89,265
Minor arterials	1994	3.5	10.5	57.9	23.6	4.5	124,877
	1995	3.7	9.0	54.7	23.9	8.7	121,443

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

NOTE: Interstates are held to a higher standard than other roads, because of higher volume and speed.

SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1995 and 1996. *Highway Statistics.* Washington, DC. Table HM-64.

change instituted over the past few years in the Highway Performance Monitoring System. The technique used to measure pavement condition is shifting from the Present Serviceability Rating (PSR) to the International Roughness Index (IRI). The Federal Highway Administration (FHWA) believes that the IRI provides a more objective standard than the PSR, and will provide a fairer way of comparing road conditions between states. Currently, the IRI is being used to measure Interstates, principal arterials, and rural minor arterials, while the PSR measures rural major collectors and urban minor arterials and collectors. Rural minor collectors are not being measured. (USDOT FHWA 1996) Surface roughness is not, however, a complete measure of highway condition (although it is an input to models that predict pavement deficiencies). FHWA is currently developing protocols for measuring other problems including rutting, cracking, and faulting. The next *Condition and Performance Report,* due to be released at the end of 1997, should provide fuller information about recent trends in bridge and highway condition, and congestion.

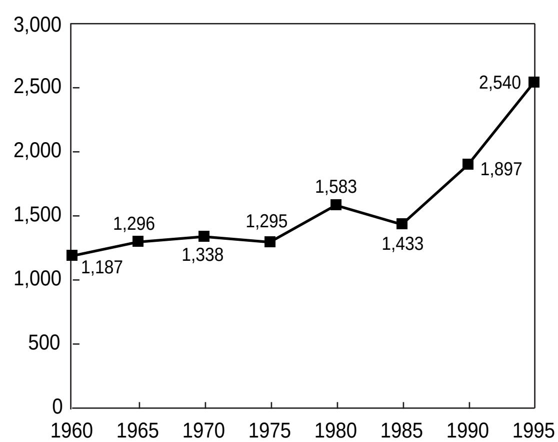
Another element of overall highway system condition and performance is the automobile fleet. The characteristics of the vehicles operated have important implications for energy consumption, pollution, and safety. The U.S. automobile fleet has grown and aged significantly over the past 15 years, and consequently there has been a decrease in the percentage of vmt in new cars. (Pisarksi 1995)

Finally, highway performance has been measured by level of service (LOS), over a range from LOS A (free flow conditions) through LOS F (stop and go traffic). Recurring congestion, indicating that traffic overwhelms the capacity of the system, is defined as LOS D (speeds beginning to decline and minor incidents cause queuing) and below. LOS D equates to a volume-service flow ratio (V/SF) of 0.8, or 80 percent of capacity. The V/SF measures the flow of traffic in relationship to a theoretical determination of the capacity. A V/SF of 0.8 or above was found to occur for 68 percent of urban Interstate highway peak-hour vehicle travel in 1994 (45 percent of the urban Interstate mileage), slightly lower then the 70 percent in 1991 and 1992, but still much higher than the 52 percent in 1980. (USDOT FHWA 1996, V6-7) (In 1995, the calculation of capacity was changed and, hence, 1995 is not comparable with earlier years. The 1995 figure was 55 percent of the urban Interstate peak-hour travel). While the V/SF measures the severity of congestion, it does not indicate the duration of congestion. One indicator of the severity and duration of congestion is provided by the Texas Transportation Institute (TTI), which assesses the delay in hours in 50 urban areas. (TTI 1996) TTI estimates that congestion nearly doubled from 7.3 million daily person-hours in 1982 to 14.2 million in 1993.

Rail Transportation

The recent history of rail freight transportation is very different when contrasted with the passenger side of the industry. Rail freight is experiencing increased traffic and revenues, and improved physical condition, despite less track. Amtrak, the nation's passenger rail carrier, has experienced decreasing patronage, mounting losses, and a deteriorating physical stock. In fiscal year 1996, Amtrak had a net operating loss of $764 million, a decline from $808 million in fiscal year 1995. (Amtrak 1997) Overall, freight train-miles per mile of rail track owned, a crude guide to congestion, increased from 1,200 in 1960 to 2,500 in 1995 (see figure 1-3). (This does not include passenger and commuter rail services that may run over the same track). Freight capacity constraints are most noticeable in the West, where most of the growth in train-miles has occurred. Train-miles increased by 42 percent between 1985 and 1995 in the West and by 16 percent in the East. (AAR 1996, 33) Since 1990, growth rates in the East and the West have been the same. Simply calculating train-miles per mile of track, however, does not take account of technological improvements that allow more trains to run on the same amount of track, and more freight to be carried on a train. Nevertheless, the rail industry considers capacity constraints as an issue. (Welty 1996)

Figure 1-3.
Freight Train-Miles per Mile of Track Owned: 1960–95



SOURCE: Association of American Railroads. 1996. *Railroad Facts: 1996 Edition.* Washington, DC.

▶ Passenger Rail

In 1995, Amtrak locomotives were on average 13.9 years old, a slight increase from the 1994 average of 13.4, but almost twice the age of locomotives in 1980. Despite aging locomotives, Amtrak reports that the percentage of locomotives available for service in 1995 was 88 percent, higher than in 1994 (85 percent) or even 1980 (83 percent). Although the average age of passenger railcars dropped slightly between 1994 and 1995, the average of 21.8 years in 1995 was much higher than the average age in 1980 (14.3 years). The percentage of railcars available for service in 1995 was 90 percent, a slight improvement over 1994 and much higher than the 1980 total of 77 percent. (USDOT BTS 1996)

On-time performance of Amtrak passenger trains improved in 1995 to 76 percent from 72 percent in 1994 and 1993. In 1996, however, on-time performance fell back to 71 percent. In 1996, short- and long-distance trains were on time 76 percent and 49 percent, respectively. (Amtrak 1997)

▶ Freight Rail

Judging by the introduction of new rail stock, the physical condition of freight rail carriage continues to improve. In 1995, 901 new locomotives were introduced into service, the third straight annual increase and almost three times the number introduced in 1992.

The labor productivity of the U.S. freight rail system, the highest in the world, has increased further over the last few years. In 1992, metric ton-kilometers per employee (mtk/employee) for U.S. Class I railroads were approximately twice as high as the Canadian rail system, at about 4 million metric mtk/employee, making it second behind the United States. Most western European countries were below 1 million metric mtk/employee in the early 1990s. (Galenson and Thompson 1994, Annex B) Some efficiency gains in the United States have resulted, because of the abandonment of branch lines since deregulation. Between 1994 and 1995, revenue ton-miles per employee-hour increased by 9 percent to 2,746. Since 1980, revenue ton-miles per employee-hour tripled, and since 1970, grew nearly fivefold. (AAR 1996, 41)

Air Transportation

There are several performance measures for air transportation, including on-time statistics and numbers of passengers denied boarding. A flight is considered on-time if it arrives at the gate less than 15 minutes after the scheduled arrival time. Canceled and diverted flights are considered late. In 1996, the proportion of on-time flights for major air carriers was 74.5 percent, a drop from 78.6 in 1995. (USDOT BTS OAI 1997) Weather accounted for 75 percent of the delay in 1994. Terminal volume was responsible for another 19 percent. Closed runways/taxiways and problems with National Airspace System equipment were responsible for 2 percent each of the delays. The remaining 2 percent of delays resulted from other causes. (USDOT FAA 1996)

The number of passengers denied boarding increased from 824,000 in 1994 to 843,000 in 1995. (USDOT BTS 1996, 55) This is a very small number, and when total passengers enplaned is taken into account, the rate of denial drops slightly.

Water Transportation

About the only measure of water transportation system and vessel condition is age. The number of locks owned and operated by the Army Corps of Engineers was 275 in 1995. Of these, 61 percent were opened before 1960. (US Army Corps of Engineers 1996a). Of the 8,281 self-propelled vessels in the domestic fleet at the end of 1995, 46 percent were over 20 years old. Of the non-self-propelled vessels, 35 percent were over 20 years old. (US Army Corps of Engineers 1996b)

National measures of the overall performance of water transportation, such as port and lock congestion, are not available. The Performance Monitoring System for inland waterways, however, provides data on average processing time, lock closure, average time closed, and lock traffic for individual locks. (US Army Corps of Engineers 1996a)

Pipelines

As pipelines age, corrosion can reduce their ability to support stress and higher pressures. Preventive maintenance and replacement can, of course, offset the effects of aging, but incidents still occur. In the gas industry in 1995, there were 161 incidents, resulting in 18 fatalities and 53 injuries, less than in 1994, when there were 221 incidents with 21 fatalities and 110 injuries. In the oil pipeline industry, there were 188 incidents in 1995 causing 3 fatalities and 11 injuries, far fewer than the 244 incidents and 1,858 injuries in 1994. (USDOT BTS 1996, 153)

Special Profile: Urban Transit[7]

Beginning in the 1960s, a major infusion of government financial assistance halted—and eventually began to reverse—a post-World War II decline in transit service and ridership. Local public agencies were created to take over transit operations of financially distressed private operations. From 1975 to 1985, federal, state, and local governments contributed more than $40 billion to finance these newly created public transit authorities' day-to-day operating expenses, one-third more than passengers contributed in fare revenues. Transit service in U.S. cities (as measured by the number of vehicle-miles operated) expanded almost 20 percent between 1975 and 1985 (erasing much of the previous decade's loss in service), while nationwide transit ridership grew by nearly 15 percent. (APTA 1985 and 1990)

Nearly 400 local public agencies provided bus transit service in U.S. cities during 1985, while 29—primarily in the nation's oldest and largest cities—operated one or more forms of rail mass transit (see table 1-4). Together these agencies served nearly 300 of the nation's urbanized areas, with many of the largest cities receiving service from several transit operators.

Since 1985, the number of urban areas served has increased slightly, and vehicle-miles have increased an additional 13 percent. Service con-

Table 1-4.
Extent of U.S. Urban Transit Service

	Operators		Urban areas served	
Transit mode	**1985**	**1995**	**1985**	**1995**
All modes	407	398	298	316
All rail modes[1]	29	34	14	22
Heavy rail	12	13	10	11
Light rail	8	16	8	16
Commuter rail	15	16	8	10
Bus	392	381	298	316

[1] These numbers do not add because some rail operators provide more than one mode of transit and some urban areas are served by more than one mode of transit.

SOURCE: (1) U.S. Department of Transportation, Federal Highway Administration. 1986. *National Urban Mass Transportation Statistics, 1985.* Washington, DC. (2) U.S. Department of Transportation, Federal Transit Administration. 1996. *1994 National Transit Database.* Washington, DC

[7] This section is largely based on the Federal Transit Administration's (FTA's) Section 15 database (now known as the National Transit Database). Demand response service is omitted, as it historically served a much different market than conventional service, although this may be changing due to implementation of the 1990 Americans with Disabilities Act (see chapter 8). While many operators provide demand response service, total ridership is small. A full account of the transit industry would also include transit provided in rural areas (FTA Section 18 operators) and to persons with special needs (FTA Section 16 operators).

sumed, measured in passenger-miles traveled, has remained constant at about 37 billion, but ridership has fallen. The overall decline in transit ridership masks differences in ridership by mode and urban area: patronage on some transit services grew rapidly while others registered substantial declines. Although the extent of transit service expanded, overall patronage of transit service (i.e., the fraction of service that was actually used by riders) declined.

The data on transit use can be examined not only from the standpoint of ridership, but also in terms of broader public policy objectives. (USDOT FHWA FTA MARAD 1995, 59–61) Transit systems provide mobility options for many people who are unable to travel by automobile or other private vehicle due to personal circumstances such as income, disability, or age. The mobility needs of such persons, including their use of transit, are discussed in chapters 7 and 8 of this report. In many areas, transit plays a role in strategies for mitigating congestion and air pollution. Some communities are also emphasizing transit in their efforts to enhance the quality of life and reduce urban sprawl. These aspects of transit and their role in metropolitan area planning are discussed in *Transportation Statistics Annual Report 1996*.

Transit Coverage

Between 1985 and 1995, two developments in U.S. urban transit service are notable: an increase in the number of cities served by rail transit; and the continued extension of bus service into the outlying suburban areas of larger metropolitan regions, as well as into smaller urbanized areas. These developments began during the 1970s, and continue to be important factors influencing the extent and pattern of urban transit service. Partly as a result of these developments, the level of urban transit service provided nationwide continued to grow between 1985 to 1995.

The number of local public agencies in U.S. cities that provide rail transit service (including heavy rail, streetcar or light rail, and commuter rail[8]) grew from 29 during 1985 to 34 by 1995, with most of the growth taking place in agencies operating light-rail service (table 1-4). In the same period, the number of metropolitan areas served by some type of rail mass transit grew from 14 to 22, led by a doubling of the number of areas served by light rail. The number of route-miles of rail transit service in U.S. cities increased by about 18 percent between 1985 and 1995[9] (see table 1-5).

The second major development during the 1985 to 1995 period was the continued expansion of bus transit service, into both outlying suburban regions of larger urban areas and into smaller urban areas. The extension of bus service into lower density suburbs began during the 1970s as a response to continued decentralization of population and employment within U.S. metropolitan areas. Suburban service extensions in many metropolitan areas were facilitated by the creation of regional transit authorities, which often extended routes into previously unserved areas in an effort to secure a broader geographic base. Many smaller urban areas established new services, often in response to concerns about automobile-related air pollution and energy consumption, or the mobility of transportation-disadvantaged groups. The number of agencies

[8] Most public agencies that provide commuter rail service contract with private railroads or Amtrak to operate the service.

[9] Since 1985, Baltimore, Buffalo, Denver, Long Beach (California), Portland (Oregon), Sacramento, San Jose, and St. Louis opened new light-rail lines, while San Diego added to the system it inaugurated in 1984. (Most new light-rail lines serve outlying suburbs and operate primarily on exclusive rights-of-way, thus resembling more closely their newer heavy-rail counterparts than traditional streetcar lines.) Atlanta, San Francisco, and Washington, DC, added to their heavy-rail systems, while Los Angeles began service on a new heavy-rail line in 1994. Miami and New Haven added commuter rail service during this period, while Los Angeles and Washington, DC, extended commuter rail services begun during the previous decade.

Table 1-5.
Growth in U.S. Urban Transit Service

	Vehicles in rush-hour service			Vehicle-miles operated (millions)			Route-miles serviced		
Transit mode	**1985**	**1995**	**Change**	**1985**	**1995**	**Change**	**1985**	**1995**	**Change**
All modes	54,437	57,183	5%	2,101	2,377	13%	143,606	163,941	14%
All rail modes	11,832	13,120	11%	626	773	23%	5,251	6,185	18%
Heavy rail	7,673	7,973	4%	445	522	17%	1,322	1,458	10%
Light rail	534	734	37%	16	34	113%	384	568	48%
Commuter rail	3,625	4,413	22%	165	217	32%	3,545	4,159	17%
Bus	42,605	44,063	3%	1,475	1,604	9%	138,355	157,756	14%

SOURCES: (1) U.S. Department of Transportation, Federal Transit Administration. 1986. *National Urban Mass Transportation Statistics, 1985.* Washington, DC. (2) U.S. Department of Transportation, Federal Transit Administration. 1997. *1995 National Transit Database.* Washington, DC.

providing bus transit service in U.S. urban areas declined slightly between 1985 and 1995, yet the number of urban areas, as well as the total route mileage they served, both increased somewhat during the decade (see tables 1-4 and 1-5).

Increases in rail transit vehicles in service and service levels generally paralleled the expansion of route-miles between 1985 and 1995. The rising number of vehicles used to provide rush hour service was similar to the expansion of route mileage, especially for light rail and commuter rail. Growth in the number of vehicle-miles of rail service greatly outpaced the increase in route mileage, particularly for light rail (see table 1-5). This indicates that rail transit provided a high level of service to a limited number of heavily traveled corridors, both in cities historically served by rail and in metropolitan areas where new rail transit lines were added or extended during this period.

In contrast, the growth in the number of buses in service during rush hour was only about one-fifth as large as the increase in bus route mileage during the past decade. Growth in vehicle-miles of service also was less rapid than growth in route mileage. This disparity could be because routes extended into outlying suburban areas or added in smaller urban areas are served less frequently than existing routes, and service frequencies on some bus routes in larger metropolitan areas were reduced as other routes were extended into suburban areas.

Transit Ridership and Utilization

Total urban transit passenger-miles remained constant between 1985 and 1995. Passenger-miles traveled increased for all rail transit modes, but declined for buses. Heavy rail increased slightly, from 10.4 billion pmt in 1984 to 10.6 billion in 1995. Commuter rail pmt increased about 26 percent, reaching 8.2 billion in 1995. Light rail grew the fastest, increasing from about 350 million pmt in 1985 to 860 million pmt in 1995. Bus pmt was about 17 billion in 1995, about 14 percent less than in 1985.

Overall ridership in 1995 was about 11 percent less than in 1985. Some modes gained riders, while ridership on buses and older subways fell (see table 1-6). Increases in transit ridership between 1985 and 1995 were mainly in rail transit services that have opened since the 1970s. Ridership on all rail transit modes in the 14 metropolitan areas

Table 1-6.
Changes in Transit Ridership: 1985–95

Transit mode	Annual riders (millions) 1985	1995	Percentage change 1985–95
All modes	8,276	7,328	–11
Heavy rail	2,296	2,083	–9
Older subways[1]	2,033	1,696	–17
Modern systems[2]	263	387	47
Light rail	131	204	56
Traditional streetcars[3]	125	125	0
New light rail[4]	5	78	1,349
Commuter rail	269	344	28
Older systems[5]	262	324	24
New Services[6]	7	20	175
Bus	5,580	4,698	–16

[1] Boston, Chicago, Cleveland, New York, and Philadelphia.
[2] Atlanta, Baltimore, Los Angeles, Miami, San Francisco, and Washington, DC.
[3] Boston, Cleveland, Newark, New Orleans, Philadelphia, Pittsburgh, and San Francisco.
[4] Baltimore, Buffalo, Denver, Los Angeles, Portland (OR), Sacramento, San Diego, San Jose, and St. Louis.
[5] Boston, Chicago, New York, and Philadelphia.
[6] Baltimore, Miami, New Haven, Los Angeles, San Francisco, Washington, DC

SOURCE: (1) U.S. Department of Transportation, Federal Transit Administration, 1986. *National Urban Mass Transportation Statistics, 1985.* Washington, DC. (2) U.S. Department of Transportation, Federal Transit Administration. 1997. *1995 National Transit Database.* Washington, DC.

with new service[10] rose by 76 percent during this time, as the service provided by their expanding rail systems increased dramatically. At the same time, however, the number of bus riders—who accounted for more than 80 percent of all transit passengers in these cities during 1985—fell by 16 percent, partly as a result of the replacement of bus routes by rail lines in many of the most heavily traveled corridors in these cities. The net result was that total transit ridership in cities with new rail systems remained nearly unchanged over the decade. Transit ridership is most commonly measured by the number of passenger boardings. Boarding statistics may overstate the number of transit trips when rail service replaces major bus routes formerly serving the same corridors, because there may be an increased frequency of transferring between feeder buses and rail vehicles.

Ridership on the nation's older subway systems, which serve Boston, Chicago, Cleveland, New York, and Philadelphia,[11] declined 17 percent during this period, most likely in response to fare increases and a decline in downtown employment in some of these cities (see table 1-6). Consequently, by 1995 recently constructed systems carried nearly 19 percent of all heavy-rail passengers nationwide, up from 11 percent in 1985.

Ridership on streetcar lines that serve several older U.S. cities remained unchanged between 1985 and 1995, reflecting the maturity of the older residential suburbs and downtown areas they typically serve (table 1-6). The opening of modern light-rail service in several U.S. cities during that decade produced a large addition to the ridership, although much of this increase resulted from their substitution for major bus routes formerly serving the same corridors. Nevertheless, by 1995 these modern light-rail lines together carried well over half as many riders as the older streetcar systems remaining in U.S. cities.

The number of passengers carried by commuter railroads, which have traditionally carried riders to downtown Boston, Chicago, New York, and Philadelphia, increased by 24 percent from 1985 to 1995 (see table 1-6). Buoyed by the addition of new lines in Miami and New Haven and by a major extension of service in the Los Angeles metropolitan area, ridership on newer commuter rail services also increased rapidly

[10] Atlanta, Baltimore, Buffalo, Denver, Los Angeles, Miami, New Haven, Portland (OR), Sacramento, St. Louis, San Diego, San Francisco, San Jose, and Washington, DC.

[11] With the exception of the Cleveland subway, which was constructed during the 1950s, these systems date from the late 1800s and early 1900s.

during that decade. Even by the end of 1995, however, total patronage on these newer services amounted to only about 6 percent of the number of passengers riding commuter trains in their traditional markets.

The average number of passengers boarding transit vehicles during each mile they operate and the average number of passenger-miles per vehicle-mile are measures of transit use (see table 1-7). By these two measures, utilization of the passenger-carrying capacity provided by most transit modes declined between 1985 and 1995, with the exception of passenger boardings for commuter railroad service in traditional markets and in new light-rail service. Ridership on older subway systems fell, but high service levels were generally maintained. In addition, the continued extension of newer heavy-rail systems into lower density outlying areas—where it is difficult for even high-quality service to compete with automobile travel—reduced both measures of their use. Capacity utilization on older streetcar systems changed only slightly over the decade, reflecting the previously discussed stability in their ridership levels. The modern light-rail lines that began service during the decade experienced more frequent passenger boardings but lower average passenger loads than the system in San Diego that was already operating in 1985, probably reflecting the typically shorter trips made by their riders.

Commuter rail service usage remained stable over the decade in its traditional big-city markets (Boston, Chicago, New York, and Philadelphia), while the expansion of service and the opening of new rail systems combined to sharply reduce both measures of usage in these markets (see table 1-7). Similarly, the frequency of passenger boardings on bus transit service fell greatly between 1985 and 1995, although the decline in typical bus passenger loads shown in the table was less pronounced, as the average trip length of bus passengers increased slightly over the decade. On balance, both the frequency of passenger boardings and the typical passenger loads carried by all transit vehicles declined, an indication that the overall capacity of the service they provided was less heavily used during 1995 than a decade earlier.

The concentration of transit ridership during commuting hours, the heavy directional orientation of these peak-hour passenger flows, and public demands to maintain some service during off-peak hours and over entire metropolitan areas

Table 1-7.
Changes in Transit Service Utilization

Transit mode	Boardings per vehicle mile		Average passenger load[1]	
	1985	1995	1985	1995
All modes	3.9	3.1	18	16
Heavy rail	5.2	4.0	23	20
Older subways[2]	5.4	4.2	23	20
Modern systems[3]	3.8	3.2	24	22
Light rail	8.2	6.0	22	22
Traditional streetcars[4]	8.8	7.9	21	20
New light rail[5]	3.2	4.4	28	23
Commuter rail	1.6	1.6	39	38
Older systems[6]	1.6	1.6	39	38
New services[7]	2.0	1.2	50	35
Bus[8]	3.8	2.9	13	11

[1] Passenger-miles per vehicle-mile.
[2] Boston, Chicago, Cleveland, New York, and Philadelphia.
[3] Atlanta, Baltimore, Los Angeles, Miami, San Francisco, and Washington, DC.
[4] Boston, Cleveland, Newark, New Orleans, Philadelphia, Pittsburgh, and San Francisco.
[5] Baltimore, Buffalo, Denver, Los Angeles, Portland (OR), Sacramento, San Diego, San Jose, and St. Louis.
[6] Boston, Chicago, New York, and Philadelphia.
[7] Baltimore, Miami, New Haven, Los Angeles, San Francisco, Washington, DC
[8] Number of urban areas served in 1985 = 298 and 1995 = 316.

SOURCES: (1) U.S. Department of Transportation, Federal Transit Administration, 1986. *National Urban Mass Transportation Statistics, 1985.* Washington, DC. (2) U.S. Department of Transportation, Federal Transit Administration. 1997. *1995 National Transit Database.* Washington, DC combine to make underutilization of transit capacity not surprising.[12] As mentioned before, transit often serves broader public objectives, such as providing low-cost transportation alternatives for people without cars, and easing congestion, which are not reflected in ridership figures.

Transit Condition

The condition of urban transit equipment, as measured by the age of vehicles, varies a great deal by type of system, although overall there has not been much change between 1985 to 1995 (see table 1-8). The fleet of articulated, full-size, and mid-size buses has become older, but many smaller buses were added for paratransit services over the past few years, stabilizing the age of the total bus fleet. Between 1985 and 1995, the average age of heavy-rail vehicles increased, but dropped for light-rail vehicles. Commuter railcars aged, particularly powered railcars. The average age of commuter locomotives decreased slightly from 1985 to 1995.

In rail transit, the condition of power stations, systems, bridges and tunnels, and maintenance improved between 1984 and 1992 (see table 1-9). (USDOT FHWA FTA MARAD 1995) A survey of bus maintenance facilities in 1992 found that 57 percent were in good or excellent condition. (USDOT FTA 1993) Another 32 percent were found to be in poor or substandard condition, and the remaining facilities were found to be adequate. A survey of rail transit facilities found that overall conditions improved between 1984 and 1992, particularly those elements most in need of upgrading. (USDOT FTA 1992) Maintenance yards and facilities in bad or poor condition were significantly improved between 1984 and 1992 (see table 1-9).

[12] During 1990, 43 percent of transit trips were for the purpose of commuting to and from work, and most commuting trips tended to be made during morning and evening rush hours. Another 22 percent of transit trips were for travel to school or church, primarily during weekday morning peak hours. (USDOT FHWA 1993, 4-68)

Table 1-8.
Average Age of Urban Transit Vehicles

Type of vehicle	1985	1995
Commuter train locomotives	16.3	15.9
Unpowered commuter railcars	19.1	21.4
Powered commuter railcars	12.3	19.8
Heavy rail	17.1	19.3
Light rail	20.6	16.8
Articulated buses	3.4	10.9
Full-size buses	8.1	8.7
Mid-size buses	5.6	6.9
Small buses	4.8	4.1
Vans	3.8	3.1

SOURCES: (1) U.S. Department of Transportation, Federal Transit Administration, 1986. *National Urban Mass Transportation Statistics, 1985.* Washington, DC. (2) U.S. Department of Transportation, Federal Transit Administration. 1997. *1995 National Transit Database.* Washington, DC

U.S. Transportation Events

Every year the Bureau of Transportation Statistics discusses a few key events that caused major disruptions in transportation trends or that highlight a significant factor in transportation. This report looks at the effect of two snowstorms on transportation, one in the Northeast at the start of 1996 and the other at the end of 1996 in the Northwest. Transportation at the 1996 summer Olympic Games in Atlanta is also discussed here. Other noteworthy events that occurred in 1996, such as the rise in retail gasoline prices in the spring and summer, are discussed in subsequent chapters.

Table 1-9.
Physical Condition of U.S. Transit Rail Systems
(In percent)

	Bad		Poor		Fair		Good		Excellent	
Type of system	**1984**	**1992**	**1984**	**1992**	**1984**	**1992**	**1984**	**1992**	**1984**	**1992**
Stations	0	0	15	5	56	29	23	63	6	3
Track	0	0	7	5	49	32	31	49	12	14
Power systems										
Substations	6	2	23	19	5	17	43	56	23	6
Overhead	20	0	12	33	27	10	36	52	5	5
Third rail	13	0	26	21	19	20	36	53	6	6
Structures										
Bridges	1	0	16	11	51	28	28	54	4	7
Elevated	0	0	1	1	80	72	3	15	16	12
Tunnels	0	0	5	5	49	34	35	51	11	10
Maintenance										
Facilities	4	2	54	34	14	12	24	35	4	17
Yards	4	2	53	7	26	26	16	55	1	9

SOURCE: U.S. Department of Transportation, Federal Transit Administration. 1992. *Modernization of the Nation's Rail Transit Systems: A Status Report.* Washington, DC.

Weather Events

A heavy snow at the beginning of 1996 in the northeastern and mid-Atlantic regions and another heavy snow at the end of the year in the Northwest severely impacted transportation into, out of, and within those areas. Although these were not the year's only weather-related transportation problems, they were two of the more severe events.

On January 7 and 8, 1996, two feet of snow fell in the northeastern and mid-Atlantic states, paralyzing an area from Richmond, Virginia, to Boston, Massachusetts. Airlines and airports were very hard hit. Airports were closed from January 7, a Sunday, through noon on January 9, when runways began opening. During the afternoon of January 9, an additional six inches of snow fell. Normal operations at Logan Airport in Boston did not resume until January 11. The impact on airlines depended to a large extent on the proportion of service in the affected area. For instance, USAir, with one of its hubs at Baltimore-Washington International Airport, canceled nearly 50 percent of its scheduled flights. The number of stranded airplanes and passengers was minimized, however, by precanceling flights and flying planes away from the affected area. (*Aviation Week and Space Technology* 1996, 29, 32) In addition, many international flights were either canceled or diverted to distant airports. For instance, Delta Airline's incoming European flights were diverted to Atlanta, Cincinnati, and Orlando.

Intercity travel was also hindered for several days, as many highways up and down the East Coast were impassable. Rail was the only mode of transportation that allowed intercity travel in the Northeast Corridor, and Amtrak ran almost normal service. (Phillips 1996, D8) There were some delays as speeds were reduced, and many electric locomotives had to be taken out of service (diesel trains were largely unaffected by the snow). In addition, some major delays occurred on long-distance trains. For instance, the Chicago-Washington Cardinal was stuck in Charleston, West Virginia, for two days while tracks in New River Gorge were cleared. Without Amtrak, however, passenger travel between some major cities would have been all but curtailed.

Local transportation was a problem in most cities affected by the storm. New Jersey Transit ran no buses Sunday night and Monday. New York City Transit canceled buses on Monday after 200 got stuck in snowdrifts or were caught behind other vehicles. The District of Columbia came in for very heavy criticism because of its poor job of clearing roads.

Local transportation was also affected in the northwestern United States due to back-to-back storms beginning on Thursday, December 26, 1996. The Seattle area, for instance, first had up to 15 inches of snow and then another 6 inches fell on December 29, with ice storms in between. Parts of western Washington had 10-foot snowdrifts, prompting the governor to declare a state of emergency in 15 counties. (Egan 1996, D18) In the Seattle area, the King County Department of Transportation was forced to cancel transit service on Sunday, December 29, because many of its articulated buses became stuck in snow. This problem was exacerbated by the failure to plow or sand transit routes and low fuel reserves. Also, the trolley system broke down when overhead wires iced. Seattle was criticized for its snow-clearing plan, which did not prioritize routes leading to hospitals or those used for transit. In the Seattle area's rural Snohomish County, public transit was only slightly disrupted, because the local transit agency provided a list of routes for plowing. Only 3 of 62 routes were disrupted during the storms, although there were delays. (Nelson et al 1996)

Movement into and through the region was impacted in several ways. All three main routes across the Cascades in Washington state—Interstate 90 over Snoqualmie Pass, Route 2 over Stevens Pass, and Route 12 over White Pass—were closed by snow and then avalanches. Interstate 90 remained closed for several days beginning with the first snow, causing scheduled bus service over the Cascades to be canceled. Avalanches also closed a 45-mile stretch of Interstate 45 on the Oregon side of the Columbia River Gorge. (*New York Times* 1996, A11) An estimated 400 arrivals and departures were canceled when the Seattle-Tacoma International Airport closed. Flooding and mudslides caused Amtrak to cancel passenger trains between Seattle and Eugene, Oregon. (Eng 1996)

Olympic Games in Atlanta

Contrary to much of the media coverage during the Olympic Games in Atlanta (e.g., Drozdiak 1996, A1), the expanded transportation system put in place by various public agencies, including the Metropolitan Atlanta Rapid Transit Authority (MARTA) under contract with the Atlanta Committee for the Olympic Games (ACOG), was considered a success.[13] Over the 17 days of the event, the transportation system handled approximately 15,000 athletes and coaches from 197 countries, 20,000 media people, 49,000 staff, 80,000 special guests, and about 2 million spectators expected to use 11 million tickets. The

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[13] Much of this account in based on a panel discussion "Transportation System Performance During the Atlanta Games: The Disaster That Wasn't" at the 76th Transportation Research Board Annual Meeting, January 13, 1997. The panel included Michael Meyer (Georgia Institute of Technology), David Williamson (Metropolitan Atlanta Rapid Transit Authority), Marion Waters (Georgia Department of Transportation), Andrew Bell (Hartsfield International Airport), Douglas Monroe (*Atlanta-Journal Constitution*), and Sam Subramaniam (Booz Allen and Hamilton, Inc.). (See also Applebome 1996, B18.)

transportation system moved approximately 18 million passengers in all, twice its normal load.

To manage this many passengers, MARTA opened 3.1 miles of new heavy rail into an area previously unserved and three new heavy-rail stations. MARTA also removed seats in heavy-rail passenger cars allowing them to carry 10 percent more passengers, borrowed 1,400 buses from transit agencies around the country, and extended service on some routes to 24 hours. The city also improved 11 pedestrian corridors with wider sidewalks, better lighting, and improved signage, and the Georgia Department of Transportation restriped Interstates for high-occupancy vehicle operation. Some companies hired private bus shuttles to get workers downtown during the games.

Another strategy to improve traffic flow, particularly during the work week, was to ask businesses to minimize commuter travel. Some businesses encouraged workers to take vacations during the games. Others arranged for employees to make their commute earlier or later, or if possible to telecommute. One company provided cots for essential workers to sleep at work. Ordinary business deliveries were suspended downtown. Overall, the program was largely successful, and it was reported that traffic ran smoothly during the work week. (Schwartz 1996, 3, 9)

During the games several forms of intelligent highway systems technology were deployed to manage traffic. Video cameras were used along freeways to monitor traffic conditions and accidents and breakdowns. Speed-detecting radar was used along several freeways. Surveillance allowed for rapid response to incidents and the implementation of management control strategies. Traffic information was also provided to the public in various ways: 44 changeable message signs were constructed on highways and more than 100 information kiosks were set up. Information was also available via a cable television channel dedicated to traffic information and an Internet site with real-time traffic information. (See chapter 11 for further discussion of information technologies and transportation.)

The Olympic Games also created many challenges for freight movement. Congestion in and around the Atlanta area caused many trucking firms to reroute their vehicles. During the games, motor vehicle traffic was prohibited from much of central Atlanta area, consequently trucks were only permitted to make deliveries between midnight and 6 a.m. Making things more difficult was the strict security precautions in effect during the games (heightened by the bombing in Centennial Olympic Park). All packages bound for an Olympic site had to be x-rayed, each truck had to have a thorough inspection every day, drivers had to be accredited by the Atlanta Council of Governments and have a background check, and vehicles parked for any length of time had to have security personnel guarding them. Faced with these constraints, United Parcel Service (UPS) arranged large deliveries of packages to the area after midnight; couriers on foot made deliveries throughout the day. UPS and another package delivery firm, DHL, experimented with helicopters to bring in freight, using 16 locations around the city and 50 helicopters. Freight shipments by rail, including food products, increased substantially just before the Olympics. During the Olympics, tightened security around one of CSX's rail lines that passed close to the games and heightened restrictions on hazardous materials transportation affected both CSX and Norfolk Southern trains. (Bradley 1996)

There were a number of transportation problems, particularly in the first few days of the games. One highly publicized case involved rowers from Britain, Poland, and Ukraine who hijacked a bus to get to an event. In another case, a judo wrestler missed his event because of traffic congestion.

Some difficulties were caused by bus drivers from other cities who were recruited for the games and had little knowledge of Atlanta and no experience driving on major freeways. About 50 of the 3,000 bus drivers resigned early because of such problems. Transportation officials attempted a solution by having escorts with knowledge of the area ride along and give directions.

While some of these relatively minor events were given high visibility by the media, there were also newspaper reports that many athletes had no transportation problems. Efforts by government and Olymic officials helped to ensure adherence to planned services and traffic patterns, thus alleviating many problems.

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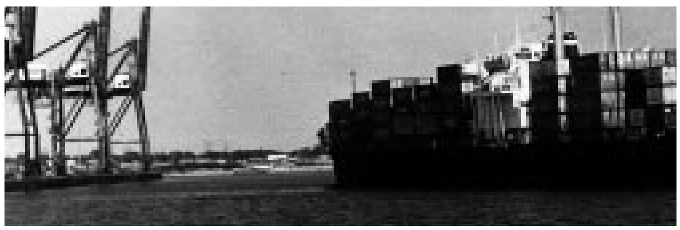
Transportation and the Economy



Transportation is an indispensable component of any economy and society. It can increase the value of goods by moving them to locations where they are worth more. It allows people to commute to places of employment where their time has higher value. By extending the spatial boundaries of commodity and labor markets, transportation encourages competition and production. Transportation stimulates demand for various goods and services, thereby contributing to U.S. economic growth. To meet this demand, the transportation sector employs millions of workers.

This chapter begins with a discussion of the importance of transportation in the economy, followed by an analysis of consumer expenditures for transportation over the past decade, categorized by region, race, and sex. It continues with transportation-related employment and labor productivity in the transportation industry by mode, and ends with a discussion of government transportation expenditures and revenues.

Transportation's Economic Importance

The economic importance of transportation can be measured either from the demand side or from the supply side. From the demand side, gross domestic product

(GDP)[1] is the net value of goods and services produced by the economy in a given year; the importance of transportation from the demand side is measured as the share of transportation-related final demand (defined below). From the supply side, GDP is the income generated (or value-added) by all industries of the economy in the production of goods and services; the importance of transportation is measured as the share of value-added originating from the for-hire transportation industry.[2] GDP adds up to the same total whether it is measured from the demand side or from the supply side, but, for reasons that will become clear, transportation appears more important when viewed from the demand side. This section discusses the importance of transportation from the demand side, and compares it with other social functions. Finally, it addresses the supply side.

Transportation-Related Final Demand in GDP

Transportation-related final demand is defined as the value of all goods and services purchased by consumers and governments for transportation purposes, plus all goods and services purchased by businesses as investments for transportation purposes. Final demand data are compiled regardless of industry origin. This means, for example, that even though automobiles are the output of the automotive industry, not the output of the transportation industry, consumer and government demand for automobiles is counted in transportation-related final demand, because automobiles are purchased for transportation purposes.

The share of transportation-related final demand in GDP measures the importance of transportation demand to the economy, and indicates how society values transportation. The share of transportation-related final demand in GDP, however, is not a correct measure of the contribution of the transportation *industry* to the economy. This is because transportation-related final demand includes not only the value of the for-hire transportation industry's output but also the value of outputs of nontransportation industries, such as cars from the automobile manufacturing industry, gasoline from the petroleum refinery industry, and automobile insurance services from the insurance industry.

The major components of GDP, from the final demand side, are consumer expenditures, government expenditures, capital investments, and exports and imports. Tables 2-1a and 2-1b present transportation-related final demand and its share in GDP in current dollars and chain-type 1992 dollars, respectively. (See box 2-1 for an explanation of chain-type indices.) In current dollars, transportation-related final demand totaled $777 billion in 1995, up 3.5 percent from 1994. At the same time, GDP grew 4.5 percent, from $6.9 trillion in 1994 to $7.2 trillion in 1995. (USDOC BEA 1996) Consequently, the share of transportation-related final demand in GDP declined slightly from 10.8 percent in 1994 to 10.7 percent in 1995.

Transportation-related final demand, however, grew faster than GDP over the longer period from 1991 to 1995. Measured in chain-type 1992 dollars, GDP grew 11 percent between 1991 and 1995, while transportation-related

[1] GDP is defined as the net output of goods and services produced by labor and property located in the United States, valued at market prices. As long as the labor and property are located in the United States, the suppliers (workers and owners) may be either U.S. residents or residents of foreign countries.

[2] As defined here, the transportation industry comprises only those establishments whose primary economic activity is to provide transportation services to the public for a fee. A more complete measure of transportation's importance from the supply side would also include the contribution of in-house transportation services within companies. As is discussed subsequently, research is underway to develop better measures of these in-house services.

Table 2-1a.
U.S. Gross Domestic Product Attributed to Transportation-Related Final Demand: 1991–95
(In billions of current dollars)

	1991	1992	1993	1994	1995
Gross domestic product	$5,916.7	$6,244.4	$6,550.2	$6,931.4	$7,245.8
Total transportation in gross domestic product	10.5%	10.7%	10.8%	10.8%	10.7%
Total transportation final demand	**623.9**	**669.4**	**708.2**	**751.2**	**777.2**
Personal consumption of transportation	**436.8**	**471.6**	**503.8**	**536.5**	**554.9**
Motor vehicles and parts	187.6	206.9	226.1	245.3	247.8
Gasoline and oil	103.9	106.6	108.1	109.9	114.6
Transportation services	145.3	158.1	169.6	181.3	192.5
Gross private domestic investment	**82.7**	**89.9**	**103.3**	**122.0**	**130.5**
Transportation structures	3.2	3.7	4.1	4.9	5.6
Transportation equipment	79.5	86.2	99.2	117.1	124.9
Net exports of goods and services	**–16.8**	**–15.5**	**–25.9**	**–38.0**	**–44.8**
Exports (+)	**115.8**	**125.0**	**125.7**	**132.7**	**133.7**
Civilian aircraft, engines, and parts	36.6	37.7	32.7	31.5	26.2
Automotive vehicles, engines, and parts	40.0	47.0	52.4	57.6	60.9
Passenger fares	15.9	16.6	16.6	17.5	18.3
Other transportation	23.3	23.7	24.0	26.1	28.3
Imports (–)	**132.6**	**140.5**	**151.6**	**170.7**	**178.5**
Civilian aircraft, engines, and parts	11.7	12.6	11.3	11.3	10.7
Automotive vehicles, engines, and parts	85.7	91.8	102.4	118.3	124.9
Passenger fares	10.0	10.6	11.3	12.7	13.4
Other transportation	25.2	25.5	26.6	28.4	29.5
Government transportation-related purchases	**121.2**	**123.4**	**127.0**	**130.7**	**136.6**
Federal purchases	16.2	16.8	17.7	19.3	21.0
State and local purchases	89.2	95.3	99.5	102.8	106.2
Defense-related purchases	15.8	11.3	9.8	8.6	9.4

NOTE: In 1996, the Bureau of Economic Analysis revised its estimates for prior years in the National Income and Product Accounts. Consequently, the numbers in table 2-1a are different from data previously reported by BTS in *Transportation Statistics Annual Report 1996*.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics calculations based on: U.S. Department of Commerce, Bureau of Economic Analysis. 1996. *Survey of Current Business.* Various issues.

final demand grew 14 percent in real terms. Private domestic investment in transportation was about $131 billion in 1995, or about 17 percent of all transportation-related final demand. Private domestic investment in transportation structures (e.g., rail tracks) and equipment (e.g., airplanes) grew more rapidly than transportation-related final demand as a whole. In real terms, private investment in transportation structures grew 53 percent and private investment in transportation equipment grew 44 percent between 1991 and 1995. (USDOC BEA 1996)

A nation's demand can be met by domestic production and/or imports. By the same token, a nation's production can be used to meet both domestic demand and exports. If transportation-related exports are larger than transportation-related imports, total transportation-related final demand will be greater than domestic transportation-related final demand, and vice versa. Because, in fact, the United States has a trade deficit in transportation-related goods and services, its domestic transportation-related final demand is greater than its transportation-related final demand. Between 1991 and 1995, U.S. domestic transportation-related final demand

Table 2-1b.
U.S. Gross Domestic Product Attributed to Transportation-Related Final Demand: 1991–95
(In billions of chained 1992 dollars)

	1991	1992	1993	1994	1995
Gross domestic product	$5,916.7	$6,244.4	$6,550.2	$6,931.4	$7,245.8
Total transportation in gross domestic product	10.5%	10.7%	10.8%	10.8%	10.7%
Total transportation final demand	**639.5**	**669.4**	**689.3**	**715.1**	**729.0**
Personal consumption of transportation	**448.9**	**471.6**	**490.3**	**509.9**	**511.3**
Motor vehicles and parts	193.2	206.9	218.6	228.2	221.0
Gasoline and oil	103.4	106.6	109.1	110.4	113.3
Transportation services	152.3	158.1	162.6	171.3	177.0
Gross private domestic investment	**84.9**	**89.9**	**101.4**	**116.1**	**122.9**
Transportation structures	3.2	3.7	3.9	4.4	4.9
Transportation equipment	81.7	86.2	97.5	111.7	118.0
Net exports of goods and services	**–16.7**	**–15.5**	**–26.0**	**–35.5**	**–40.1**
Exports (+)	**118.3**	**125.0**	**123.6**	**129.0**	**127.2**
Civilian aircraft, engines, and parts	37.8	37.7	31.8	29.8	24.0
Automotive vehicles, engines, and parts	40.8	47.0	51.9	56.6	59.1
Passenger fares	16.3	16.6	16.3	16.8	16.6
Other transportation	23.4	23.7	23.6	25.8	27.5
Imports (–)	**135.0**	**140.5**	**149.6**	**164.5**	**167.3**
Civilian aircraft, engines, and parts	12.0	12.6	11.0	10.7	9.8
Automotive vehicles, engines, and parts	87.2	91.8	100.7	112.6	115.6
Passenger fares	10.3	10.6	11.5	12.8	12.8
Other transportation	25.5	25.5	26.4	28.4	29.1
Government transportation-related purchases	**122.4**	**123.4**	**123.6**	**124.6**	**134.9**
Federal purchases	16.6	16.8	17.0	18.0	18.0
State and local purchases	90.0	95.3	96.9	98.2	107.8
Defense-related purchases	15.8	11.3	9.7	8.4	9.1

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics calculations based on: U.S. Department of Commerce, Bureau of Economic Analysis. 1996. *Survey of Current Business.* Various issues.

Box 2-1.

Measuring Real Economic Growth: Chain-Type Indices

Gross domestic product (GDP) estimations consist of two phases: 1) estimating current-dollar values, and 2) separating the current-dollar values into a price-change component and a quantity-change component. Each phase contains many steps with interrelated data processes. Although measuring change in current-dollar GDP is conceptually straightforward, separating the price- and quantity-change elements is not. Because they cannot be observed directly in the economy, aggregate price and quantity changes must be estimated. In the past, changes in real GDP were calculated using fixed-weighted indices (FWI). A fixed-weighted quantities index uses the prices of a single base year to value the output in every year, and a fixed-weighted price index uses the quantities of the base year as weights to calculate a GDP price index.

A FWI has a notable disadvantage. When used for a long period, it results in a substitution bias that causes an overstatement of growth for years after the base year and an understatement for years before the base year. The bias occurs when a consumer substitutes products whose relative prices are declining for products whose relative prices are rising. Substitutions of this type are commonly made by consumers. In general, products whose quantities have increased the most are those whose prices have increased the least. Therefore, economic growth between any two years will be evaluated at relatively higher prices if the beginning year is used as a base year and hence the calculated growth rate will be higher. The opposite will be true if the end year is used as a base year.

The question is: Which calculation—the beginning year or the end year as a base year—is correct? There is no single correct answer to this question because either year's prices are equally valid for valuing the changes in quantities. A common sense approach to the weighting problem is to take an average of the two calculations. Economic theory indicates that a method of averaging called the Fisher Ideal Index, which takes into account the geometric mean of the two calculations, is a preferred form of averaging.

The Bureau of Economic Analysis recently started using the Fisher Ideal Quantity Index to calculate change between adjacent years. Annual changes are then chained (multiplied) together to form a time series.

Chain-type indices recognize the need to use weights that are appropriate for the specific periods being measured. Chain-type indices have important advantages over an FWI. First, instead of merely reflecting overall inflation, they capture the effect of relative changes in prices and in the composition of output, thereby taking into account the substitution effect. They also provide a more accurate description of cyclical fluctuations in the economy. This, in turn, will improve analyses of productivity and returns on investment. Finally, they eliminate the inconvenience and confusion of updating weights and base periods, and thus rewriting economic history every few years.

grew 17 percent from $656.2 billion to $769.1 billion in chain-type 1992 dollars, faster than both the transportation-related final demand and GDP. (USDOC BEA 1996)

In real terms, imports of transportation-related goods and services grew 24 percent between 1991 and 1995, while exports grew less than 8 percent. Consequently, the trade deficit in transportation-related goods and services, measured in chain-type 1992 dollars, swelled from $16.7 billion in 1991 to $40.1 billion in 1995. (USDOC BEA 1996)

Transportation and Other Major Social Functions

Transportation-related final demand in GDP can be compared with demand for other socioeconomic activities. Because production is only the means and consumption is the end, the general public may understand the importance of a socioeconomic activity better from a consumption perspective rather than from a production perspective. For example, when asked about food, consumers are more likely to think about how much they spend on food, not how much food is produced. Similarly, transportation-related final demand shows how much the American people, governments, and businesses spend for the purpose of transportation.

In order to compare transportation with other major socioeconomic activities, GDP can be divided into six major social functions: food, housing, transportation, health care, education, and other. Their values and shares in GDP are presented in table 2-2, which shows that housing is the largest social function in the American society. Health care ranks second, followed by food, transportation, and education.

Between 1991 and 1995, the economy grew 22 percent in current dollars. Transportation, housing, health care, and education grew faster than GDP, while food and "other" grew more slowly. Among the functions, health care grew the fastest—33 percent between 1991 and 1995. Housing was second, increasing by 29 percent, transportation-related final demand was third, at 25 percent, and education was fourth, at 24 percent. Demand for food grew by only 18 percent, less than GDP growth in the same period. Consequently, the shares of health care, housing, and transportation in GDP increased between 1991 and 1995, while the shares of food and "other" decreased. Education shares remained essentially level during this period. (USDOC BEA 1996) These changes reflect a general trend in economic development. As income increases, people's demands shift away from basic needs to services that improve the quality of their life, such as health care and personalized transportation.

For-Hire Transportation Industry

Just as transportation as a social function uses goods and services from many industries in the economy, the for-hire transportation industry provides transportation services throughout the economy and society. The aggregate measure of its importance is transportation value-added, which is the share of GDP contributed by the for-hire transportation industry.

The for-hire transportation industry adds value when it provides products and services to other industries, governments, and consumers. For example, coal increases in value when it is transported from the site where it is mined to a

Table 2-2.
U.S. Gross Domestic Product by Social Function: 1991 and 1995
(In billions of current dollars)

	1991		1995	
	Amount	**Percentage of GDP**	**Amount**	**Percentage of GDP**
Total GDP	5,916.7	100.0	7,245.8	100.0
Housing	1,371.0	23.2	1,762.9	24.3
Health	804.4	13.6	1,067.70	14.7
Food	779.1	13.2	915.9	12.6
Transportation	623.9	10.5	777.2	10.7
Education	407.8	6.9	503.9	7.0
Other	1,930.5	32.6	2,218.1	30.6

KEY: GDP = gross domestic product.

NOTE: Percentages do not add due to rounding.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics calculations based on: U.S. Department of Commerce, Bureau of Economic Analysis. 1996. *Survey of Current Business.* Various issues.

powerplant where it is used to produce electricity. The value an industry adds is the net output of that industry. Because value-added from all industries sums up to GDP, the share of the value-added originating in an industry measures the contribution of that industry to the economy.

For-hire transportation GDP reached $222.8 billion (current dollars) in 1994, larger than that of agriculture, mining, communications, public utilities, and education, but smaller than that of construction, manufacturing, and health care. (USDOC BEA 1996) In 1994, for-hire transportation accounted for 3.2 percent of total GDP in current dollars and 3.3 percent in constant dollars.

The GDP contribution varies enormously among the seven for-hire transportation subindustries, and in 1994 ranged from $95.1 billion for trucking and warehousing to $5.7 billion for pipelines (current dollars) (see table 2-3). The shares of the various modes were stable from the late 1980s to the 1990s, with trucking and warehousing accounting for about 43 percent of transportation GDP at the high end and pipelines accounting for about 3 percent at the low end (see figure 2-1). The modal distribution, however, has changed dramatically since 1959, the earliest year for which data are available. In that year, the railroad industry accounted for 38.3 percent of total transportation GDP. In 1994, it accounted for only 10.9 percent. During this same period, the share of trucking and warehousing went up from 31.7 to 42.7 percent. The biggest gain was the air transportation industry. Its share in total transportation GDP nearly tripled from 7.9 percent in 1959 to 22.9 percent in 1994.

It is important to understand that the current national account statistics cited above include only those establishments that provide transportation services on a for-hire basis.[3] The national account does not presently allow accurate estimation of the contribution of establishments that

[3] The national account is a comprehensive and detailed record of U.S. economic activities and interactions between sectors of the economy. The Bureau of Economic Analysis created this database using Census Bureau information.

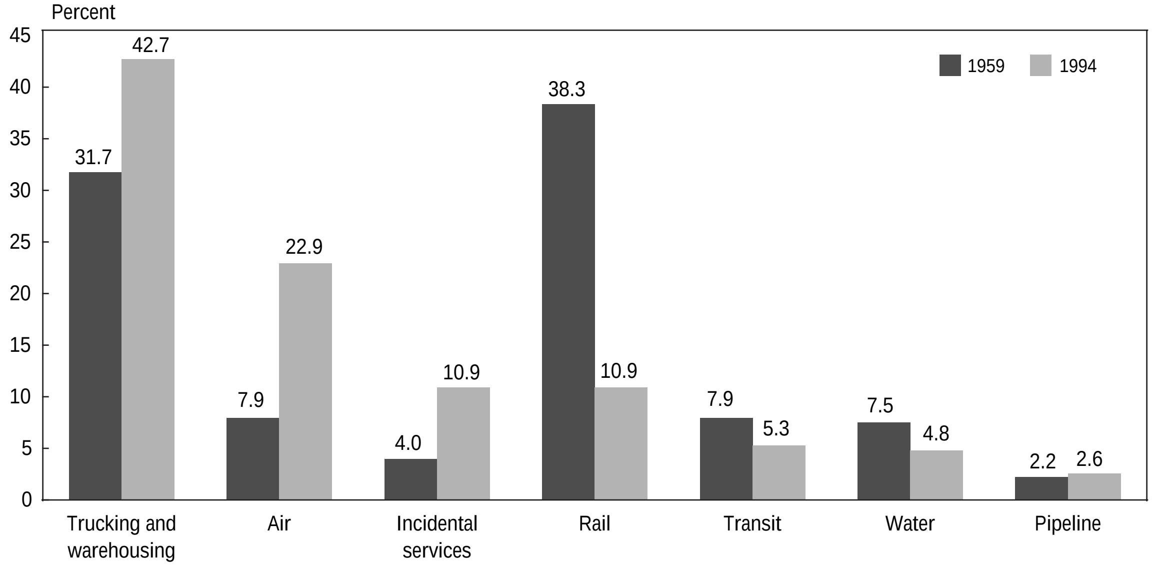
Table 2-3.
U.S. Gross Domestic Product Attributed to For-Hire Transportation: 1990–94
(In billions)

	Current dollars					Chained 1992 dollars				
	1990	**1991**	**1992**	**1993**	**1994**	**1990**	**1991**	**1992**	**1993**	**1994**
Total	$176.4	$185.8	$192.8	$207.6	$222.8	$176.7	$185.5	$192.8	$205.1	$215.5
Trucking and warehousing	75.8	77.9	82.2	88.4	95.1	73.7	78.5	82.2	88.3	89.6
Air	39.4	40.8	43.0	48.6	51.1	39.5	39.4	43.0	45.2	49.9
Railroad	19.6	21.9	22.1	23.0	24.3	18.7	21.7	22.1	24.0	26.2
Incidental services	17.8	19.4	19.6	20.8	24.3	19.2	19.2	19.6	20.8	21.9
Transit	9.0	10.2	10.9	11.3	11.7	10.3	10.5	10.9	10.9	11.1
Water	9.7	10.7	10.3	10.3	10.6	10.7	11.1	10.3	10.4	10.9
Pipeline	5.0	5.0	4.9	5.2	5.7	4.8	5.2	4.9	5.7	6.0

NOTE: Numbers may not add due to rounding.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis. 1996. *Survey of Current Business.* August.

Figure 2-1.
Change in the Modal Share of For-Hire Transportation: 1959 and 1994



NOTE: Calculated from the gross domestic product attributed to for-hire transportation.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis. 1996. *Survey of Current Business.* August.

provide transportation services to their owner companies, so-called in-house transportation. Were in-house transportation included, the transportation industry's share of GDP would be larger. The U.S. Transportation Satellite Account (a joint project of the Bureau of Transportation Statistics (BTS) and the U.S. Department of Commerce, Bureau of Economic Analysis), will provide a more complete picture of in-house transportation when the project is completed.

Consumer Expenditures for Transportation

This section discusses consumer expenditures in the United States, using data from the Department of Labor, Consumer Expenditure Survey. How much people pay for transportation, as determined by such surveys, is one of the better indicators of the importance of transportation to society. Expenditures reflect people's preferences and incomes as well as available goods and services. As these factors change, the pattern of consumer expenditures also will change. See chapter 7 for a discussion of household income and mobility trends among socioeconomic and demographic groups.

Between 1984 and 1994, American household spending, on average, increased from $21,975 to $31,751 (in current dollars), growing 3.7 percent annually. The proportion of expenditures on housing, health care, and insurance and pensions went up, while the share of food and apparel went down. The share of transportation in household expenditures reached its peak at 20.3 percent in 1986. Thereafter, it declined and reached its low of 17.4 percent in 1991. From 1991 to 1994, it rose again so that transportation averaged 19 percent of household spending in 1994, following housing at 31.8 percent.

Transportation expenditures by households grew at an average annual rate of 3.5 percent between 1984 and 1994, measured in current dollars (see table 2-4). This growth rate was slightly lower than the growth rate for total household expenditures. While expenditures on all other transportation items increased, household spending on gasoline and motor oil fell from an average of $1,058 in 1984 to $986 in 1994 (again, in current dollars). (USDOL BLS 1984–94) This is a 6.8 percent decrease, even without considering inflation. The decline in household spending on gasoline and motor oil reflects lower fuel prices and greater vehicle fuel efficiency. (USDOL BLS 1984–94) BTS analysis shows that the increase in vehicle fuel efficiency contributed two-thirds and the fall in fuel prices contributed one-third to the reduction in household expenditures on transportation between 1984 and 1994. As the figures for average household expenditures on gasoline, vehicle-miles traveled, vehicle fuel efficiencies, and gasoline prices come from different sources and are based on different assumptions and samples, they may not be comparable.

Table 2-4.
Household Expenditures on Transportation: 1984 and 1994

Type of expenditure	1984	1994
Average annual household tranportation expenditures (in current dollars)	$4,304	$6,044
Percentage of components of transportation expenditures:		
Vehicle purchases	**42.1**	**45.1**
Cars and trucks, new	23.9	23.0
Cars and trucks, used	17.6	21.3
Other vehicles	0.6	0.7
Gasoline and motor oil	**24.6**	**16.3**
Other vehicle expenses	**27.4**	**32.3**
Vehicle finance charges	4.9	3.9
Maintenance and repairs	11.2	11.3
Vehicle insurance	8.1	11.4
Vehicle rental, licenses, other charges	3.1	5.7
Purchased transportation service	**5.9**	**6.3**

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics. 1984–1994. Consumer Expenditure Survey.

Vehicle finance charges constitute a household expenditure that grew much more slowly than the total. On average, these charges increased from $213 in 1984 to $235 in 1994. (USDOL BLS 1984–94) This slower increase is due to falling interest rates, and low or even zero interest rates offered by car manufacturers as an incentive to purchase vehicles. (This may indicate a switch in category, as producers substituted low interest charges for price rebates.)

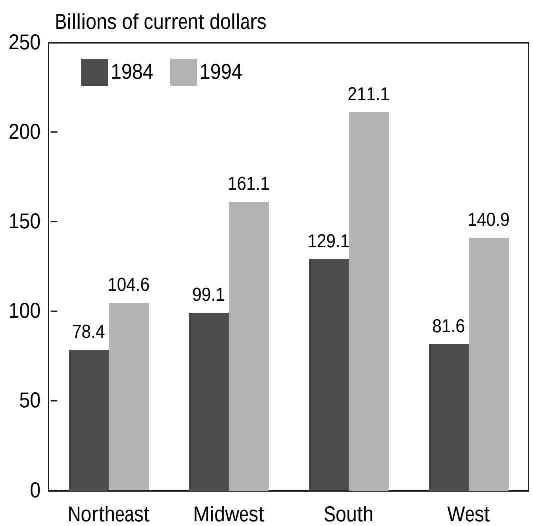
In contrast, the average household expenditure on vehicle insurance doubled from $349 in 1984 to $690 in 1994. Household expenditures on vehicle rental, licenses, and other charges also increased greatly from 1984 to 1994. Another growing item on the household shopping list was used cars and trucks. (USDOL BLS 1984–94) Two factors may have caused this change. First, the expected useful life of new cars has increased, which in turn increases the remaining life of used cars on the market. In 1993, the average automobile in use was 8.3 years old, compared with 7.5 years in 1984. Interestingly, despite this increase in average age, the data in table 2-4 show very little change in the expenditure share for vehicle maintenance and repair—11.2 percent in 1984 and 11.3 percent in 1994 (with both higher and lower figures in the intervening years). Second, the average price of new cars has risen faster than the average income of American households, which may account for a larger proportion of households buying used rather than new cars. Between 1984 and 1993, the average price of a new car rose 60 percent from $11,450 to $18,328, while average household income after taxes rose 50 percent from $21,237 to $31,890. (Davis and McFarlin 1996, table 3.5 for age of automobiles in use; table 2.3 for price of a new car)

Regional Differences

American households spent $618 billion on transportation-related goods and services in 1994, up 59 percent from $388 billion in 1984 (expressed in current dollars). (USDOL BLS 1984–94) The regional distribution of household transportation expenditures is presented in figure 2-2. A region's share of household transportation expenditures depends on its share of households, and on how much households in that region spend on transportation compared with households in other regions.

In 1994, total household transportation expenditures were about 17 percent for the Northeast, 26 percent for the Midwest, 34 percent for the South, and 23 percent for the West.

Figure 2-2.
Household Transportation Expenditures by Region: 1984 and 1994



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics. 1984–94. Consumer Expenditure Survey.

Between 1984 and 1994, only the Northeast region's share of total household transportation expenditures declined, while the other three regions' share rose.

A relatively slow increase in annual transportation expenditures per household in the Northeast contributed to the region's declining share. From 1984 to 1994, average yearly household transportation expenditures in the Northeast increased 28 percent, but the increase was 48 percent in midwestern households, 42 percent in the South, and 37 percent in the West. More relative use of mass transit for personal travel contributed to the fall in transportation's share of household spending in the Northeast. In 1994, northeastern households spent, on average, $123 on intracity mass transit, higher than the other three regions, and more than two and a half times the national average.

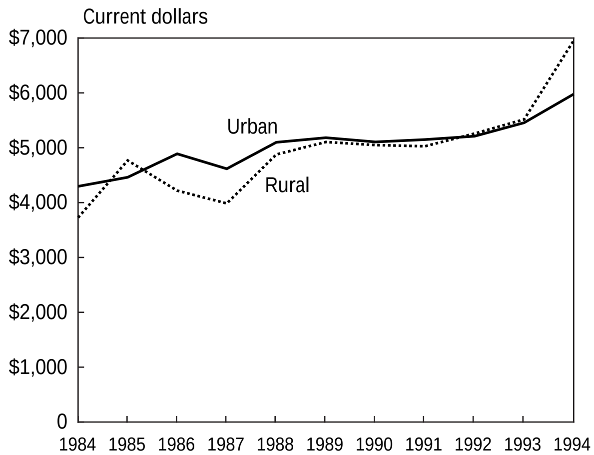
Rising shares of total household transportation expenditures for the South and West reflect their increasing proportion of the total population. The faster increase in annual household transportation expenditures in the Midwest, on the other hand, offset the effect of the region's population decline. As a result, the Midwest region's share of total household transportation expenditures increased, rather than decreased.

Rural and Urban Expenditures

In 1994, rural household spending on transportation was $6,807, or 115 percent of urban spending ($5,919). In 1984, however, average rural household spending on transportation was 88 percent of urban spending (see figure 2-3).

The major factor behind the relative surge of transportation expenditures by rural households was increased spending on vehicles. In 1984, average rural spending on vehicles was $1,577, or 85 percent of the average urban household expenditure on vehicles ($1,860). Between 1984 and 1994, average urban household expendi-

Figure 2-3.
Urban and Rural Household Transportation Expenditures: 1984–94



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics. 1984–1994. Consumer Expenditure Survey.

tures on vehicles grew 39 percent, compared with the 128 percent increase for rural households. One explanation for the difference is that rural residents depend almost completely on household-owned vehicles, while urban residents' demand for transportation is partially met by transit. In 1994, rural households spent on average $3,601 to buy vehicles, 40 percent more than urban households ($2,581). (USDOL BLS 1984–94)

Expenditures by Sex of Household Head

On average, male-headed households spend more on transportation than female-headed households, both in dollars and in percentage of total household expenditures. Between 1988 and 1994, however, the share of transportation expenditures increased in households headed by females, while the share in households headed by males decreased. In the 1988–89 survey year, male-headed households devoted 19.9 percent of their total spending to transportation, while female-headed households spent only 13.9 percent. By the 1993–94 survey year, the share for male-headed households dropped to 18.9 percent, and the share for female-headed households rose slightly to 14.1 percent. Moreover, the income gap between male- and female-headed households decreased. In 1994, the average income for households headed by males ($23,525) was 1.34 times the average income for households headed by females ($17,519). (USDOL BLS 1984–94)

Female-headed households spend less on vehicles, both absolutely and proportionally, than do male-headed households. In the 1988–89 survey year, male-headed households spent, on average, 42 percent of their transportation dollars on vehicles, while female-headed households spent only 36 percent. Between 1989 and 1994, however, female-headed households increased their spending on vehicles faster than they did on transportation as a whole. As a result, by the 1993–94 survey year, female-headed households spent 38 percent of their transportation budget on vehicles, while male-headed households remained at 42 percent.

Although female-headed households spend less on vehicles than do male-headed households, they spend proportionally more on new vehicles and vehicle insurance. In the 1993–94 survey year, new vehicle expenditures, on average, accounted for 19 percent of male-headed household transportation expenditures, but more than 25 percent of female-headed household transportation outlays. In the same year, vehicle insurance accounted for 11 percent of male-headed household transportation spending, but 15 percent for female-headed households.

Transportation Employment

Employment is another important indicator of transportation's contribution to the economy. This section discusses three overlapping, but conceptually different, measures that may be used to calculate transportation employment: 1) employment in the for-hire transportation industry; 2) employment by transportation function; and 3) employment by transportation occupation. Each is useful, but each has significant weaknesses. Because statistical coverage of the for-hire transportation industry is extensive, employment in this industry (counted as full-time equivalent workers) is most often used as the measure of transportation employment. Transportation functions, however, are performed not only by employees of for-hire transportation industries, but also by employees of all nontransportation industries that have their own in-house transportation operations. Ideally, employment by transportation function, the second category, would include all persons working in transportation operations, regardless of industry or position. In-house transportation, however, is not well covered in current statistics, so complete data on employment by transportation function are not readily available. The third category, employment by transportation occupation, covers every industry, but includes only people with skills specific to transportation, such as truck drivers and aircraft pilots. There is an employment measure for each transportation occupation, however, persons with general skills who apply those skills to transportation endeavors are not counted as being employed in transportation occupations.

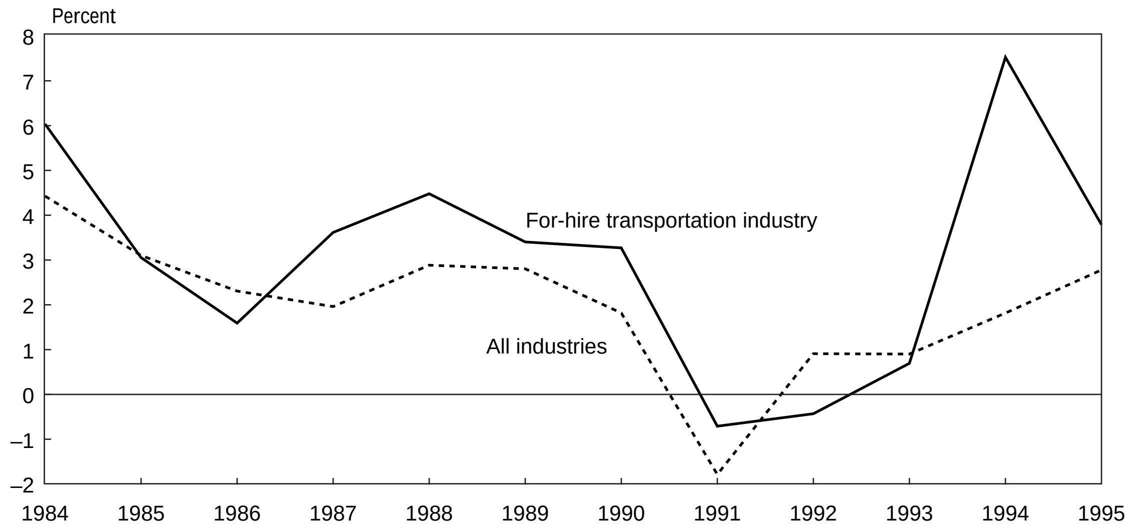
Because these three measures all yield different employment figures, they could provide useful information on transportation employment from different perspectives and could be used for different analytical purposes. For example, data on employment in the trucking industry tells us how many people work in the for-hire trucking industry, which includes truck drivers, managers, clerks, and other support staff. Employment by trucking occupation tells us how many people work as truck drivers, regardless of industry. Employment by trucking function tells us how many people work in trucking and trucking support activities throughout the economy, for example, including mechanics and dispatchers. Conceptually, employment by function covers all people working in the for-hire trucking industry and all employment by trucking purpose in every other industry. Still, because such comprehensive data are not available on employment by transportation function, the following discussion of data on transportation employment will focus on figures for industry and occupational employment.

Employment in the For-Hire Transportation Industry

The for-hire transportation industry employed nearly 3.9 million workers in 1995. (USDOL BLS 1996) For most of the 1980s and 1990s, employment in the transportation industry either grew at a higher rate or declined less in a recessionary period, such as 1991, than total national employment. The exceptions occurred in 1986, 1992, and 1993 (see figure 2-4). Transportation employment growth resumed in 1994 and 1995.

The growth pattern differs significantly between the seven transportation modes for which there are data. In 1994—the year of highest growth for transportation employment as a whole—trucking, transit, and transportation services had double-digit increases from the previous year, while the railroad and pipeline industries experienced employment losses. (USDOL BLS 1996) Table 2-5 shows the modal structure of transportation employment in 1983 and 1995. The railroad industry lost employment share over the period, although that trend was set long before 1983. During these 13 years, the railroad industry's employment share fell by more than half, from 14 percent in 1983 to 6 percent in 1995. Water and pipeline shares also decreased.

Figure 2-4.
Annual Rate of Employment Growth: 1984–95



SOURCES: U.S. Department of Labor, Bureau of Labor Statistics, Office of Employment Projections. 1994. The National Industry-Occupation Employment Matrix, 1983–1993 Time Series. July.
U.S. Department of Labor, Bureau of Labor Statistics. 1995 and 1996. *Monthly Labor Review.* June

In contrast, trucking, air, transit, and transportation services increased their modal shares. Trucking's employment share rose slightly from 45 percent in 1983 to 48 percent in 1995, a net increase of more than 644,000 workers, almost equal to the combined workforce of the railroad and transit industries in 1995. Over the same period, the air industry's share rose from 17 percent to 20 percent. (USDOL BLS 1996)

Employment in Transportation Occupations

Almost all nontransportation industries in the United States have some in-house transportation operations. For example, a grocery store chain may have its own trucking operations and warehouses; a manufacturing company may have its own rail freight cars; many firms have their own fleets of company automobiles or their own general aviation aircraft, with employees to manage these functions. In-house transportation operations are not separated from their parent activities in the national accounts data and employment statistics. Thus, the numbers for an

Table 2-5.
Employment in For-Hire Transportation by Mode: 1983–95
(In percent)

Mode	1983	1995
Trucking	44.5	47.6
Air	16.6	20.1
Transit	9.3	10.8
Services	8.3	10.5
Railroad	13.7	6.1
Water	6.9	4.4
Pipeline	0.7	0.4

SOURCES: (1) U.S. Department of Labor, Bureau of Labor Statistics, Office of Employment Projections. 1994. The National Industry-Occupational Employment Matrix, 1983-93 Time Series. July.
(2) U.S. Department of Labor, Bureau of Labor Statistics. 1995 and 1996. *Monthly Labor Review, Employment and Earnings.* June.

industry always include some transportation-related employment. Because there are no data on transportation-related employment in non-transportation industries, employment estimates by occupation are used to arrive at the total number of people working in a transportation function.

Operating on the principle that occupations are grouped by functions and skills, the Occupational Employment Statistics (OES) system of the Bureau of Labor Statistics (BLS) classifies workers into seven divisions: 1) managerial and administrative; 2) professional, paraprofessional, and technical; 3) sales and related areas; 4) clerical and administrative support; 5) service; 6) agriculture, forestry, fishing, and related areas; and 7) production, construction, operations, maintenance, and material handling. Transportation and materials handling is 1 of 10 major groups within the last division. At the most detailed level, there are 13 transportation occupations classified and covered in the OES system.

In 1993, the latest year for which detailed occupational data are available, 3.5 million people worked in various transportation occupations[4] (see table 2-6). The largest occupational category was truck drivers, 63 percent of the total. The next largest group was bus drivers, who accounted for 16 percent. The combined total for the six railroad transportation occupations was 3.3 percent of the transportation total, only slightly larger than taxi drivers and chauf-

[4] This does not include 1.3 million workers in material-moving occupations. If these workers are included, the number of people employed in transportation occupations would total 4.8 million.

Table 2-6.
Employment in Selected Transportation Occupations: 1985 and 1993
(In thousands)

Standard occupational code	Occupations	1985	1993
NA	Total U.S. civilian employment	99,700.0	112,000.0
NA	Total in selected transportation occupations	3,055.4	3,492.3
97001	Truck drivers, light and heavy trucks	1,967.9	2,196.3
97110	Bus drivers	456.6	567.0
97198	All other motor vehicle operators	291.8	342.6
97300	Rail vehicle operators[1]	126.2	115.3
68026	Flight attendants	73.1	93.3
97702	Air flight pilots and flight engineers	66.5	82.8
97114	Taxi drivers and chauffeurs	47.2	72.4
39002	Air traffic controllers	26.1	22.6

[1] Rail vehicle operators include:
97302 Railroad conductors and yardmasters
97305 Locomotive engineers
97308 Railyard engineers, dinkey operators, and hostlers
97310 All other rail vehicle operators
97314 Subway and streetcar operators
97317 Railroad brake, signal, and switch operators

KEY: NA = not applicable.

NOTE: Cited employment numbers are from an establishment-based survey and differ from those found in the Census Bureau's household-based Current Population Survey.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Employment Projections. 1994. The National Industry-Occupation Employment Matrix, 1983–93 Time Series. July.

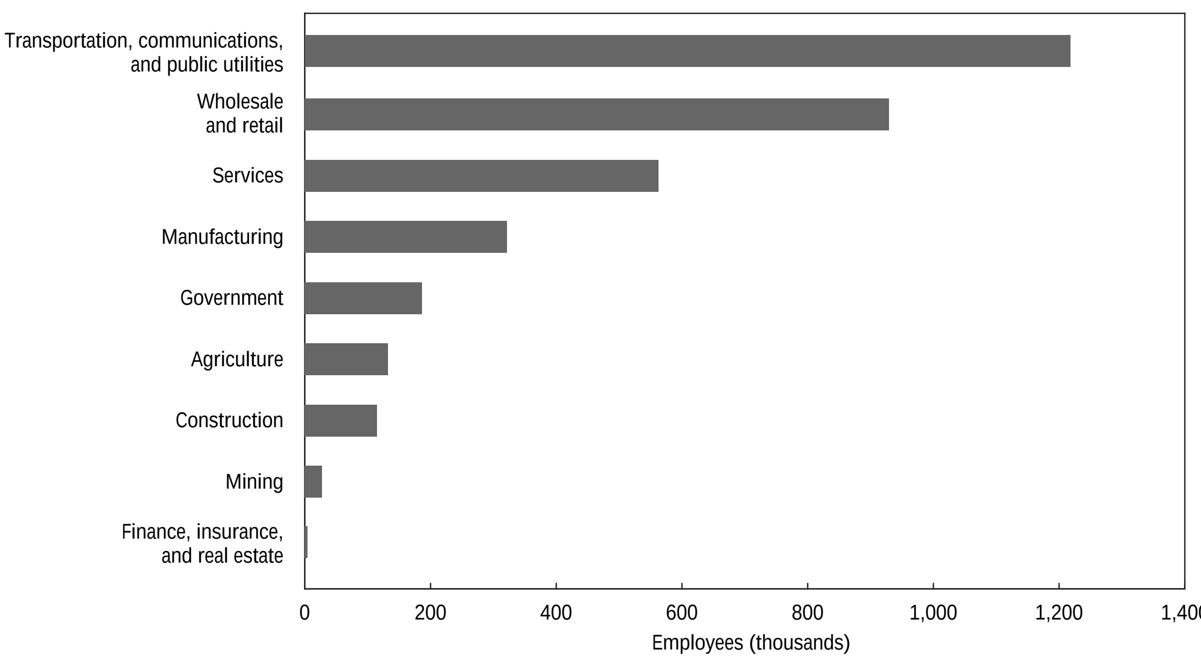
feurs (2 percent). Air flight occupations accounted for 5.7 percent of the total.

The distribution of transportation jobs across industries depends on the occupation. For example, flight attendants are found in only one industry—air transportation, but every industry employs some truck drivers. Not surprisingly, the nontransportation industry with the largest number of transportation jobs is wholesale/ retail, accounting for 27 percent of total transportation jobs in 1993 (see figure 2-5). Most workers in transportation occupations are employed in nontransportation industries, not in transportation industries (65 percent versus 34 percent).

Combining employment in the transportation industry and by transportation occupation outside the transportation industry provides a low-end estimate of the number of people working in transportation functions in the entire economy. In 1993, about 5.8 million people worked in transportation functions. This included 3.5 million working in for-hire transportation industries and 2.3 million in transportation occupations in nontransportation industries. People employed in for-hire transportation industries include both transportation occupations and supporting occupations, such as managers and clerks. (USDOL BLS OEP 1994)

It is worth emphasizing that the 5.8 million figure does not include those people who work in the transportation part of nontransportation industries and are in positions that are not defined as one of the transportation occupations. For example, a bookkeeper or a material mover might work full time in a manufacturing firm's transportation function, but not be included in the 5.8 million. Nor are those included who drive extensively in order to conduct business:

Figure 2-5.
Number of Employees in Transportation Occupations by Major Industry: 1993



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Employment Projections. 1994. The National Industry-Occupation Employment Matrix, 1983–1993 Time Series. July.

for example, insurance agents who drive a company car. The 1990 Census of Population recorded 137,400 driver-sales workers throughout the economy.

Not every transportation-related occupation is identified in the OES system. For example, ship captains, mates, sailors, and dockhands are not identified separately. None of these 167,400 workers would have been counted as a transportation worker. It should be clear from these examples that the real level of employment by transportation function is higher than the estimates.

For comparison purposes, the Bureau of Transportation Statistics report, *National Transportation Statistics 1997*, showed nearly 10 million people employed in transportation industries, transportation equipment manufacturing industries, and other related industries, such as highway and street construction, and federal, state, and local governments in 1993.

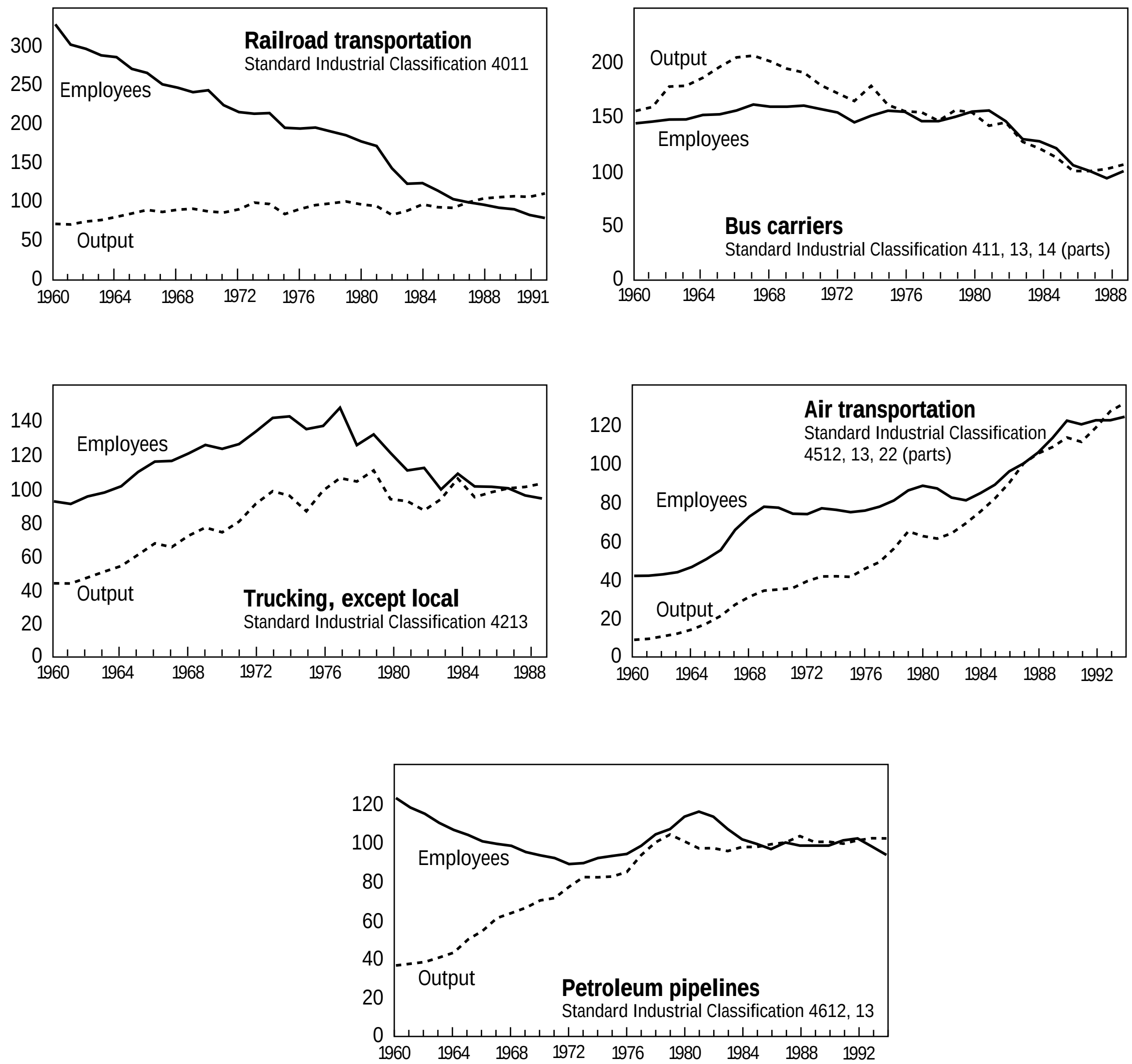
Labor Productivity in the Transportation Industry

It is difficult to draw a complete picture of transportation employment from employment data alone. For example, transportation creates millions of jobs, but employment data do not provide information about productivity. Labor productivity measures provide this information on an industry basis, not by occupation. Labor productivity measures relate output to labor input—they report on how productively people work. It is important to note that changes in labor productivity are also driven by factors other than labor, such as capital. Labor productivity can be calculated on a per-employee basis or on a per-employee-hour basis. A per-employee-based measure shows how much a typical worker produces within a certain period of time, usually a year. A per-employee-hour-based measure shows how much a worker produces within a typical working hour. This latter measure is more informative if many people work part time or overtime. (For more information on how labor productivity is measured, see USDOT BTS 1995, chapter 6.)

BLS publishes productivity measures for all transportation modes except water. Some of these measures are based on per-employee and per-employee-hour data and some on one of the two. Data for bus carriers and intercity trucking extend only to 1989, and updated data on railroads are available through 1992. Data on air transportation and petroleum pipelines are available through 1994.

Labor productivity in air transportation is calculated only on a per-employee basis. This measure gained 1.8 percent in 1994, much less than in 1993 when it increased 7.1 percent. This was caused by slow growth in *output* (7.1 percent in 1993 v. 3.4 percent in 1994) and faster growth in *employment* (no growth in 1993 v. 1.5 percent growth in 1994). Labor productivity in petroleum pipelines increased 0.7 percent in 1994 from the previous year on a per-employee-hour basis. On a per-employee basis it increased much faster, 4.5 percent. Both were caused by decreasing output and an even faster decreasing labor input. The values of the two measures are so different because the number of employees decreased much faster than the number of employee-hours in the industry (4.4 percent v. 0.7 percent). The smaller decrease in employee-hours means that pipeline workers worked longer hours. A closer look at the data shows that mostly nonsupervisory employees worked longer hours. For other modes of transportation there are no additional data available except for the revisions made by BLS. Figure 2-6 shows revised BLS data for various modes.

Figure 2-6.
Labor Productivity by Mode (Index 1987 = 100)



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Productivity and Technology. 1996. Informational material.

It is interesting to compare long-term productivity growth in transportation with that in the overall economy (see table 2-7). Over the span of nearly four decades, except for bus carriers, labor productivity growth in the transportation industries was higher than that in the overall business sector.

Table 2-7.
Annual Growth in Labor Productivity

	Growth rate	Period covered
All businesses[1]	2.0%	1959–94
Air transportation	4.6	1959–94
Petroleum pipelines	3.8	1959–94
Railroad transportation	5.9	1959–92
Trucking	2.8	1954–89
Bus carriers	0.2	1954–89

[1] Excludes farming.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Productivity and Technology. 1996. Informational material. May.

Government Revenues and Expenditures on Transportation

Federal, state, and local governments spend considerable sums on the nation's transportation system. They build, maintain, and regulate roads, airports, mass transit facilities, ports and waterways, railroads, and pipelines. Governments pay for these services through transportation user taxes and fees. State and local governments also rely on grants from the federal government. When total revenues from these sources are less than expenditures (i.e., coverage is less than 100 percent), governments tap general tax revenues.

Revenues

Government transportation-related revenues totaled $85 billion, covering 73 percent of government transportation expenditures in fiscal year (FY) 1993. State governments collected approximately half of all transportation-related revenues, the federal government collected about

Table 2-8.
Government Transportation Revenues and Expenditures Before Transfers: Fiscal Years 1983 and 1993
(In millions)

	Current dollars		Constant 1987 dollars		Percentage growth
	1983	1993	1983	1993	1983–93
Revenue					
Total	40,029	85,034	46,047	68,883	49.6
Federal	12,507	27,311	13,744	21,954	59.7
State	19,806	41,428	23,247	33,681	44.9
Local	7,716	16,295	9,056	13,248	46.3
Expenditures					
Total	63,136	116,012	72,363	93,983	29.9
Federal	23,262	36,670	25,563	29,477	15.3
State and local	39,874	79,342	46,800	64,506	37.8

NOTE: A 2.5¢ per gallon federal motor fuel tax for deficit reduction put in effect in December 1990 has contributed to the fast increase in federal revenues. These revenues are not available for transportation expenditures, which grew much more slowly.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics. 1997. *Federal, State, and Local Transportation Financial Statistics, Fiscal Years 1982–94.* Washington, DC.

one-third, and local governments about one-fifth (see table 2-8). By mode, about 70 percent of government transportation revenues were generated from highway use, 15 percent from air, 10 percent from transit, and 4 percent from water.[5] (USDOT BTS 1996)

In real terms, total transportation-related revenues increased by 50 percent from FY 1983 to FY 1993, with federal revenues increasing faster than state or local government revenues. Air transportation revenues increased the fastest (73 percent), followed by water (63 percent), highway (46 percent), and transit (43 percent).[6] (USDOT BTS 1996)

At all levels of government, but particularly at the federal level, transportation-related revenues increased faster than expenditures from FY 1983 to FY 1993, increasing overall coverage from 63 percent to 73 percent; federal coverage jumped from 54 percent to 74 percent. Coverage for state and local governments increased slightly. At all levels of government, coverage was very high for highways in FY 1993. For most modes, there were substantial changes in coverage between FY 1983 and FY 1993 (see table 2-9).

Table 2-9.
Transportation Expenditures Covered by Transportation-Generated Revenues: Fiscal Years 1983 and 1993
(In percent)

	Federal government		State and local government	
Mode	**1983**	**1993**	**1983**	**1993**
Highways	81	93	75	84
Air	67	61	99	90
Water	15	41	68	79
Transit	13	78	41	32
Pipeline	U	U	NA	NA

KEY: U = data are not available; NA = not applicable.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics. 1997. *Federal, State, and Local Transportation Financial Statistics: Fiscal Years 1982–94.* Washington, DC.

Expenditures

In FY 1993, federal, state, and local governments spent $116 billion on transportation in current dollars, an increase of 30 percent *after* inflation from the FY 1983 level (see table 2-8). During this period, state and local government spending on transportation (before federal government transfers) increased much faster than did spending by the federal government. As a result, transportation spending by state and local governments as a proportion of all public sector transportation spending increased from 63 to 68 percent. After transfers from the federal government in the form of programs and project grants, state and local spending was approximately 88 percent of all transportation-related spending by governments in FY 1993, about the same as in FY 1983.

Most government transportation spending goes to highways—60 percent in FY 1993, unchanged from FY 1983. Air transportation and pipelines are the only modes whose shares of government spending increased during this period, from 10 percent in FY 1983 to 15 percent in FY 1993, and from 0.02 percent to 0.03 percent, respectively. The shares of water and rail declined (from 7 percent to 5 percent and from 2 percent to 0.7 percent, respectively) and transit remained almost constant (20 percent in FY 1983 to 19 percent in FY 1993). (USDOT BTS 1996)

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[5] The two largest sources of federal revenues are the Highway Trust Fund (HTF), which has highway and transit accounts, and the Airport and Airway Trust Fund. The distribution assumes that HTF revenues generated by transit are credited to the transit account.

[6] In this chapter, the data on revenues collected from highway users differ from data reported in the Federal Highway Administration's (FHWA) *Highway Statistics*, table HF10. The difference is partly attributable to various data sources and BTS inclusion of items, such as vehicle operator license taxes and local parking charges, excluded by FHWA.

Table 2-10.
Government Investment in Infrastructure and Equipment After Transfers: Fiscal Years 1983 and 1993

	All government		Federal		State and local	
	1983	1993	1983	1993	1983	1993
	Current dollars in billions					
Total capital outlays	148.7	228.4	80.7	90.7	68.0	137.8
Total construction	62.1	116.3	8.8	11.4	53.3	105.0
Capital outlays on transportation	25.4	52.5	1.1	2.2	24.4	50.3
Construction in transportation	21.3	44.0	0.8	1.1	20.6	43.0
	Constant 1992 dollars in billions					
Total capital outlays	199.6	223.3	106.0	88.4	92.9	135.0
Total construction	83.4	113.7	11.6	11.1	72.8	102.8
Capital outlays on transportation	34.1	51.3	1.4	2.1	33.3	49.3
Construction in transportation	28.6	43.0	1.1	1.1	28.1	41.9

SOURCES: (1) U.S. Department of Commerce, Bureau of the Census. 1984. *Governmental Finances 1982–83*. Washington, DC.
(2) U.S. Department of Commerce, Bureau of the Census. 1996. *Government Finances: 1992–93*. [cited 23 December 1996] Available at http://www.census.gov.

Investment

This section focuses on government fixed investment in transportation, an important subject for which limited data are available. The Census Bureau defines capital outlays for government fixed investment as direct expenditures primarily for construction of buildings, roads, and other improvements, and purchase of equipment, land, and existing structures. Capital outlays also include expenditures on additions, replacements, and major alterations to fixed works and structures. Expenditures for repairs to such works and structures, however, are classified as current operating expenditures.

In FY 1993, federal, state, and local governments together invested $52.5 billion in transportation infrastructure (construction) and equipment, only 4 percent of which was *directly* invested by the federal government (see table 2-10). This percentage, however, does not reflect the important role of the federal government in financing transportation investment through grants to state and local governments. Transportation investment was 23 percent of total government investment in FY 1993, up from 17 percent in FY 1983. In constant dollars, government transportation investment grew at an average annual rate of 4.2 percent between FY 1983 and FY 1993, almost four times as fast as total investment (1.1 percent). (USDOC Census 1984; USDOC Census 1996)

Government investment in transportation focused on infrastructure much more heavily than did its investment in other sectors of the economy. Of the total transportation investment, infrastructure accounted for 84 percent in both FY 1983 and FY 1993. Transportation infrastructure accounted for 34 percent of total infrastructure investment in FY 1983, and 38 percent in FY 1993. (USDOC Census 1984; USDOC Census 1996)

Federal, state, and local governments differ somewhat in where they put their transportation

Table 2-11.
Government Transportation Investment by Mode: Fiscal Years 1983 and 1993
(In billions)

Investment	Fixed investment 1983	Fixed investment 1993	Construction outlays 1983	Construction outlays 1993
	Current dollars			
Transportation total	25.4	52.5	21.3	44.0
Highways	18.8	38.4	16.5	34.0
Airports	1.7	6.4	1.3	4.7
Parking facilities	—	0.4	—	0.3
Water transportation and terminals	1.4	1.2	1.2	0.7
Transit	3.6	6.2	2.2	4.3
	Constant 1992 dollars			
Transportation total	34.1	51.3	28.6	43.0
Highways	25.2	37.5	22.1	33.2
Airports	2.3	6.3	1.7	4.6
Parking facilities	—	0.4	—	0.3
Water transportation and terminals	1.9	1.2	1.6	0.7
Transit	4.8	6.1	3.0	4.2

KEY: — = zero or a value too small to report.

NOTES: Numbers may not add due to rounding.
Fixed investment equals outlays for structures (shown above), plus outlays for equipment (not shown).

SOURCE: U.S. Department of Commerce, Bureau of the Census. 1984. *Governmental Finances 1982–83.* Washington, DC: U.S. Department of Commerce, Bureau of the Census. 1996. *Government Finances: 1992–93.* [cited 23 December 1996] Available at http://www.census.gov.

investment dollars. Compared with state and local governments, the federal government spends a higher percent of its direct investment in transportation on equipment and a relatively lower percentage on infrastructure. In FY 1993, infrastructure accounted for 50 percent of the federal government's and 85 percent of state and local governments' investment in transportation. (USDOC Census 1984; USDOC Census 1996)

The lion's share of total transportation investment is for highways—73 percent in FY 1993, almost exactly the same as in FY 1983. Urban transit received $6.2 billion in FY 1993, 12 percent of the total, down from 14 percent of the total in FY 1983 (see current dollars portion of table 2-11). Airport investment grew rapidly during these 10 years, nearly doubling its share of total transportation investment and overtaking transit.

Investment in highway, transit, and airports is heavily slanted toward construction (see table 2-11). Almost 90 percent of public investment in highways in FY 1993 was for construction. For transit, the number was 67 percent, and for airports, 73 percent. (USDOC Census 1984; USDOC Census 1996)

The only mode experiencing a loss of investment in absolute terms between FY 1983 and FY 1993 was water transportation and terminals due to a decrease in construction. Equipment investment, however, increased 67 percent in real terms.

Table 2-12.
Transportation Investment by Mode and Level of Government: Fiscal Years 1983 and 1993
(In billions, after transfers)

Investment	Federal 1983	Federal 1993	State 1983	State 1993	Local 1983	Local 1993
Current dollars						
Transportation total	1.1	2.2	14.6	31.2	9.8	19.1
Highways	0.2	0.7	13.4	28.7	5.3	9.0
Airports	0.3	1.0	0.2	0.8	1.3	4.6
Parking facilities	—	—	—	—	—	0.4
Water transportation and terminals	0.6	0.6	0.2	0.2	0.5	0.4
Transit	—	—	0.9	1.4	2.8	4.8
Constant 1992 dollars						
Transportation total	1.4	2.1	19.9	30.6	13.4	18.7
Highways	0.3	0.7	18.3	28.1	7.2	8.8
Airports	0.4	1.0	0.3	0.8	1.8	4.5
Parking facilities	—	—	—	—	—	0.4
Water transportation and terminals	0.8	0.6	0.3	0.2	0.7	0.4
Transit	—	—	1.2	1.4	3.8	4.7

KEY: — = zero or a value too small to report.

NOTES: Numbers may not add due to rounding. The data on federal direct investment in transportation in the cited sources are based on information in the *Budget of the United States*. The coverage of many aggregates in the sources, however, is different and not comparable to figures in published budget documents. For example, the analytical report of the budget lists federal direct investment in airports as $0.1 billion in FY 1993, compared with the $1 billion figure shown above.

SOURCES: (1) U.S. Department of Commerce, Bureau of the Census. 1984. *Governmental Finances 1982–83.* Washington, DC.
(2) U.S. Department of Commerce, Bureau of the Census. 1996. *Government Finances: 1992–93.* [cited 23 December 1996] Available at http://www.census.gov.

Government transportation investment differs markedly by modal structure (see table 2-12). In FY 1993, all levels of government invested heavily in highways, but the proportions were quite different, with state governments putting 92 percent of their transportation investment into highways, local governments 47 percent, and the federal government 32 percent. Not only did the states put a higher percentage of their total investment into highways, but their total investment was bigger to begin with; consequently, in FY 1993 the states made 75 percent of the government investment in highways. A significant portion of state and local investment in highways, however, was financed though federal transfers, similar to total transportation investment. (USDOC Census 1984; USDOC Census 1996)

In FY 1993, local governments invested more in airports and urban transit combined than they did in highways, and, indeed, local governments were responsible for over 70 percent of the government investment in these two modes in that year (see box 2-2).

Box 2-2.

Intermodal Facilities and Public Investment

How much have governments invested in intermodal transportation facilities? Currently, robust data are not available to answer this question. Before attempts are made to collect such data or make estimates, it is important to clarify several conceptual issues, particularly the definition of an intermodal transportation facility.

When passengers or freight are moved by more than one transportation mode from origin to destination, this is called intermodal transportation. Aside from trips in private motor vehicles, passenger transportation is usually intermodal, because passengers often cannot complete a trip without using more than one mode. For freight transportation, intermodal service consists of moving products in a container or trailer by a combination of rail plus truck or oceangoing ship, or by truck and air combinations. Also, noncontainerized commodities are moved by combinations of trucks, trains, barges, and pipelines. Although all it takes for a transportation service to be intermodal is to move passengers or freight by more than one transportation mode in a given trip, success in this endeavor is dependent on intermodal transportation facilities.[1]

Following the Bureau of Economic Analysis's practice of classifying fixed assets into structures and equipment, an intermodal transportation facility is defined here as a structure that is built and operated for the purpose of facilitating intermodal transfer of people and goods. Therefore, intermodal facilities are defined by what they are used for rather than by their properties. For example, a rail track connecting railyards in two cities is not very different from one that branches off from the central rail system and extends to an airport or seaport. The latter, however, is an intermodal facility by our definition, but the former is not. Intermodal transportation facilities include rail/marine terminals, other container terminals, on-dock railyards, rail/motor carrier transfer points, rail and road links to off-airport locations, and shuttle bus, taxi stands, and parking facilities at airport terminals, train stations, and bus terminals.

As mentioned above, comprehensive data are currently not available on government investment in intermodal transportation facilities. Reports from business journals and government agencies, however, indicate that both the private sector and governments are increasingly investing in such facilities. Some airports are constructing facilities for intermodal services, many of which are partly financed by governments.

Intermodal investment in public ports is large. According to a Maritime Administration report, the U.S. public port industry invested $12.5 billion from 1946 through 1992 in capital improvements for new facilities and the modernization and rehabilitation of existing ones. (USDOT 1994) Much of this was for intermodal facilities. Two examples are the ports of Long Beach and Los Angeles, the largest U.S. container ports.

[1] Intermodal transportation services may be offered without always requiring large investments in special facilities. For example, a shuttle service may be offered between an airport's passenger terminal and a train station using the existing connecting roads and loading areas.

REFERENCES

U.S. Department of Transportation (USDOT), Maritime Administration. 1994. *Public Port Financing in the United States.* Washington, DC.

Not surprisingly, parking facilities received the smallest public investment, $400 million in FY 1993, three-quarters of which went to construction.

Economic Returns

Government investment in transportation affects the economy in both the short and long term. As a component of final demand, government investment immediately affects employment and production. Changes in the nation's transportation infrastructure influence the growth of the economy and productivity in the long run. This section summarizes and updates the discussion of long-term effects, which were featured in BTS's *Transportation Statistics Annual Report 1995*. (USDOT BTS 1995) A review of several studies on the effects of government investment in transportation shows that many noneconomic or nonmarket benefits to our society, such as national security, were not captured in their calculations of economic returns. Also, rate of return calculations were done with techniques and data that are often subject to criticism.[7]

[7] For a discussion of these criticisms, see Gramlich 1994 and Munnell 1992.

Since the 1980s, a great deal of research has been devoted to assessing the economic returns from government investment in public infrastructure, including transportation infrastructure. Most of these studies examined public capital[8] and its impacts on production at the national, regional, state, or industry levels. Some studies tried to identify and analyze specific types of investment. For transportation, highway capital stock (i.e., existing infrastructure) is the most often studied. An early example is a Congressional Budget Office study, which reported the rates of return for various types of highway expenditures in the 1980s. (CBO 1988) Although the picture is mixed, it is not surprising that very different kinds of investment projects yield quite different returns.

Some research conducted since the late 1980s has tried to estimate the effect of public capital stock on private production and its related costs. The results indicated that public capital stock had a large effect. Output elasticity is one way to estimate this effect. This measure shows how much private sector output changes if public capital stock increases by 1 percent. A 1996 study prepared for the Federal Highway Administration (FHWA) (Nadiri and Mamuneas 1996) offers strong evidence of the many ways highway capital in the United States contributes to the productivity of 35 different industries and the overall economy. In particular, it suggests that the return on the investment of a dollar in highway infrastructure generally has been greater than the return on a dollar of private capital investment. As the Interstate Highway System neared completion in the 1980s, however, the rate of return on highways fell gradually to just under the return on private capital in the economy.

[8] Public capital is defined as equipment, infrastructure, and other durable goods that are financed and managed by federal, state, and local governments.

The results of the 1996 FHWA study also indicate that the contribution of highway capital to productivity growth is relatively small in almost all industries and at the aggregate level, except in a few nonmanufacturing industries. Another interesting finding of the study is that highway capital appears to substitute for private capital and labor. In other words, highway investment was found to reduce the demand for labor, private capital, and material inputs in the manufacturing industries, but increased the demand for labor and material inputs and decreased the demand for private capital in nonmanufacturing industries.

It is not easy to generalize from these studies. Although most of the results indicate that public capital stock in general and transportation infrastructure capital in particular have a positive economic contribution to private production and productivity, the results are mixed. Such mixed results pose difficulties for interpretation, because the specific linkages between capital stocks and the economy are not well understood. There is also disagreement about where efforts should be focused. Some argue that the best approach is not to analyze the numbers but to set up institutional structures that permit state and local governments to determine the best approach. (Gramlich 1994) Others argue that more emphasis should be put on encouraging efficient use of the existing capacity. (Winston 1992) This disagreement, however, does not cast doubt on the positive contributions of transportation infrastructure to our economy and society. As one researcher noted: “At this point, an even-handed reading of the evidence—including the growing body of cross-sectional results—suggests that public infrastructure is a productive input which may have large payoffs.” (Munnell 1992)

Data Needs

Additional analysis and supporting data could lead to improved understanding of the relationships between transportation and the rest of the economy, particularly the economic impacts of government transportation investment and transportation infrastructure capital stock. Given the magnitude of highway investment and highway capital, further research in this area could have a big payoff. As shown above, all levels of government make substantial investments in transportation infrastructure other than highways.

The lack of reliable and sufficiently detailed data on the stock of transportation infrastructure impedes understanding of the contribution of public investment in transportation infrastructure to U.S. economic growth. The Bureau of Economic Analysis and other researchers derived their capital stock data using the perpetual inventory method.[9] Inputs to this procedure include original investment flows, average service lives, and retirement patterns. Data on depreciation are needed to estimate net capital stock from gross capital stock.

The Census Bureau is another source of data. Census data offer more details, but are available only in current dollars, which makes analyses of changes over time difficult. Neither data source reflects adjustments that take the quality of infrastructure into account. This impedes analysis of infrastructure capital effects, as both the level of stock and its quality are important.

A thorough investigation of current construction and use of existing intermodal facilities within each transportation mode is a necessary first step for a complete picture of investment in these facilities. Without better data on transportation infrastructure, both investment and capital stocks, a solid understanding of its contribution to the economy is impossible even with sophisticated theories and estimation methods.

Systematic cost analyses of transportation services need to be developed both for passenger and freight transportation. Such analyses would show the cost of transportation services to consumers and businesses, and whether these services are becoming relatively more or less expensive over time, compared with other goods and services. Some data such as BLS's consumer and producer price indices could be explored for this purpose, although the cost data would have to be obtained from other sources.

[9] The perpetual inventory method starts with investment flows in both current and constant dollars. The gross capital stock for a given period is obtained by cumulating past investment and deducting the cumulated value of investment that has been discarded, using estimated average service life and retirement patterns. The net capital stock is equal to the gross stock, less accumulated depreciation on the items in the gross stock.

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chapter three

Transportation Safety

Two basic questions provide a useful framework for transportation analysis and discussion: is the transportation system getting better or worse, and what is meant by better or worse? A similar inquiry can be made of transportation safety: is the safety record getting better or worse, and what do we mean by safe? This chapter examines safety trends and recent events that shed light on transportation safety.

The transportation system's safety performance is usually assessed by examining changes over time in the number and rate of deaths or injuries, and exposure to risk in each mode. By these standards, the statistics clearly show that most modes have become safer over the past 20 to 30 years, despite more intensive use. Much of the improvement results from use of innovations developed through research, education efforts by the transportation community, and improved emergency response and care. Hidden in the aggregates, however, are certain risk factors that continue to prompt concern about transportation safety.

Transportation crashes have major adverse consequences for society, entailing huge medical, property, and social costs. The devastating impacts of disabling injuries on the affected individuals and their families, lost productivity, and damage to the infrastructure and the environment are prime examples. Reducing transportation risks is a multifaceted process that includes public and private spending for prevention programs, intervention strategies (e.g., improved lighting and street markings), technological advances, regulations, and statutory mandates.

Transportation Safety in Context

How do transportation-related fatalities compare with all accidental fatalities? Accidental fatalities include deaths from unintentional injuries that occur at work, at home, or at other locations. Despite population growth, accidental deaths from all causes have declined in the United States (see table 3-1). In 1970, 6 percent of the 1.92 million deaths in the United States were accidental. By 1993, accidental deaths dropped to 4 percent of the 2.27 million total. Transportation-related accidents are decreasing as a percent of *total* deaths, but have remained fairly constant at about half of all *accidental* deaths. As discussed later in this chapter, faster and better medical response has contributed to the decrease in all accidental deaths and deaths from transportation crashes. Transportation measures, such as greater use of safety belts, also have helped to keep transportation fatalities below what they would otherwise have been.

There are many ways to compare transportation safety with other everyday risks. One study estimated a range of fatalities from everyday risks, inferring that the chance of being killed in a motor vehicle crash was 1 in 5,000, and 1 in 250,000 for an aviation accident. Exposure to other factors, such as smoking cigarettes, puts individuals at far greater risk than transportation activities. (Vicusi 1993) A classic 1979 study discusses a variety of ordinary activities that individually increase the chances of death by 1 in 1 million annually, that is, by one ten-thousandth of a percent per year. For example, transportation activities such as annually traveling 6 minutes by canoe, 10 minutes by bicycle, 300 miles by car, or 6,000 miles by jet were considered equivalent in risk to annually smoking 1.4 cigarettes or drinking one-half liter of wine.[1] (Wilson 1979)

Still another way to evaluate transportation and other risks is to estimate years of life lost from various causes by a segment of the population. The U.S. National Center for Health Statistics, part of the Centers for Disease Control,

[1] To develop these equivalent risks today, the exposure estimates would need to be recalculated to account for improvements in highway and aviation safety, and, possibly, changes in the scientific understanding of the hazards of smoking or alcohol consumption.

Table 3-1.
Transportation Fatalities Compared with Total and Accidental Fatalities: Selected Years

	1970	%	1980	%	1992	%	1993	%
Resident population	203,984,000		227,225,000		255,039,000		257,800,000	
Deaths from all causes	1,921,000	100.0	1,990,000	100.0	2,176,000	100.0	2,269,000	100.0
Accidental deaths	114,638	6.0	105,718	5.3	86,777	4.0	90,523	4.0
Transportation deaths	56,494	2.9	54,642	2.7	41,847	1.9	42,631	1.9
Transportation's share of accidental deaths	NA	49.3	NA	51.7	NA	48.2	NA	47.1

NA = not applicable.

NOTE: Transportation deaths have been adjusted slightly to conform to BTS published statistics.

SOURCE: U.S. Department of Commerce, Bureau of the Census. 1996. *Statistical Abstract of the United States, 1996*. Washington, DC. Tables 14, 90, and 138.

Table 3-2.
Years of Potential Life Lost Before Age 65 by Cause of Death
(Per 100,000 persons under 65)

Cause of death	1970	Percent	1993	Percent	1970–93 (Percentage change)
All causes	8,595.9	100.0	5,477.6	100.0	–36.3
Motor vehicle crashes	**889.4**	**10.3**	**514.7**	**9.4**	**–42.1**
Other unintentional injuries	709.7	8.3	376.9	6.9	–46.9
Suicide	250.2	2.9	306.4	5.6	22.5
Homicide and legal intervention	271.8	3.2	386.2	7.1	42.1
Other causes	6,474.8	75.3	3,893.4	71.1	–39.9

SOURCE: U.S. Department of Health and Human Services, National Center for Health Statistics, Centers for Disease Control. 1996. *Health, United States, 1995.* Washington, DC. Tables 1 and 31.

reports data on years of life lost before age 65 in motor vehicle crashes. Motor vehicle crashes account for nearly 60 percent of years of life lost from all accidents before age 65. Since 1970, years of life lost before age 65 from motor vehicle crashes dropped by 42 percent, years lost from other accidents fell by 47 percent, and years of life lost before age 65 from all causes of death fell by 36 percent (see table 3-2). (Crashes involving motor vehicles account for about 95 percent of transportation fatalities and, thus, slightly under 50 percent of accidental deaths from all causes.)

An estimation of "years of life lost before age 65" is useful for an analysis of accidental deaths, including transportation crashes, because accidents are such a prominent cause of death before age 65. After age 65, accidental death is far less likely than death from natural causes, despite more deaths due to falls in that age group.

Expressing data for years of life lost before age 65 has shortcomings, however. The death of a younger person counts for more than the death of an older person, and the death of anyone 65 or older would not be counted at all. There is also a potential problem in comparing figures for different years, because similar figures could conceal a difference in the number of fatalities. For example, if the fatality rate in an age group fell by about the same percentage as the number of people in that age group increased, years of life lost would not change, even though the underlying picture would be quite different. Thus, an analysis of road safety based on years of life lost needs a further input: death rates as a function of age.

Of course, other measures are needed besides the number of deaths or years of potential life lost as a fraction of the population to evaluate transportation risk. In the case of highway safety, for example, the data should be expressed as a percentage of motorists, or, better, per vehicle-miles traveled (vmt). There is also a key need to express the data in terms of injury rates and trends in injury severity over time.

Transportation Safety Trends

Transportation, whether viewed in absolute numbers of fatalities or normalized by some measure of exposure, has become safer in recent decades. Table 3-3 presents historic data for fatalities, injuries, and accidents/incidents by mode.

The economy, as measured by gross domestic product, grew from $3.4 trillion in 1970 to $6.7 trillion in 1995 (in constant dollars). (USDOC 1996, table 685) Transportation activity is a derived demand, and tends to reflect overall economic conditions. Hence, exposure to risk has also greatly increased, making the absolute decline in most fatality, injury, and accident series impressive. For example, the number of people killed in crashes involving motor vehicles in 1995 would have been nearly three times as great had the 1969 fatality rate of 5.0 deaths per 100 million vmt continued. (The 1995 rate was 1.7 fatalities per 100 million vmt).[2]

There are many possible explanations for the improvement. Research, development, and use of innovative practices and technologies have helped improve safety. Examples include safer designs for highways, crashworthiness standards, safety partnerships with the states, drug and alcohol countermeasures, occupant protection devices, and training and education programs. Better emergency response and medical intervention capabilities, including improved on-scene equipment, in-transport treatment of crash victims, and faster delivery to trauma centers through airlifts, also play a role. Phase-in of more sophisticated technology has improved communications between emergency medical personnel at the accident scene and physicians at trauma centers. Assigning precise weights to these factors is difficult. Moreover, strategies and regulations aimed at making transportation safer vary widely in cost.

Figure 3-1 shows fatality rates by specified unit of exposure for selected transportation modes. (Rates are expressed as occupant fatalities where data permit.) The long-term improvement in transportation safety is evident. Fatalities, injuries, and economic costs from transportation continue to be dominated by crashes involving motor vehicles, particularly passenger cars and light trucks (see table 3-4).

Although a crash of a commercial plane, train, or bus receives a great deal of public scrutiny, travel in commercial passenger vehicles is generally much safer than travel in private vehicles—whether on highways, through the air, or on water. Over 90 percent of the fatalities listed in table 3-4 were occupants of cars (which, with the exception of taxicabs, are not involved in the commercial transport of passengers), light trucks, or motorcycles, or were pedestrians or pedalcyclists. More people died in recreational boating and general aviation (including private business planes and private-use planes) crashes than died in trains, buses, or planes in commercial aviation crashes combined. The comparison is even more dramatic for trains, because most of the fatalities listed were people outside trains, not passengers.

Even though motorcycle fatalities per vmt have steadily declined for many years, motorcycle crashes and fatality rates are among the highest of any mode of transportation (see figure 3-1). Motorcyclists are 16 times as likely as passenger car occupants to die in a motor vehicle crash, and about 4 times as likely to be injured, per vmt. (USDOT NHTSA 1996d)

Review of Recent Crashes

Table 3-5 shows some examples of transportation crashes and incidents that occurred between late 1994 and mid-1996.[3] Of particular note (at

[2] The decrease in occupancy rate for motor vehicles over this period could account for a small part of the decrease in fatality rate.

[3] While the focus here is on crashes and incidents in 1995, some events that occurred in late 1994 and early 1996 are included for purposes of illustration and breadth. The crashes of ValuJet flight 592 into the Everglades and TWA flight 800 into Long Island Sound, both tragedies occurring later in 1996, are also listed because so many lives were lost.

Table 3-3.

Fatalities, Injuries, and Accidents/Incidents by Transportation Mode

Year	Air carrier[1]	Commuter air[2]	On-demand air taxi[3]	General aviation[4]	Motor vehicles[5]	Rail[6]	Transit[7]	Water[8]	Recreational boating	Gas and hazardous liquid pipeline
Fatalities: 1960–95										
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	R 30
1975	R 124	28	69	1,252	44,525	575	N	243	1,466	R 15
1980	1	37	105	1,239	51,091	584	N	206	1,360	19
1985	526	37	76	955	43,825	454	N	131	1,116	R 33
1990	39	7	50	766	44,599	599	339	85	865	9
1991	50	77	R 70	R 786	41,508	586	300	30	924	14
1992	33	21	R 68	R 857	39,250	591	273	R 96	816	15
1993	1	24	42	R 736	40,150	653	281	R 110	800	17
1994	239	25	R 63	R 723	40,716	611	320	R 69	784	22
1995	168	9	52	732	41,798	567	274	46	836	21
Injuries: 1985–95										
1985	30	16	43	517	N	31,617	N	172	2,757	126
1990	39	11	36	391	3,231,000	22,736	54,556	175	3,822	76
1991	26	30	27	420	3,097,000	21,374	52,125	110	3,967	98
1992	13	5	19	418	3,070,000	19,408	55,089	R 167	3,683	118
1993	16	2	24	386	R 3,189,000	17,284	52,668	R 160	3,559	112
1994	35	6	32	452	R 3,307,000	14,850	58,193	R 179	4,084	R 1,968
1995	25	P 25	P 14	P 398	R 3,507,000	12,546	56,991	145	4,965	64
Accidents/incidents: 1985–95										
1985	R 21	21	154	R 2,739	N	3,275	N	3,439	6,237	R 517
1990	24	16	106	R 2,215	6,471,000	2,879	58,002	3,613	6,411	R 378
1991	26	22	87	R 2,175	6,117,000	2,658	46,467	2,222	6,573	R 449
1992	18	23	76	R 2,073	6,000,000	2,359	36,380	R 3,244	6,048	R 389
1993	23	16	69	R 2,039	R 6,106,000	2,611	30,559	R 3,425	6,335	447
1994	R 23	10	R 85	R 1,990	R 6,496,000	2,504	29,972	R 3,972	6,906	R 465
1995	35	P 12	P 76	P 2,066	R 6,699,000	2,459	25,683	R 4,196	8,686	349

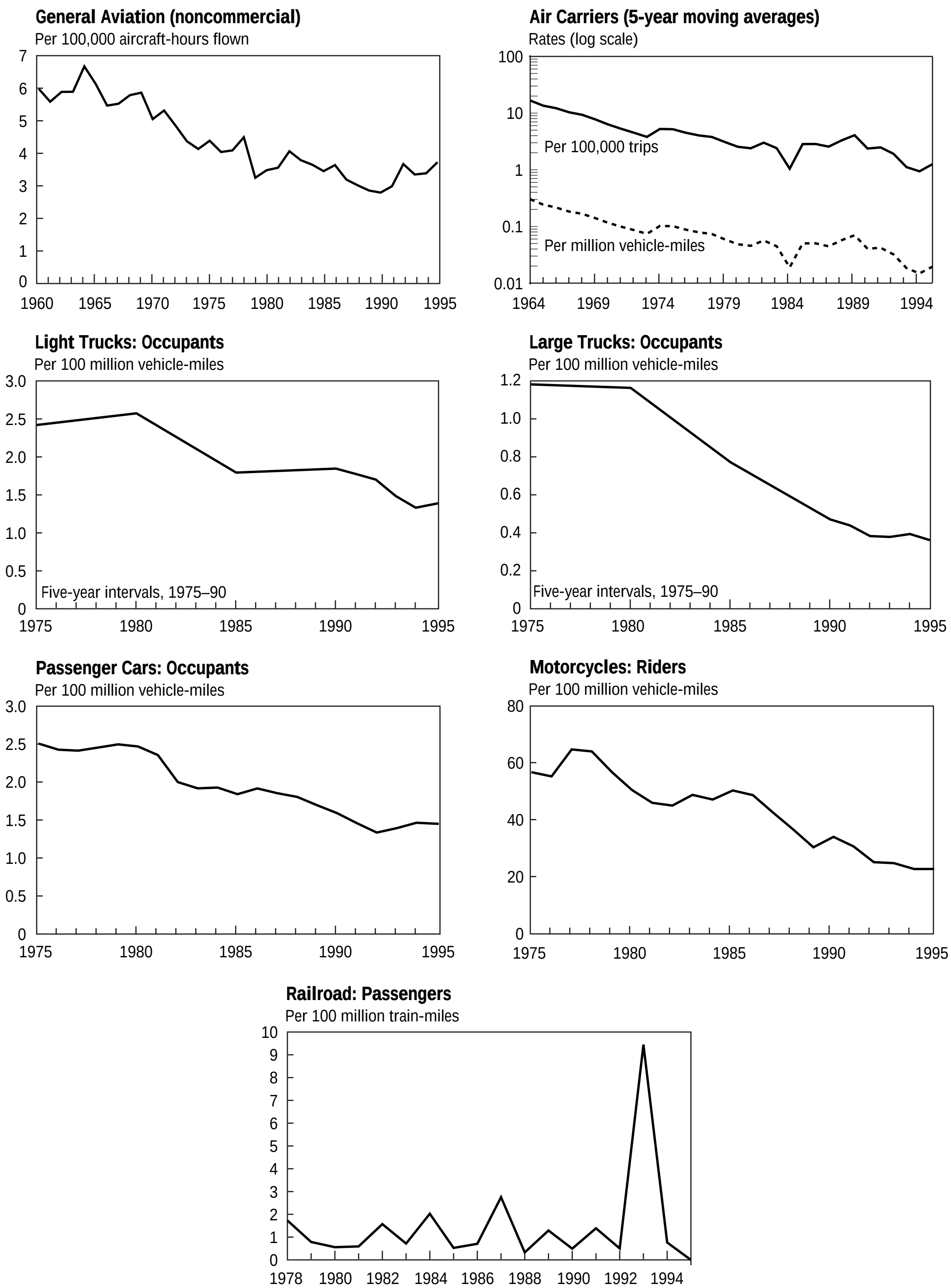
[1] Large carriers operating under 14 CFR 121, all scheduled and nonscheduled service.
[2] All scheduled service operating under 14 CFR 135 (commuter air carriers).
[3] Nonscheduled service operating under 14 CFR 135 (on-demand air taxis).
[4] All operations other than those operating under 14 CFR 121 and 14 CFR 135.
[5] Includes passenger cars, light trucks, heavy trucks, buses, motorcycles, other or unknown vehicles, and nonoccupants. Motor vehicle fatalities at grade crossings are counted here.
[6] Includes fatalities resulting from train accidents, train incidents, and nontrain incidents. 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.
[7] Includes motor buses, commuter rail, heavy rail, light rail, demand response, 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 include only collisions and derailments/vehicles going off the road.
[8] Vessel casualties only.

KEY: R = revised; P = preliminary; N = data are nonexistent or not cited because of changes in reporting procedures.

SOURCES: Various sources, as compiled and reported in U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.

Motor vehicle injury and accident/incident data for 1993, 1994, and 1995 provided by the National Highway Traffic Safety Administration.

Figure 3-1.
Fatality Rates for Selected Modes



SOURCE: Various sources, as compiled and reported in U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997*. Washington, DC. December.

the beginning of the 1995 listings) is the number of highway crashes that resulted in death or police-reported injury on a typical day in 1995. Table 3-5 is not intended to be representative of incidents in these modes or to reflect the relative frequency of accidents by mode. The incidents were selected either because they had particularly serious consequences, or are indicative of ongoing safety concerns frequently cited by industry, government, or the public.

It is helpful to view accidents by causes or contributing factors that can be generalized across the modes. Well-known causes include:

- human error due to drowsiness and fatigue, operator distractions, or negligence;
- alcohol and/or drug consumption;
- excessive speed;
- equipment or mechanical failure;
- deteriorating infrastructure;
- converging, meeting, overtaking, or crossing mistakes;
- faulty navigation or traffic control devices;
- miscommunication; and
- adverse environmental or weather conditions.

Table 3-6 shows the major causes of a subset of accidents and incidents for each major mode. A recurrent theme is human error. Over the years, the Department of Transportation (DOT), the National Transportation Safety Board (NTSB), and others have devoted considerable resources to reduce human error, through education and training, ergonomics, work rules, and similar measures. Human error nevertheless remains a leading cause of transportation accidents (as was discussed in more detail in *Transportation Statistics Annual Report 1996*). On the highway, a railroad track, or in the air, a vehicle operator's close attention and quick reaction can make the difference between a crash and a near miss. At the other end of the spectrum, pipeline accidents are often caused by external events such as excavation work.

Table 3-4.
Distribution of Transportation Fatalities:1995

Category[1]	**1995**	**Percent**
Total	44,394	
Passenger car occupants	22,358	50.4
Light-trucks occupants	9,539	21.5
Pedestrians struck by motor vehicles	5,585	12.6
Motorcyclists	2,221	5.0
Recreational boating	836	1.9
Pedalcyclists struck by motor vehicles	830	1.9
General aviation	732	1.6
Large-truck occupants	644	1.5
Other and unknown motor vehicle occupants	480	1.1
Railroads[2] (excluding grade crossings)	475	1.1
Air carriers	168	0.4
Other nonoccupants struck by motor vehicles[3]	109	0.2
Commuter rail	92	0.2
Heavy-rail transit	79	0.2
Grade crossings, not involving motor vehicles[4]	71	0.2
Air taxis	52	0.1
Waterborne transportation	46	0.1
Bus occupants[5]	32	<0.1
Gas distribution pipelines	16	<0.1
Light-rail transit	15	<0.1
Commuter air	9	<0.1
Hazardous liquid pipelines	3	<0.1
Gas transmission pipelines	2	<0.1
Other counts, redundant with above[6]		
Grade crossings, with motor vehicles	508	
Transit buses	82	
Demand response and other transit vehicles	6	

[1] Unless otherwise specified, includes fatalities outside the vehicle.
[2] Includes fatalities outside trains except at grade crossings.
[3] Includes all nonoccupant fatalities except pedalcyclists and pedestrians.
[4] Grade-crossing fatalities involving motor vehicles are assumed to be included in counts for motor vehicles.
[5] Includes school, intercity, and transit bus occupants.
[6] Fatalities at grade crossings with motor vehicles are assumed to be included under relevant motor vehicle modes. For transit bus and demand response transit, occupant fatalities are counted under "bus," and nonoccupant fatalities under "pedestrians," "pedalcyclists," or other motor vehicle categories.

SOURCE: Various sources, as compiled and reported in U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.

Table 3-5.
Selected Transportation Crashes and Incidents: October 1994–July 1996

Date	Mode	Location	Incident	Consequence
10/94	Pipeline	Houston, TX	Ruptured petroleum and petroleum product pipelines and fire during flood conditions	Massive fire on ship channel, 547 injuries, $16 million in damages
10/31/94	Air	Roselawn, IN	American Eagle ATR crashed during descent to new holding pattern	68 deaths
12/14/94	Rail	Cajon Pass, CA	Intermodal train collides with rear end of standing coal train	49 cars derailed (4 hazmat), 1 death, 1 injury, $4 million in damages
Typical day, 1995	Highway	United States	102 fatal crashes, about 6,000 crashes resulting in injury	115 deaths, over 9,500 injuries
2/7/95	Hazmat (rail)	Sweetwater, TN	Tank car failure	Release of 10,400 gallons of carbon disulfide, 1/2 mile evacuation around site
2/9/95	Transit	New York, NY	Subway collision	15 injuries, $1.5 million in damages
4/20/95	Water	Corpus Christi, TX	U.K. ship Maersk Shetland collides with tugboat	4,514 barrels of cumene released, 3,000 evacuated
5/2/95	Grade crossing	Sycamore, SC	Amtrak crash into lowbed trailer at grade crossing	33 injuries, more than $1 million in damages
5/27/95	Water	Seward, AK	Fire on U.S. fish processing vessel Alaska Spirit	1 death, $3 million in damages
6/5/95	Transit	New York, NY Williamsburg Bridge	Rear-end collision between 2 subway trains	1 death, 69 injuries
6/8/95	Air	Atlanta, GA	ValuJet #597, engine failed during takeoff, then fire	1 serious injury, plane destroyed
8/22/95	Commuter rail	New York, NY	2 commuter trains collide	1 death, 45 injuries

Table 3-5.
Selected Transportation Crashes and Incidents: October 1994–July 1996 ***(continued)***

Date	Mode	Location	Incident	Consequence
10/23/95	Hazmat	Bogalusa, LA	Failure of rail tank car	Release of nitrogen tetroxide, 3,000 evacuated, hundreds treated for irritated eyes and sore throats
10/25/95	Grade crossing	Fox River Grove, IL	School bus hit by commuter train	7 deaths, 24 injuries
11/12/95	Air	Windsor Locks, CT	Jet struck trees, landing short of runway	Passengers evacuated, 1 injury
12/20/95	Air	Buga, Colombia	AA, crash into mountain	160 deaths, 4 serious injuries
1/6/96	Transit	Rockville, MD	Head-on collision between 2 subway trains	1 death, more than $2 million in damages
1/19/96	Water	near Point Judith, RI	Fire on tug and subsequent grounding of its tankbarge tow	828,000 gallons of heating oil spilled
2/1/96	Rail	Cajon Pass, CA	Derailment of freight train	2 deaths, hazmat spill, I-15 closed
2/9/96	Commuter rail	Secaucus, NJ	Collision, derailment of commuter trains with fire	3 deaths, 158 injuries
2/16/96	Rail	Silver Spring, MD	Collision and derailment with fire on MARC commuter and Amtrak trains	11 deaths, 136 injuries, diesel fuel tank rupture, $7.5 million in damages
3/6/96	Hazmat	Selkirk, NY	Tank car failure	Release of propane
3/12/96	Rail	Weyauwega, WI	Derailment of freight train with fire	Propane fire, 1,700 evacuated for 3 days, no injuries
5/11/96	Air	Everglades, FL	ValuJet #592, fire and crash	110 deaths
7/17/96	Air	Long Island Sound, NY	TWA #800, explosion (unknown cause) and crash	230 deaths

SOURCES: Typical day highway data are derived from U.S. Department of Transportation, National Highway Traffic Safety Administration. 1996. *Traffic Safety Facts, 1995.* Washington, DC. Tables 1 and 2.
Other crash and incident data compiled by Michael A. Rossetti, Volpe National Transportation Systems Center. 1996.

Table 3-6.
Causes of Incidents and Accidents by Mode
(Percentage distribution)

Mode and time period	Cause of accident: Vehicle operator	Equipment	Environmental conditions[1]	People outside of vehicle[2]	Other[3]	Total[4]
Highway (700 recent crashes)	87	3	10	—	—	100
Aviation (accidents, 1986–90)						
Part 121[5]	51	12	28	33	—	124
Part 135[6]	73	—	34	35	—	142
Air taxi	77	12	30	13	—	131
General aviation (incidents, 1992)	84	23	65	—	—	172
Helicopter	76	29	42	—	—	147
Marine (incidents, 1992)	52	32	15	—	1	100
Rail (accidents, 1989–92)	33	15	33	6	13	100
Natural gas pipeline (incidents, 1992)	2	17	—	48	33	100
Hazardous liquid pipeline (incidents, 1992)	7	36	—	22	35	100
Hazardous materials (incidents, 1992)	73	20	—	3	4	100

[1] Includes natural environment (e.g., weather) and human-made environment (e.g., right-of-way).
[2] Actions by persons outside the vehicle (e.g., for air—controllers, mechanics, and operators of airport equipment; for rail—grade-crossing accidents).
[3] Cause is undetermined or in categories other than those listed.
[4] Totals for aviation exceed 100 percent because multiple causes were often assigned to one incident/accident.
[5] Scheduled and nonscheduled service by U.S. air carriers.
[6] Scheduled commuter service.

KEY: — = zero or a value too small to report.

SOURCE: Adapted from Federico Peña, Secretary of Transportation. 1994. Testimony at hearings on Intermodal Transportation Safety before the House Committee on Public Works and Transportation, 10 February and 2 March.

Highways

Although individual highway crashes seldom receive nationwide attention, 115 people died and over 9,500 people were injured in motor vehicle crashes on an average day in 1995 (see table 3-5). Drivers were the cause of most crashes. As is discussed below, voluntary choices by drivers, such as speeding or use of alcohol and/or drugs before driving, are contributing factors in a high proportion of fatal crashes. Passenger choices—such as whether or not to use a safety belt—also affect the likelihood that they will die in a serious crash.

While much progress has been made in discouraging drivers from drinking, 41 percent of fatalities involving motor vehicles in 1995 arose from alcohol-related crashes, compared with 57 percent in 1982. (USDOT NHTSA 1996b, 85) Alcohol use varied greatly among drivers of different types of vehicles. The intoxication rate for drivers of large trucks involved in fatal crashes was 1.3 percent in 1995, versus 19.2 percent and 22.4 percent for drivers of passenger cars and light trucks, respectively. Operators of motorcycles have the highest incidence of intoxication (over 29 percent) than for any other motor vehicle operators involved in fatal crashes.

Excessive speed or driving too fast for weather, road, or traffic conditions continues to be a major factor in motor vehicle crashes. The National

Highway Traffic Safety Administration (NHTSA) estimated that speed-related crashes cost over $29 billion in 1995, and that speed was a contributing factor in 31 percent of all fatal crashes involving motor vehicles. This translates into about 13,000 deaths involving speed-related crashes in 1995. Many fatal crashes involve both drinking and speeding. In 1995, 42 percent of intoxicated drivers involved in a fatal crash were speeding, compared with just 14 percent of sober drivers in fatal crashes. (USDOT NHTSA 1996g, 1)

The relationship between speed limits and crash rates is receiving considerable attention due to the November 1995 repeal of the federal 55 miles-per-hour (mph) speed limit, allowing states to set local highway speed limits. Figure 3-2 shows state speed limits on rural interstates in effect as of mid-December 1996. It is still too early to determine if the increase in speed limits has caused a change in the number of fatalities or accidents. NHTSA and the Federal Highway Administration (FHWA) are now analyzing the costs and benefits of the repeal, and a report is due on September 30, 1997.[4] Some states have reported preliminary numbers relating motor vehicle crashes to increases in the speed limit. The results are mixed across the states (Schmid 1996) and it is premature to reach any conclusions before the national study is completed.

Most prior studies seem to show a correlation between higher speeds and increased fatalities, but some analysts disagree that this is always the case. One study found that states that raised their speed limit on rural Interstates to 65 mph in 1987, when they were permitted to do so, experienced drops ranging from 3.4 to 5.1 percent in highway fatality rates. (Lave 1995) Other studies (sponsored by NHTSA) of the 1987 change found different results. After 1987, NHTSA reported that fatalities on rural Interstates in states that increased speed limits were 30 percent higher than expected. In these states, there was an estimated increase of 539 fatalities and $900 million in economic costs annually. (USDOT NHTSA 1995) According to reports in the press, some states are opting for tradeoffs as a consequence of the 1995 repeal, such as authorizing increases in speed limits but lowering limits of permissible blood alcohol concentrations, or imposing stricter regulations on the use of seatbelts. (Karr 1996)

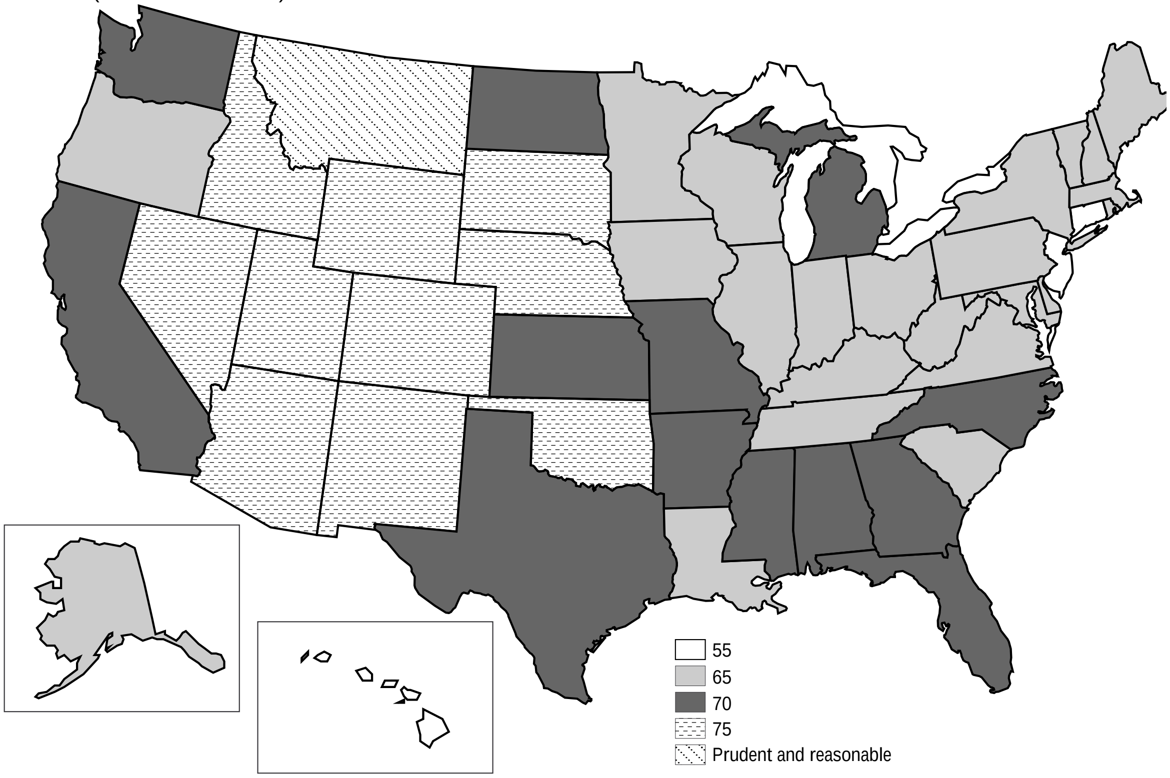
As of December 1995, 49 states, the District of Columbia, and Puerto Rico, had laws mandating the use of safety belts in passenger cars, as well as some other types of vehicles. Observed use ranges from 61 percent in states that only enforce belt requirements when a motorist is stopped for another infraction, to 75 percent in states with the toughest enforcement. Safety belt use has increased over the years, reaching 68 percent for passenger vehicles in 1995. NHTSA estimates that safety belts, airbags, and child restraints saved nearly 10,600 lives in 1995.

Many fatalities could be avoided through greater use of safety belts. Of those killed in crashes in 1995, at least 60 percent were unrestrained. (USDOT NHTSA 1996b) NHTSA further calculates that, if *all* motor vehicle occupants over the age of four had used safety belts, there would have been 9,835 fewer deaths in 1995 from highway crashes. It is now incontrovertible that the use of restraints in motor vehicles saves lives and reduces injuries. Lap/shoulder safety belts, when used, reduce the risk of fatal injury to front seat passenger car occupants by 45 percent, and the risk of moderate-to-critical injury by 50 percent. For light truck occupants, the corresponding numbers are 60 percent and 65 percent, respectively. (USDOT NHTSA 1996e)

In 1996, NHTSA issued a report reviewing 10 years of data on the effectiveness of airbags.

[4] The study was mandated by Section 347 of the National Highway System Designation Act of 1995, Public Law 104-59.

Figure 3-2.
State Speed Limits on Rural Interstate Highways
(as of December 1996)



NOTE: Speed limits on urban Interstates and other roads are generally lower by 10 mph. Also, 10 states (AR, CA, IL, IN, MI, MT, OH, OR, TX, and WA) have separate limits for trucks. Washington, DC, which has no rural Interstates, is not included.

SOURCE: Adapted from data provided by the Insurance Institute for Highway Safety, Arlington, VA, by Barbara S. Eversole, Volpe National Transportation Systems Center, 1996.

(USDOT NHTSA 1996a) The report estimated that, if no vehicles had been equipped with airbags, there would have been 1,136 additional fatalities between 1986 and 1995. (Allowing for statistical uncertainty, the range is 692 to 1,622). It concluded that airbags had reduced fatalities of drivers of passenger cars by 11 percent, and by 30 percent in head-on crashes. The risk of fatality was reduced for both belted and unbelted drivers. NHTSA also estimated the life-saving effectiveness of passenger airbags for the first time. For passengers in the right front seat who were 13 years of age or older, NHTSA concluded there was a 27 percent reduction in fatalities in head-on crashes, and a 13.5 percent reduction in fatality risk for crashes as a whole. (USDOT NHTSA 1996a, vi–vii) NHTSA also found that deployment of passenger-side airbags in low-severity crashes fatally injured some children riding in the front seat. Therefore, children aged 12 and under are safest riding in the back seat with proper restraints. The issue of airbag deployment and children is discussed in more detail in the section on child safety in the transportation system.

In addition to infants and children, an inflating airbag also poses a greater risk to adults who are shorter than 5 feet 2 inches than to taller adults. From 1990 through 1996, at least 25 adults were killed by these devices, 12 of them women who were 5 feet 2 inches tall or shorter. (USDOT NHTSA NCSA 1997)

DOT is taking steps to minimize the dangers to people at risk from airbag deployment. Among other things, the Department has extended its existing policy allowing manufacturers to install cut off switches for airbags in vehicles without a back seat or with a back seat that is too small for a child safety seat. It also has proposed a rule permitting dealers to deactivate airbags on request. Future plans call for manufacturing smart airbags that deploy in a manner consistent with a person's size and the type of crash. (USDOT 1996e)

Airlines

Travel by commercial airline is, by all measures, a very safe form of transportation. Individual airline crashes, however, often result in many fatalities, and are subject to a great deal of scrutiny, not only by regulatory authorities, but by the media and the public at large. Two 1996 crashes—the ValuJet crash in the Florida Everglades and the crash of TWA flight 800 into Long Island Sound—received front page coverage for weeks.

While investigations into these two crashes are still going on, some actions have already been taken as precautionary measures. After the ValuJet crash, for example, the Federal Aviation Administration (FAA) and the Research and Special Programs Administration (RSPA), both part of DOT, put new procedures in place governing shipment of hazardous materials by air. Following the TWA flight 800 crash, Congress added several provisions to DOT's fiscal year 1997 appropriation (Public Law 104-205) to enhance aviation and airport security. (USDOT 1996f)

Although less visible to the public, other airline safety issues have received recent attention. For example, wake vortex—unpredictable, funnel-shaped turbulent air flows in the wake of an aircraft—can endanger a following plane. Wake vortex is suspected as a possible cause of a 1994 Pittsburgh crash, but that crash is still under investigation. Research has focused on determining the safe separation distances between two aircraft under various conditions. In August 1996, FAA implemented new wake vortex separation standards, increasing the minimum distance small planes are allowed to follow behind large planes. The standard also reclassified 57 types of aircraft as small, including some business jets and smaller commercial aircraft. (USDOT 1996c) Although flight data recorders track large amounts of data, NTSB, following the Pittsburgh crash, asked that all Boeing 737s be retrofitted with expanded parameter flight recorders. (US House 1996b, 13–29)

Steps also have been taken to make use of enhanced ground proximity warning systems (EGPWS), which have "forward-looking capability" to prevent controlled flight into terrain (CFIT) crashes. The crash in Buga, Columbia, and the Windsor Locks, Connecticut, incident are examples of CFIT (see table 3-5). CFIT crashes occur when a normally functioning aircraft with an unimpaired pilot hits the ground or water, usually at high speed, with little warning of the impending crash. These incidents may involve low approach, premature descent, loss of altitude after takeoff or a missed approach, or an inadvertent gear-up landing. In late 1996, FAA approved EGPWS for use on certain aircraft. (USDOT FAA 1996a)

Human factors research and empirical evidence are putting a spotlight on flight crew issues. FAA proposals to address fatigue would require, among other things, a minimum rest period of 10 hours per day for commercial pilots. (USDOT

FAA 1995) Currently, pilots may work for 16 hours and can be required to work another shift after an 8-hour rest. Flight crew training is another important human factors issue, especially for commuter or regional airlines. FAA recently released a new software program to help regional carriers develop improved pilot training programs. (USDOT FAA 1996b) Regional and commuter airline safety issues, including the December 1995 announcement of a single safety standard (subject to common sense exceptions) for commuter and major airlines, are discussed in detail in *Transportation Statistics Annual Report 1996*. (USDOT BTS 1996b)

Railroads

Most fatalities associated with railroad operations are people outside the train, rather than train passengers. For example, between 1990 and 1995, rail operations resulted in the deaths of about 13 passengers a year, while nonpassenger fatalities (including those at highway-rail grade crossings) averaged about 1,200 a year—mostly people outside the train.[5] (USDOT BTS 1996a, 143)

Roughly half the fatalities are at grade crossings: in 1995, 579 people died and almost 1,900 were injured. On October 25, 1995, in Fox River Grove, Illinois, a commuter train traveling about 50 mph collided with a school bus, killing 7 children and injuring 24. The signaling systems may have failed to clear the intersection in time. At the crossing where the accident occurred, the train tracks were very close to the nearby street intersection, which caused insufficient clearance for the last three feet of the school bus after it had crossed the tracks and come to a stop at a red light. This underscores the importance of state efforts to identify such intersections, and to establish effective coordination between highway and rail agencies. (See the section on the safety of children in the transportation system for discussion of school bus safety issues.)

Another grade-crossing accident occurred on May 2, 1995, with a collision between a tractor-lowbed semi-trailer and an Amtrak train in Sycamore, South Carolina. The subsequent train derailment and damage to the truck resulted in 33 injuries and over $1 million in damages. The truck had become lodged at the crossing, which had a high vertical profile or hump, and was unable to move for 30 minutes prior to being struck by the train. NTSB pointed to grade-crossing incompatibility with this type of vehicle configuration, the trucking company's failure to provide training to the driver about grade-crossing safety, and the lack of information about emergency notification procedures at the crossing site. (NTSB 1996a)

While states, localities, and railroads play key roles in implementing grade-crossing safety measures, reducing grade-crossing collisions and fatalities has been a DOT priority for many years, and the Department has undertaken a number of initiatives. Fatalities have been reduced, but are still at an unacceptable level. Addressing this issue requires coordinated action by many players. In March 1996, a task force convened by DOT on grade-crossing safety suggested numerous actions different levels of government could take, often in conjunction with industry, to address grade-crossing concerns. (USDOT 1996a)

More broadly, some ways to improve rail safety include fitting trains with end-of-train and positive train control devices, and raising standards for passenger cars and tank cars. Positive train separation devices are electronic control systems that can reduce the number and severity of accidents when the engineer fails to take preventive action. Two-way end-of-train braking

[5] The average of 13 passenger fatalities includes a disastrous derailment in 1993 that claimed 47 lives. Between 1975 and 1995, the median number of passenger deaths per year on trains was five.

devices enable engineers to apply emergency braking from both the front and rear of the train. According to DOT's Federal Railroad Administration (FRA), most Class I railroads[6] were committed to install these devices by the end of 1996 in trains operating on grades of 2 percent or more, and by July 1997 on most trains operating over 30 mph. Most other trains will be required to install these devices under a rule put into effect in early 1997. (USDOT 1997)

Transit

A subway crash in January 1996 at a Washington Metropolitan Area Transit Authority station was noteworthy, as it occurred during a blizzard. The trains were operating in automatic mode even though manual mode is permissible in bad weather. NTSB found some safety systems were asked to do more than they were designed to do.

The National Transit Database (NTD) collects accident data from 524 public transit agencies. These data are validated and then published as the Safety Management Information Statistics (SAMIS). (USDOT FTA 1996) The SAMIS data exclude all purchased service transportation, while the NTD data do not. SAMIS may understate transit safety problems, because most purchased service transportation is also demand responsive and may have a higher risk profile than other transit modes. The SAMIS project was started in 1990. Accident data collected in previous years under the Section 15 system are not directly comparable.

Marine and Water

Occupational fatality rates for sailors and deckhands are among the highest of any occupational category.[7] A National Research Council study called commercial fishing one of the most dangerous occupations. (NRC 1991)

The May 1995 fire aboard the vessel Alaska Spirit exemplified NTSB concerns about lack of fire detection and suppression equipment on commercial fishing and processing ships (see table 3-5). NTSB recommended that the U.S. Coast Guard and the National Fire Protection Association develop fire safety standards for these vessels. (NTSB 1996b) Concerns other than fire, include low visibility and a range of human factors. NTSB is currently looking at inspections, licensing of vessel masters, and crew training.

Because of the potentially serious consequences of marine accidents in congested waterways of major ports, the U.S. Coast Guard has supported the development of Vessel Traffic Services (VTS) to improve safety and navigation. A port needs study sponsored by the Coast Guard found favorable cost-benefit ratios in 7 of the 23 ports examined for VTS systems. (USDOT Volpe 1991) VTS can be expensive, however. In addition, the Coast Guard's Ports and Waterways Safety System Project is evaluating user requirements at priority ports in relation to VTS.

Recreational Boating

As shown in table 3-4, 836 people died in recreational boating accidents in 1995.[8] The annual fatality count is far lower than it once was, even though the number of boats and their speed are increasing. Alcohol is a major factor in recreational boating accidents; estimates indicate that half or more of these accidents involve the use of alcohol. (USDOT BTS 1996a, table 3-28, 150) A study by the Volpe Center suggested that boaters with a blood alcohol concentration of 0.10 percent were 10 times more likely to die in a boating accident than someone with no alcohol in

[6] Class I railroads are defined as railroads with operating revenues above $255.9 million in 1995. (AAR 1996)

[7] These numbers are discussed later in the chapter in the section on safety and transportation workers.

[8] Fatality rates are expressed as deaths per number of registered boats.

their blood. (USDOT Volpe 1988) Greater use of personal flotation devices also could reduce fatalities.

Because jurisdiction over recreational boating is largely local, much of the initiative lies with state legislatures. The Coast Guard collects data on boating accidents from the states, but, aside from fatal accidents, accidents, injuries, and property damage may be underreported. Moreover, exposure data are weak.

Gas and Hazardous Liquid Pipelines

There are over 1.7 million miles of gas and hazardous liquid pipelines in the United States (including gas distribution pipelines). Pipeline incidents can pose serious hazards, as seen in the disastrous flood in late 1994 in the Houston area, which caused a major gasoline pipeline to burst. The resulting conflagration moved down the Houston Ship Channel at speeds of up to 60 mph, injuring hundreds of people and disrupting vessel traffic on the busy ship channel. Both RSPA and the industry consider excavation damage to be the leading cause of pipeline accidents, however.

Three types of pipeline data are available from RSPA: gas transmission, gas distribution, and hazardous liquids. Data for gas pipelines are more complete than for petroleum or other hazardous liquids. Gas pipeline operators are required to submit annual reports with data on mileage, diameter, cathodic protection, and coating systems. Liquid pipeline operators are only required to report mileage.

A recent NTSB report expressed concern about RSPA's ability to collect and analyze accident data for petroleum pipelines, identify accident trends, and evaluate operator performance. NTSB found that this data should be collected and reported in sufficient detail to show the cause of the accident, and factors that would either decrease or increase the likelihood of occurrence. NTSB also found that the data should more thoroughly explore the consequences of accidents; currently, environmental impacts are simply included with property damage. (NTSB 1996c)

National-level mapping data showing the location of natural gas and hazardous liquid pipelines are limited. As directed by the National Pipeline Safety Act of 1992, RSPA issued "Strategies for Creating a National Pipeline Mapping System" in late 1996. In the next phase, RSPA plans to develop pipeline mapping data guidelines. (USDOT 1996d)

Cross-Modal Issues

Some safety issues (e.g., the safety of children using the transportation system) cut across modes, and may serve as the basis for intermodal comparisons. Other safety factors (e.g., vehicle design) are unique to a particular mode. A transportation accident in one mode can affect other parts of the transportation system. For example, the February 1, 1996, freight train derailment at Cajon Pass, California (see table 3-5) closed Interstate Highway 15 for several hours. Similarly, the October 1994 pipeline rupture and subsequent fires in Houston temporarily closed the busy Houston Ship Channel.

In the following pages, special attention is given to five cross-modal issues:

- the safety of children in the transportation system,
- occupational safety of transportation workers,
- transportation of hazardous materials,
- efforts to develop common measures of safety across modes, and
- efforts to estimate the economic costs of transportation accidents.

Child Safety

The safety of children in the transportation system is a subject of great concern. As passengers, children have little control over the decision to ride in a vehicle and they depend on others to transport them safely.

► Motor Vehicles

In the 1- to 14-year-old age group, motor vehicle crashes are the leading cause of death.[9] NTSB and others have highlighted transportation risks to children from, among other things, school bus incidents, lack of school bus seatbelts, passenger airbag deployments, recreational boating accidents, and lack of child restraint systems on commercial aircraft. Transportation safety statistics as a whole show adverse outcomes for child occupants in several modes. The one- to four-year-old age group seems particularly at risk (see motor vehicle death rates in figure 3-3). Children are also victims of accidents as pedestrians, and are prone to bicycle accidents. Carjacking incidents have also victimized children in recent years. To focus these varied concerns, DOT and the Department of Health and Human Services jointly sponsored a child safety conference in 1995. The conference set goals for enhancing the safety of children in transportation, and made their transportation-related injuries and fatalities a public health priority (see USDOT 1995).

After improving markedly between 1970 and 1990, the death rate for children under one year of age in motor vehicle crashes stayed the same in 1993 as it was in 1990 (see figure 3-3). It is too soon to tell whether this hiatus is temporary. Among the three groups below age 15, the one- to four-year-old group has exhibited consistently higher death rates than infants or those aged 5 to 14.

Child passenger protection data show that the percentage of unrestrained children killed in automobile crashes is about double that of the percentage killed who were restrained (US House 1996a, 1286, taken from NTSB analysis of 1992 Fatal Accident Reporting System data). According to NHTSA, child safety seats reduce fatal injuries in motor vehicle crashes by 69 percent for infants under one year old, and by 47 percent for toddlers aged one to four. Cumulatively, child restraints have proven to be very effective, with over 2,900 lives estimated to have been saved from 1982 through 1995. Since 1985, every state has had a mandatory child restraint law in effect.

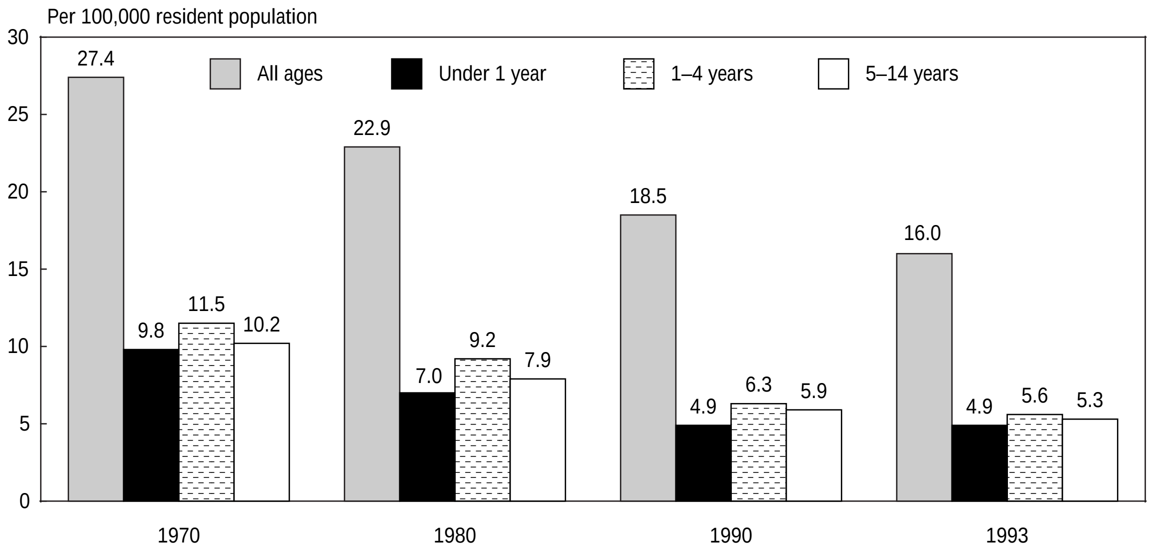
Deployments of passenger-side airbags in low-severity crashes, however, apparently caused the deaths of at least 9 infants and 27 other young children in the 1990 through 1996 period. (All but two children were either improperly restrained or unbelted.) (USDOT NHTSA NCSA 1997) Efforts are being made to modify new airbags to address the problem, but the current design of airbags in existing vehicles may continue to pose a hazard for young children riding in the front seat. This risk can be avoided if children aged 12 or under ride in the back seat of passenger vehicles and use appropriate restraint systems. On May 23, 1995, NHTSA issued a rule allowing manufacturers the option of installing a deactivation switch for passenger airbags in light trucks and passenger cars in which child restraints could be used only in the front seat.

► Aircraft

For many years, NTSB has recommended special child restraint systems (CRS) aboard aircraft for children under two years of age, and urged more research into protecting other children who are too large to fit into a CRS. A CRS is an alternative to placing a child inside a parent's lap belt. Use of FAA-approved CRS has thus far been permitted, but FAA does not require them. Not all airlines, however, allow child safety seats on board the aircraft. Among airlines that do allow

[9] Except for infants under one year of age, motor vehicle crashes are the leading cause of death for Americans until their mid-thirties.

Figure 3-3.
Fatality Rates in Motor Vehicle Crashes



SOURCE: U.S. Department of Health and Human Services, National Center for Health Statistics. 1995. *Vital Statistics of the United States.* Washington, DC.

these safety seats, flight attendants sometimes are not aware of the policy allowing their use. Moreover, some safety seats are too large to fit in aircraft passenger seats. FAA analyzed the issue in response to a congressional requirement, and in a controversial June 1995 report concluded that mandating CRSs could divert some passengers to automobiles if families traveling with a CRS have to pay extra fare, thus resulting in a net decrease in safety. (US House 1996a, 1264 and 1996b, 224)

The issue of young children flying aircraft received national attention in 1996, with the crash of a private aircraft carrying seven-year-old Jessica Dubroff, her father, and a flight instructor. The crash occurred during the course of a widely publicized cross-country trip by the young pilot trainee. A recent NTSB report attributed the crash to an improper decision by the flight instructor, who was the pilot in command, to take off in stormy weather, in an overweight aircraft, and on an itinerary based partly on media commitments. (NTSB 1997)

► Bicycles

In 1995, 280 bicyclists under the age of 15 were killed in traffic crashes (about one-third of such fatalities). In addition, 29,000 children on bicycles were injured in traffic crashes. (USDOT NHTSA 1996f) A recent study by the Consumer Product Safety Commission found that about 15 percent of children wore helmets, although earlier studies showed rates as low as 2 percent. (USCPSC 1996) The growing use of helmets was attributed to their lighter weight, positive media coverage, and local programs and laws. According to research done by the Centers for Disease Control, bicycle helmets are 85 to 88 percent effective in reducing head and brain injuries in the event of an accident. (USDOT NHTSA 1996c)

► School Buses

School bus safety is an important concern, as children can be killed both as pedestrians and as occupants. Human factors such as driver distraction or fatigue play a role in some of these accidents. From 1985 to 1995, there were 1,478 deaths from school bus crashes. The victims included 28 drivers, 128 passengers, 881 occupants of other vehicles involved in the crashes, and 403 pedestrians. Of the pedestrians killed, 300—roughly three-quarters —were less than 19 years of age. Of these, half were five to seven years old. (USDOT NHTSA 1996h)

While traveling in a school bus is relatively safe, 156 occupants of school buses were killed in crashes between 1985 and 1995. Seatbelts are required on small school buses, but not on those over 10,000 pounds. Whether seatbelts should be required on all school buses is still debated. A variety of safety design standards apply to school buses, relating to structural integrity, body joint strength, seatback height, and seat separation. Together, these are thought to provide school bus occupant protection through compartmentalization. (US House 1996a, 1287) While seatbelts would restrain students during a crash, some questions remain, such as whether all students could be relied on to release their seatbelts in case of a fire or other emergency. There are also questions about how monies for school bus safety should be spent, and whether expenditures on other transportation risks faced by children would have higher payoffs than seatbelts.

A less well-known risk to children riding school buses is clothing that catches in handrails, doors, and other equipment when a child gets out of the bus. Some deaths and injuries have occurred when children are subsequently dragged by the bus.

► Recreational Boating

Children are frequent occupants on recreational boats. In 1994, 30 children under age 12 drowned in boating mishaps, and about 50 others were injured. There were 81 accidents involving vessels with the operator under age 12, and 6 of these children died as a result of the accident. The U.S. Coast Guard estimates that 85 percent of people who die in boating accidents were not wearing personal flotation devices, and that their increased use could save up to 600 lives each year. (USDOT 1995) The Coast Guard, as well as NTSB, urge that all aboard recreational boats wear flotation devices.

Transportation Workers

Occupational risk from transportation incidents is often overlooked in safety analyses. Because of the importance of human error in transportation accidents, understanding the causes of transportation worker accidents may illuminate other aspects of safety. Moreover, as noted in an unpublished report: ". . . from the potential victim's point of view, it would be misleading to combine these [worker safety] risks with those faced by the general public. It overestimates the typical risk for the general public and understates the risk for workers. Workers also have a very different context for safety—to some extent, they get paid to accept risk." (Kowaleski 1996)

The occupational fatality data of most interest to transportation analysts is the Census of Fatal Occupational Injuries (CFOI) collected by the Bureau of Labor Statistics of the Department of Labor. CFOI data classify occupational deaths by event or type of exposure, one of which is "transportation incidents." Transportation incidents are further classified into three additional levels of detail (e.g., highway incident/noncollision/jackknifed vehicle).

Among workers as a whole, occupational fatalities in the United States remained fairly constant from 1992 to 1995, when 6,210 workers died from occupational injuries.[10] Transportation incidents were the largest single cause of these deaths in 1995, accounting for 41 percent of the total, and highway incidents account-

[10] On a disaggregated basis, some data series can show large fluctuations resulting from major events. Recent examples from 1994 include two major airline crashes, and the bombing of the Oklahoma federal building.

Table 3-7.
Occupational Fatalities: 1995

Occupational group	Total occupational fatalities (all causes)	Transportation-related fatalities (percent): Total	Highway incidents	Non-highway incidents[1]	Worker struck by vehicle	All other transportation incidents[2]
All U.S. workers	6,210	41.2	21.4	6.2	6.2	7.4
Truck drivers	749	82.9	67.8	3.5	7.9	3.7
Airplane pilots and navigators	111	98.2	U	U	U	98.2
Taxicab drivers and chauffeurs	99	24.2	18.2	U	5.1	U
Drivers-sales workers	33	45.5	45.5	U	U	U
Sailors and deckhands	30	60.0	U	U	U	60.0
Bus drivers	17	76.5	64.7	U	U	U
Railroad conductors and yardmasters	16	87.5	U	U	18.8	62.5
Locomotive operating occupations	6	100.0	U	U	U	100.0

[1] Refers to motor vehicle-related incidents occurring at, for instance, construction sites or on farms.
[2] Includes incidents occurring on modes other than highways.

KEY: U = data are unavailable or do not meet publication criteria.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics. 1996. *Census of Fatal Occupational Injuries.* Washington, DC.

ed for over half of these transportation-related deaths (see table 3-7). Truck drivers alone made up 12.1 percent of all occupational fatalities, with 749 killed, 508 of them in highway incidents. Occupational deaths caused by highway incidents increased by almost 15 percent between 1992 and 1995, while deaths in water vehicle incidents decreased by 23 percent during the same period. (USDOL 1996)

By industry, the transportation and public utilities sector, with 880 deaths in 1995, ranked second only to the construction sector in worker deaths (see table 3-8). The transportation sector fares better, however, when the number of workers in each sector is taken into account. By this measure, transportation in 1995 had an occupational fatality rate of 12.3 deaths annually per 100,000 workers; mining was highest at 25.0. Still, a job in the transportation sector is risky compared with the average job in the U.S. economy, which had a 1995 fatality rate of 4.9 deaths annually per 100,000 workers. Moreover, transportation industries not only have high death rates, but also higher than average rates of injury and illness.

Caution is needed in interpreting table 3-8: many workers in transportation industries (e.g., a ticket agent for an airline) do not work on moving vehicles, and there are many transportation jobs, such as a truck driver, in nontransportation industries (e.g., construction, services, and mining). As an example, in 1995, the air transportation industry had an overall fatality rate of 9.5 deaths annually per 100,000 workers, considerably lower than the transportation sector average of 12.3. Many air transportation jobs are much safer than those of airline pilots and navigators, whose fatality rate was 97.4 per 100,000 workers (see figure 3-4). Moreover, not all occupational deaths of workers in transportation jobs are transportation related. As table 3-7 shows, over three-quarters of occupational deaths of taxi drivers and chauffeurs are not caused by transportation incidents. Among airline pilots and navigators who die on the job,

Table 3-8.
Occupational Fatalities by Industry: 1995

Major industry group	Fatalities	Percent	Employees (thousands)	Fatalities per 100,000 employees
All industries	6,210	100.0	126,248	4.9
Construction	1,048	16.9	7,153	14.7
Transportation and public utilities	880	14.2	7,138	12.3
Trucking and warehousing	462	7.4	2,323	19.9
Local transit	116	1.9	523	22.2
Air transportation	75	1.2	792	9.5
Public administration	772	12.4	19,726	3.9
Agriculture, forestry, and fishing	752	12.1	3,515	21.4
Services	737	11.9	33,790	2.2
Manufacturing	702	11.3	20,389	3.4
Retail trade	675	10.9	20,999	3.2
Wholesale trade	254	4.1	4,973	5.1
Mining	156	2.5	625	25.0
Finance, insurance, and real estate	124	2.0	7,761	1.6

NOTE: Subgroups of major industry groups with less than 3 fatalities are not included. Thus, columns do not add up to the "All industries" total.
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics. 1996. *Census of Fatal Occupational Injuries.* Washington, DC.

however, plane crashes are overwhelmingly the cause of their death.

More than 2,500 occupational fatalities in 1995 were transportation-related. It may be instructive in the future to distinguish occupational fatalities and injuries caused by transportation incidents from nonoccupational transportation deaths and injuries. Exposure rates are at least as important as absolute numbers, especially for comparisons across modes or occupations. Thus, any comparison should be on a per unit exposure basis. For example, for the highway mode, it would be helpful to know how fatalities per occupational vehicle-mile traveled differ from fatalities per vmt as a whole. Such a comparison, which would require new data, would contribute to understanding the relative safety of transportation jobs and roughly similar nonoccupational transportation activities.

Hazardous Materials Transportation

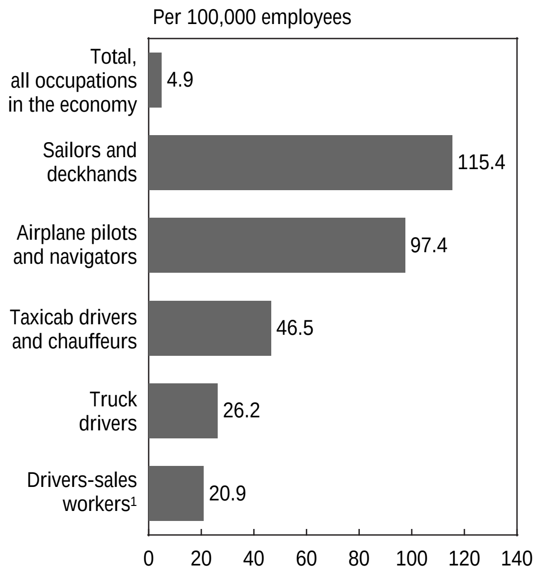
All transportation modes are involved in the movement of hazardous materials.[11] Many hazardous materials are indispensable to our economy; examples include oil and gas products, many chemicals used in agriculture, and a wide range of industrial materials.

Special handling and reporting is required when hazardous materials are transported. Data are collected separately for incidents involving oil and gas pipelines and incidents involving transportation in vehicles.

In 1995, there were 349 incidents involving oil and gas pipelines, resulting in 21 fatalities and 64 injuries. Also in 1995, there were over 14,750 hazardous materials incidents involving vehicles or vessels, of which only 294 were accident-relat-

[11] Hazardous materials require special handling in order to avoid significant risk to health, safety, or property when transported.

Figure 3-4.
On-the-Job Fatality Rates for Selected Transportation Occupations: 1995



[1] Includes individuals who drive trucks or other vehicles over established routes to deliver or sell goods such as food products; pick up or deliver items such as laundry; or refill or collect coins from vending machines.

NOTE: Rates for some occupations must be imputed, because there are fewer than 100,000 workers in the occupation.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics. 1996. *Census of Fatal Occupational Injuries.* Washington, DC.

ed. (USDOT BTS 1996a, 112). The number of incidents fluctuates from year to year, but generally exceeds 1980 levels. It is not clear that the incident occurrence rate has increased, however; reporting of incidents has improved, and economic activity has increased.

The majority of vehicular incidents over the years have involved highway transportation, followed far behind by rail and air. Recently, air transportation's share has grown, although it still accounts for less than 6 percent of incidents per year. Most hazardous waste incidents do not involve vehicular or vessel crashes, but rather minor spills or other irregularities involving hazardous materials that are legally required to be reported.

While infrequent, some hazardous materials incidents can be very serious. The possibility is under investigation that chemical oxygen generators, mislabeled empty and carried in the cargo hold, contributed to the fire that preceded the May 11, 1996, ValuJet crash into the Florida Everglades. Following the crash, RSPA placed a temporary ban on carrying these generators as cargo on passenger aircraft, pending a safety review. (The ban does not apply to properly installed generators in thermal protective casings that provide passengers and crew with emergency oxygen, or generators provided by the airline for passengers requiring oxygen for medical purposes.) (USDOT 1996b)

Hazardous materials incidents also can affect other modes and surrounding communities. On February 1, 1996, for example, a freight train carrying hazardous chemicals derailed in California. Two crew members were killed and the resulting fire closed Interstate 15 between Los Angeles and Las Vegas, rerouting and delaying 90,000 drivers who use that segment. The rural area was evacuated within a four-mile radius of the crash site. Inspectors later determined that the end-of-train braking device was not working at the time of the accident.

Hazardous materials shipments are unavoidable in an industrialized economy, and incidents may still happen despite increased vigilance. Factors such as increased trade may increase the amount of hazardous materials being transported across the southern border of the United States. Mexican law requires that most hazardous waste be shipped back to the United States from maquiladoras[12] in Mexico doing business near the U.S.-Mexico border. Under a 1983 bilateral agreement between the two coun-

[12] Maquiladoras are manufacturing or assembly plants located in Mexico that are owned by non-Mexican companies. Plants located near the U.S. border are often wholly owned by a U.S. company.

tries, the United States has consented to such imports if they comply with U.S. laws.

Comparability of Safety Measures

For society, managing risk and taking steps to reduce the frequency and severity of transportation accidents is partly a resource allocation problem. To make choices among competing options, decisionmakers need solid data. Some countermeasures to prevent crashes cost relatively little per life saved; others are very costly. A continuing question is how to allocate scarce resources for safety programs among and within modes.

There is considerable interest in developing common measures of safety that could be applied across modes. As detailed below, however, developing a common metric has been difficult. As previously indicated, safety is best measured as a rate, with some measure of loss (such as fatalities or injuries) normalized by a measure of activity or exposure (such as person-miles, vehicle-miles, exposure-hours, or person-trips). In reality, however, safety has many other dimensions, and is not easily measured or analyzed. The likelihood of a crash or other incident depends on many factors, not all of which can be known in advance or controlled. From a transportation-wide perspective, some aspects of safety are amenable to performance comparisons across different modes, while others are unique to a particular mode.

To compare safety trends among different modes, and to assess the safety of the overall transportation system, analysts need consistent and, where possible, comparable data. Data-collection procedures are highly variable and decentralized, often inconsistent and hard to compare across modes. The effort by federal agencies to develop more consistent and comparable safety measures is discussed in box 3-1.

Consistency can sometimes be achieved by consensus, although this can take time to achieve, while full comparability among different data sources is not always possible. For example, while fatality counts have long been a basic measurement of safety performance, it was not until May 1994 that all federal agencies began to use the same time period after a transportation crash or incident to attribute a death to that crash or incident. Some U.S. private groups and safety agencies in other countries continue to use different time periods to tally deaths from injuries sustained in transportation crashes.

Data about injuries and property damage are harder to standardize, and reporting agencies use different starting points for counting them. For injuries, even if agencies use a common threshold, a wide range of severity exists above the threshold. Thus, two agencies might report similar numbers that hide different distributions of severity of injury, making comparison difficult.

No single measure of exposure is equally suited for all modes. For example, for air travel, fatal crashes are more common during takeoff and landing, so the number of trips (departures) is a better measure of exposure than person-miles, while for road transportation, person-miles or vehicle-miles are better measures of exposure. Yet, for comparing safety across modes, person-miles of air travel per fatality or person-hours per fatality is also important. Comparability problems remain even if several measures—fatalities alone, or fatalities plus injuries, or these measures per person-mile, per person-trips, or per person-hours of exposure—are used.

Box 3-1.

The Federal Safety Measurement Working Group

The Safety Measurement Working Group was set up by the Department of Transportation (DOT) to develop improved ways to measure transportation safety, as called for by the National Performance Review initiated by Vice President Albert Gore in late 1993.[1] In June 1994, the group was expanded to include representatives from other agencies besides DOT.

The group developed consensus on some measures of safety across agencies, such as a 30-day period after an accident for a death to count as transportation-related. The group concluded that fatalities are the only universally collected, unambiguous loss measure.

In 1995, the group recognized the lack of uniformity among the modal administrations in collecting and reporting safety data, including:

- different severity thresholds for reporting injuries;
- different scales for measuring injury severity;
- different types of information on injuries collected;
- different dollar thresholds for reporting property damage;
- different types of information on property damage collected; and
- different measures of exposure.

It called attention to issues of comparability and reliability of data across modes, particularly when data are self-reported by the industry or other interested parties, and noted that training and priorities of police and other accident investigators could affect data quality.

[1] The National Performance Review called on DOT to develop and achieve agreement on common governmentwide measures of safety. It encouraged other federal agencies to join DOT in efforts to increase standardization of safety data throughout the government. It urged DOT to establish the benchmark to identify the actions that will offer the greatest and most economical safety improvements on a systemwide basis. It also urged DOT to establish user groups representing both internal and external customers as a step toward improving data quality on a continuing basis.

SOURCES:

U.S. Department of Transportation, Office of the Secretary of Transportation. 1994. *Findings of the Working Group on Current Measures of Transportation Safety.* Washington, DC.

_____. 1995. *Report to the Vice President from the Secretary of Transportation: Progress of the Working Group on Safety Measurement, in Response to Recommendation DOT01 from the National Performance Review.* Washington, DC.

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Economic Costs

Information about the economic costs of accidents varies greatly by mode. Most DOT modal administrations keep some information about property damages from crashes and other incidents, but the breadth of these data vary, and reporting thresholds are quite dissimilar (see table 3-9). For example, FAA has a reporting threshold of $25,000 for damage other than to the aircraft, and the Coast Guard has a reporting threshold of $500 for recreational boating accidents.

Developing a single comprehensive cost measure across modes could be impractical. The only common measure is dollars, and to arrive at a dollar cost for the sum total of fatalities, injuries, property damage, and environmental damage for an accident would entail a major analytical effort, and considerably more information than is now collected. It would be useful, however, to have additional information on the total economic costs of accidents on a mode-by-mode basis.

Compared with other types of transportation accidents, motor vehicle crashes are common events. Per crash, the cost is low compared with crashes or accidents in some of the other modes, but taken cumulatively, society bears a large burden. Although NHTSA does not collect information on the costs of individual crashes, it has estimated the overall economic costs of motor vehicle crashes. NHTSA estimated a $150.5 billion economic cost for motor vehicle crashes in 1994 and $137.5 billion in 1990. Property damage accounts for slightly over one-third of these costs (see figure 3-5). NHTSA classifies accidents in two major categories: those with property damage only, and those with personal injury, the latter further classified by severity.

Systematic data on property damages from air accidents are not collected, aside from an insurance claim database in London (Air Claims) that deals only with the aircraft itself. Salvage operations to recover the cockpit voice and flight data

Table 3-9.
Property Damage Reporting Thresholds, by Department of Transportation Modal Administration

Mode	Reporting threshold
Federal Aviation Administration	>$25,000 damage to property other than the aircraft
Federal Highway Administration	States report on trucks and buses, using specified elements and common thresholds
Federal Railroad Administration	>$6,300 in damages to railroad ontrack equipment, signals, track, track structures, and roadbed
National Highway Traffic Safety Administration	No reporting requirements for individual accidents
Federal Transit Administration	>$1,000 (SAMIS)
Research and Special Programs Administration	>$50,000 for gas pipelines, liquid pipelines, and hazardous materials
U.S. Coast Guard	>$25,000 for commercial vessels >$500 for recreational boats

SOURCES: U.S. General Accounting Office. 1994. *Transportation Safety: Opportunities for Enhancing Safety Across the Modes*, GAO/T-RCED-94-120. Washington, DC. p. 13.
U.S. Department of Transportation, Federal Transit Administration.1996. *Safety Management Information Statistics,* DOT-FTA-MA-26-0009-96-2. Washington, DC.

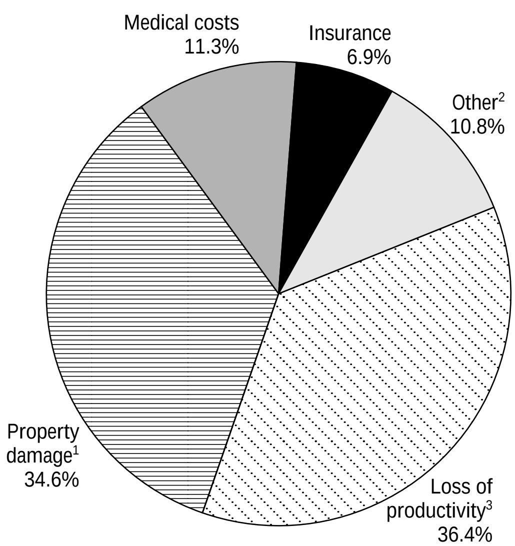
recorders and other evidence from the crash site can be very costly. For example, NTSB estimated a $675,000 recovery cost for these recorders in the Caribbean crash of February 1996, and over $1.4 million for the entire salvage operation. (US House 1996a) This pales in comparison with the 1996 ValuJet crash in the Everglades and the salvage operations for TWA flight 800. The combined costs were well over $25 million by late 1996, and are likely to be the most expensive commercial air salvage operations in history.

The Federal Railroad Administration tracks property damages over $6,300. Data from 1990 to 1995 show annual property damages ranging from a low of $119 million in 1992 to a high of $210 million in 1991. (USDOT BTS 1996a, 145) Per million train-miles, reportable damages averaged $287,000 over the same period. (USDOT FRA 1995)

Marine accidents, while rare, can result not only in loss of life, but also costly damage to ships, cargo, surrounding infrastructure, shoreline property, and the environment. Cleanup is usually expensive. For example, the ramming of the Sunshine Bridge in Tampa by a bulk carrier in 1980 caused 35 deaths when a bus and 7 cars fell into the water, plus $30 million in damage to the bridge and $1 million in damages to the vessel. (NTSB 1981)

Data-collection problems for recreational boating accidents are well known, with many accidents never reported. For 1994, about 11.4 million boats were registered, although some estimates put the number of boats at almost twice that level. An average of about 6,500 accidents per year were reported between 1990 and 1994, but the preliminary number for 1995 jumped to 8,686. Recent Coast Guard data

Figure 3-5.
Economic Costs of Motor Vehicle Crashes: 1994
(Based on $150.5 billion)



[1] Includes damage to vehicles, cargo, and roadways.
[2] Legal, workplace cost, and miscellaneous.
[3] Labor market and household.

SOURCE: L.J. Blincoe. 1996. *The Economic Cost of Motor Vehicle Crashes.* Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration.

show annual property damages at about $25 million, putting average damages at about $3,800 per reportable and reported accident. (USDOT BTS 1996a, 150)

Property damage for gas pipelines includes, but is not limited to, damage to the operator's facilities and to the property of others, gas lost, facility repair and replacement, leak locating, right-of-way cleanup, and environmental cleanup and damage. For hazardous liquid pipelines, property damage includes the cost of the commodity not recovered, damage to other parties, and the cost of cleanup. In 1995, total damages for gas transmission and distribution amounted to nearly $21 million ($10 million for transmission, $11 million for distribution), while hazardous liquid pipelines reported $32.5 million in damages. Over the past decade, the average damage from pipeline incidents has fluctuated widely, from well under $50,000 (1985, liquid) to nearly $500,000 (1994, gas).[13] (USDOT BTS 1996a, 153)

Data kept by RSPA break out each incident involving hazardous materials by mode and damages.[14] Between 1971 and 1995, trucks accounted for almost 90 percent of all incidents, and about two-thirds of all damages. Rail accounted for about 30 percent of all damages. In the same period, damages resulting from hazardous materials incidents totaled just under $500 million. Looking at the data on a per-incident basis tells a different story. Water transportation, at less than 1 percent of all incidents, has, on average, the most expensive hazardous materials accidents.

DATA NEEDS AND ANALYTICAL TOOLS

There is a sizable body of data with which to track trends in transportation safety. Generally, the data are quite detailed for highway safety and for modes involving commercial passenger transport. Significant data needs remain, however. Filling these needs could help inform decisionmaking on safety.

One problem facing safety analysts is the uneven quality of exposure data. As discussed earlier in the chapter, accident rates can be a useful measure of changes in transportation safety over time, but good rate data require good exposure data. Good exposure data are also a prereq-

[13] These estimates may be conservative. NTSB believes that the value of property losses reported to the DOT Office of Pipeline Safety are understated. For example, some accident reports may specify that damage occurred, without recording the value of the damages. In addition to damaging real property, excavation-caused accidents result in significant but unestimated losses from service outages, traffic rerouting, and other disruptions to community life. (NTSB 1996a, 1)

[14] Hazardous materials incidents are any release of hazardous materials whether or not they involved a derailment, collision, rollover, or other event. Property damage figures include product loss, carrier loss, property damage, and other.

uisite for meaningful comparisons across modes. Although there are fairly reliable estimates for the sum total of all highway vehicles, crash rate statistics are sketchy for some types of vehicles, such as multiple-trailer combination trucks. Exposure data for recreational boating and for the transportation of hazardous materials are too sketchy to be of much use.

Analyses of safety trends for nonmotorized modes—bicycling and walking—suffer from the absence of meaningful exposure measures (such as hours of exposure to traffic). Moreover, bicyclists and walkers often take trips too short in length to be counted in national surveys. Also, trips that begin and end at a residence, without an intermediate stop, are not counted, thus excluding much recreational bicycling or walking (see box 7-3 in chapter 7 for further discussion of nonmotorized travel). There is also inadequate trip data about children under five years of age, thus making evaluation of their exposure to risk difficult.

Even if an overall exposure measure for transportation safety is developed, analysts will need to continue to select appropriate data for the application at hand. For example, air carrier rates could be reported on a per-aircraft-departure (trip) basis or a per-aircraft-mile basis, whichever is best for a particular application. The per-trip basis is the most appropriate for air, because most airline accidents occur during takeoff or landing. There is, however, a distinct correlation for air carriers between fatalities per aircraft-mile and fatalities per trip[15] (see figure 3-1), although, of course, there is no correlation in the risk of fatality between the two measures for any given trip. For recreational boating, rates are best shown per exposure-hour.[16]

[15] This is because the average trip length for air carriers has changed very slowly.

[16] The Coast Guard does not collect exposure data for recreational or commercial water traffic. Some exposure data are available for waterborne transportation. The U.S. Army Corps of Engineers collects data on U.S. vessels involved in domestic trade in U.S. waters. The Bureau of the Census collects data on U.S. and foreign vessels involved in foreign trade with domestic ports.

For pipeline, analysts could use a measure like gallon-miles, because the risk of an accident is proportional to the amount of flammable gas or liquid transported and the distance it is carried.

Improved methods for intermodal safety comparisons are needed, particularly methods based on modal similarities. For most types of analyses, it is better to group passenger modes and freight modes separately. Highway and rail modes can generally be compared on a vehicle-mile or passenger-mile basis. The Federal Highway Administration and NHTSA calculate highway passenger-miles by applying an occupancy rate to vehicle-miles. Passenger-mile data for transit and intercity rail is generally good. The American Travel Survey (ATS), conducted by the Bureau of Transportation Statistics (BTS) with the Census Bureau, will supplement passenger data when its statistics begin to be released in 1997. Results from the 1995 Nationwide Personal Transportation Survey (NPTS) also are expected soon, and will provide much new information on personal travel. (See chapter 7 for a discussion of the results of prior NPTSs.)

Despite interest in developing a common measure of safety, there is a continuing need for a concise compilation of mode-by-mode safety statistics, including data presenting several rates appropriate to the specific mode. Statistics also need to be continually compiled for crashes involving two modes of transportation, such as highway vehicles and trains at grade crossings. Better information is also needed about safety incidents involving freight and passenger modes, which often share the same road or facility, but have their own set of risks.

Appropriate measures are needed for comparing the costs of incidents across the freight modes. Modal differences in the types of cargo carried need to be taken into account. For example, rail carries many bulky, heavy, lower value items such as coal, cement, and grain. Waterborne vessels carry oil, containerized goods, and bulk items, and are often moved in international trade. Trucks carry a mixed range of cargo, and are often on a tight schedule required to meet just-in-time delivery systems increasingly used by manufacturers. Air cargo tends to be time sensitive, lighter, and higher value. All four modes at times carry hazardous materials, but each presents its own risk profile and risk factors.

Data from the 1993 Commodity Flow Survey (CFS) and the 1995 ATS and NPTS will supply much-needed information about where goods and people are transported by mode, and could improve the ability to make estimates of exposure. The CFS identifies the types of goods being moved, and the portion of shipments that are hazardous. BTS is also working with the Census Bureau to improve estimates of truck travel by type of truck, as part of the Truck Inventory and Use Survey (TIUS). (The CFS and TIUS are discussed in more detail in chapter 9.) The ATS will measure long-distance trips made by a sample of U.S. households by type and purpose. In addition, the 1995 NPTS will provide detailed information about daily travel of individuals.

With state governments assuming increasing responsibility for safety, standardizing and computerizing local, state, and national safety databases is an important issue. Greater standardization across modes and across the country on basic measures of loss would help. Examples include injury and accident reporting thresholds, how injuries to crews and operators and to pedestrians and other people not in a vehicle can be counted, and how double-counting in intermodal accidents can be avoided.

As resources available for improving transportation safety are limited, a key question is what safety strategies can bring the greatest benefits to the traveling public. This question is important for all modes, but especially on the highways where most transportation fatalities occur.

As mentioned earlier, a dramatic improvement in highway safety has occurred in the last quarter century. More recent data makes clear that the rate of accidents, injuries, and fatalities per vehicle-mile have all decreased since 1988. It is not clear, however, how much of the decreasing highway fatality and injury rates is attributable to fewer and/or less severe crashes, how much to a decreased likelihood of injury and/or to less severe injuries in a crash, and how much to better post-crash medical intervention. An analysis of data that classifies injuries by severity would help bring more clarity. Few states, however, reliably report injury data by severity, and those that do, use different standards.

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Transportation, Energy, and the Environment

Moving people and goods requires more than one-quarter of total U.S. energy use and two-thirds of U.S. petroleum consumption. Despite recent inroads by alternative fuel vehicles (AFVs) and greater blending of alcohols and ethers with gasoline to produce cleaner fuel, transportation continues to be nearly totally dependent on oil for energy. Almost half of that petroleum must now be imported, raising concerns about the possibility of supply disruptions and price increases. The transportation sector appears to have reached the end of a 20-year period of steadily improving energy efficiency. Although air and rail modes continue to show efficiency gains, the energy efficiency of highway transportation, which uses almost four-fifths of all transportation energy, seems to be declining, outweighing the gains of air passenger travel and rail freight movements.

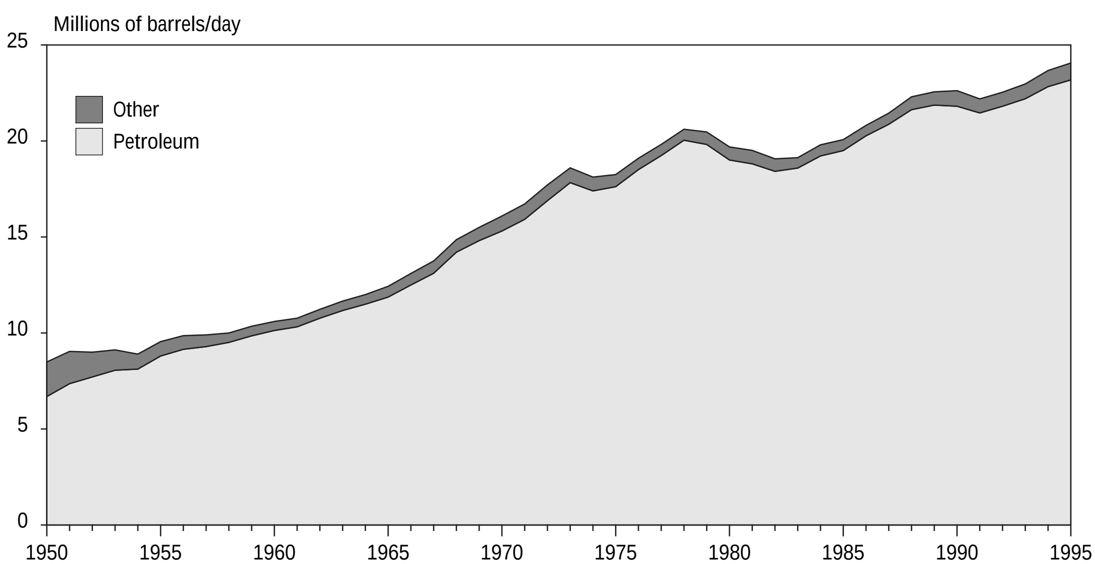
Transportation is also responsible for a substantial share of the air pollution problem in the United States, accounting for two-thirds of the carbon monoxide (CO), 42 percent of the nitrogen oxides (NO_X), and nearly one-third of the hydrocarbons (HC) produced from all sources. (USEPA OAQPS 1996) Emissions control measures stemming from the 1970 Clean Air Act and its 1977 Amendments reduced emissions from transportation sources during the past two decades in spite of steadily increasing transportation activity. The 1990 Clean Air Act Amendments (CAAA) promulgated several new strategies for further reducing emissions from transportation, some of which are discussed in this chapter.

This chapter focuses on the key energy and environmental problems and developments relating to transportation: cessation of energy efficiency improvements, use of alternative and replacement fuels, growing dependence on imported oil, air pollution and other environmental impacts, and pollution control measures and their costs. Other important environmental impacts of transportation such as water contamination, solid waste production, noise, and land use are also discussed. The chapter also identifies energy and environmental data gaps and discusses the state of the knowledge about several transportation-related environmental impacts.

Energy Use

Transportation energy use in the United States continues to increase (see figure 4-1). In 1995, the energy required to power the U.S. transportation system increased by 1.7 percent to 24.96 quadrillion Btu (quads). (USDOE EIA 1996a, table 2.1) This is consistent with the rate of growth since 1985, which has averaged 1.8 percent annually. From 1949 until the first oil price shock in 1973, transportation energy use grew at precisely twice that rate. Between 1973 and 1985, transportation energy use grew at only 0.6 percent per year, as supply shocks and higher prices dampened demand and inspired significant improvements in energy efficiency. Such major changes in transportation energy efficiency take more than a decade to accomplish because of the time needed to redesign new vehicles and turn over the existing stock. Thus, efficiency gains prompted by the oil price shocks of the 1970s were, until recently, still restraining the growth of transportation energy use. A decade after the collapse of world oil prices in 1986, the steady improvement in transportation energy efficiency that occurred in the 1970s and 1980s appears to have come to a halt. A close exami-

Figure 4-1.
Transportation Energy Use: 1950–95



SOURCE: U.S. Department of Energy, Energy Information Administration. 1996. *Annual Energy Review 1995.* DOE/EIA-0035 (96/09). Washington, DC. July.

nation of fuel economy trends for passenger cars and other light-duty vehicles, which account for half of transportation energy use, reveals that increasing horsepower and weight across this class of vehicles, rather than the popularity of light trucks, account for the stagnation of efficiency improvements.

For decades, the U.S. transportation system has been overwhelmingly dependent on petroleum. Recent energy and environmental legislation spawned a small but rapidly growing trend of alternative and replacement use. Despite this, transportation relies on oil for 95 percent of its energy needs. At the same time, petroleum prices remain volatile, as was proven in spring 1996 when U.S. gasoline prices suddenly jumped by 20¢ per gallon, and U.S. oil imports were nearing a record high.

Energy Efficiency

Transportation energy efficiency in the United States was down slightly in 1994 (the most recent year for which detailed data are available) (see figure 4-2). Some modes improved, but their gains were more than offset by an apparent 5 percent increase in the energy required per passenger-mile of highway travel. The data suggest that the cause is fewer occupants per vehicle, but uncertainties about the vehicle occupancy data preclude firm conclusions. Bus and rail transit also appear to show lower energy efficiency, but commercial air travel and intercity rail improved.

For the first year since 1985, Divisia analysis[1] of energy efficiency trends shows a decline in cumulative energy savings for transportation between 1993 and 1994. The overall trend in transportation energy efficiency, analyzed using the Divisia method, is illustrated in figure 4-3. The solid line shows actual energy use, and the dashed line projects energy use had the efficiency and modal structure in 1972 remained constant. Bars below the lines depict the cumulative effects of these factors.

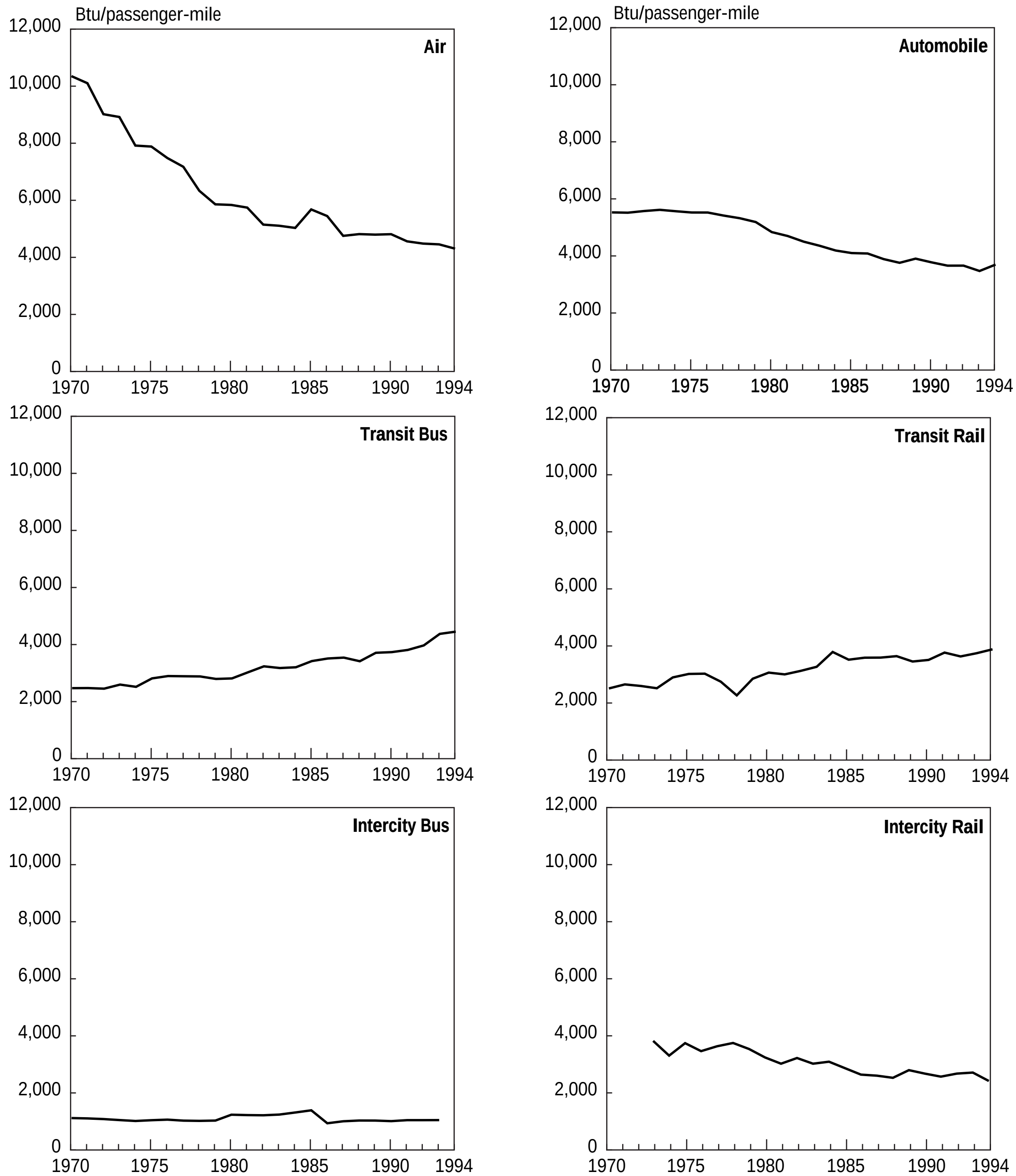
The highway mode dominates U.S. passenger travel and energy efficiency trends, with 86.7 percent of all passenger-miles. Energy use per highway passenger-mile increased by about 1 percent from 1993 to 1994, as declining vehicle occupancy rates and the continuing shift from passenger cars to light trucks more than offset a small gain in vehicle-miles per gallon (see figure 4-4). In 1994, light trucks accounted for 21 percent of highway passenger-miles. The effect of declining occupancy rates was about five times as large as the effect of modal shares.

The energy efficiency of air travel once again improved, continuing an unbroken 22-year trend. Without the cumulative gains in load factors and efficiency gains due to technological improvements of the past two decades, energy use would have been two times higher than it was in 1994. Although load factors increased and energy use per seat-mile fell, total energy use in air transportation is growing 2.3 percent annually. (Davis and McFarlin 1996, table 2.14) Air travel accounts for 9 percent of U.S. passenger-miles.

Freight transportation uses slightly more energy per ton-mile today than it would if energy use per ton-mile had not changed since 1972. Gains in modal energy efficiencies of about 10 percent were offset by shifts to more energy-intensive modes. Still, freight energy use has been growing at only 1.8 percent annually, less than the 2.7 percent increase in gross domestic product (GDP) over the same period. As the economy has

[1] Divisia analysis is a mathematical technique used to apportion changes in total transportation energy use (or emissions) among causal factors: 1) growth in transportation activity (e.g., passenger-miles and ton-miles), 2) changes in the rates of energy use (or emissions) per unit of activity, and 3) changes in the modal structure of transportation activity (e.g., the relative share of activity by mode). The Divisia method is described in detail in USDOT BTS (1996) and in Greene and Fan (1994).

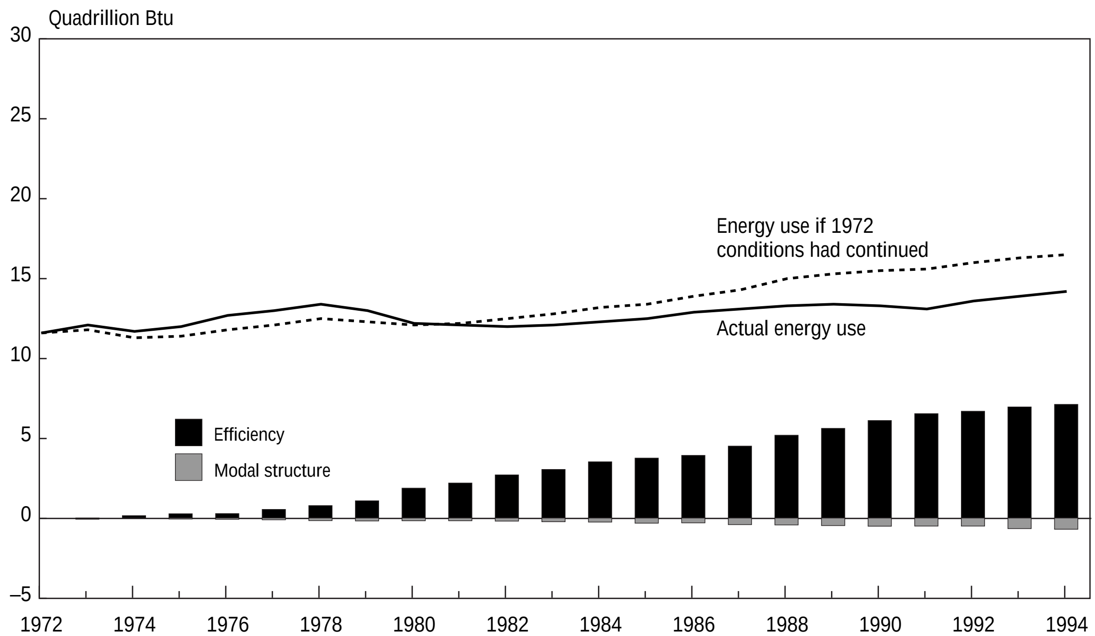
Figure 4-2.
Energy Intensity of Passenger Travel by Mode: 1970–94



NOTE: Transit rail is defined as the sum of heavy and light rail. Heavy rail is also known as subway, elevated railway, or metropolitan railway (metro). Light transit rail includes streetcars, trolley cars, and tramways. Data for intercity buses for 1994 are not available.

SOURCE: S.C. Davis and D.N. McFarlin. 1996. *Transportation Energy Data Book, Edition 16*, ORNL-6898. Oak Ridge, TN: Oak Ridge National Laboratory. Table 2.16.

Figure 4-3.
Changes in Transportation Energy Use: 1972–94
Efficiency and Modal Structure Effects



SOURCE: S.C. Davis and D.N. McFarlin. 1996. *Transportation Energy Data Book, Edition 16,* ORNL-6898. Oak Ridge, TN: Oak Ridge National Laboratory. Methodology found in D.L. Greene and Y. Fan. 1994. *Transportation Energy Efficiency Trends, 1972–1992.* Oak Ridge, TN: Oak Ridge National Laboratory. December.

been "dematerializing" (producing fewer tons per dollar of GDP), the demand for freight services also seems to be shifting toward faster, more flexible but more energy-intensive transportation systems.

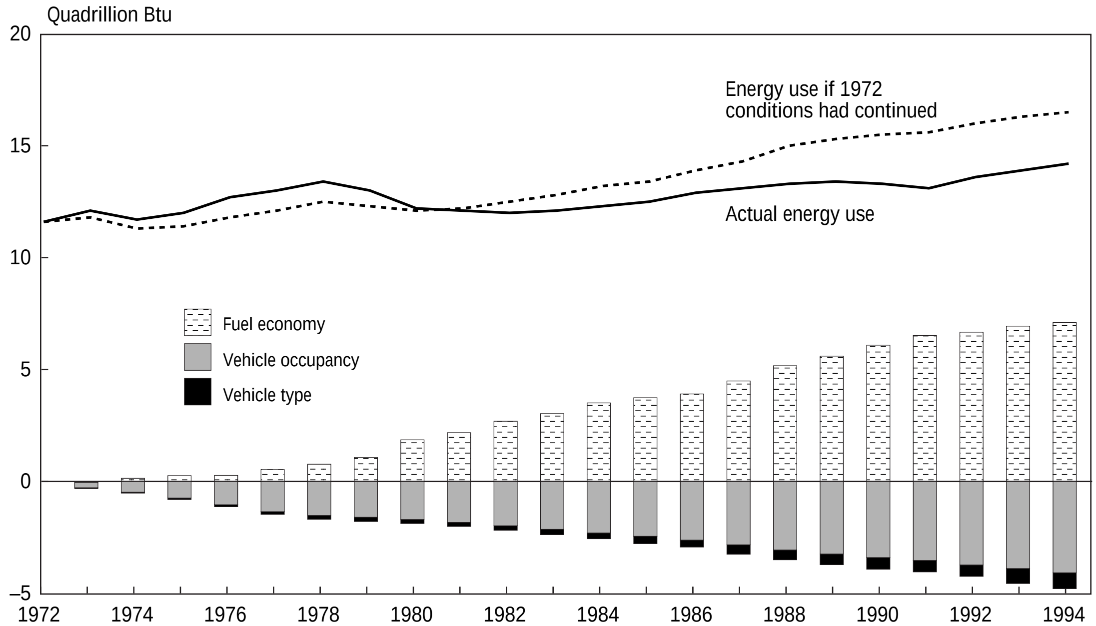
Energy savings by rail freight increased by 0.03 quads (8 percent), thanks to an equivalent increase in load factors. Rail freight energy intensities also have improved steadily for two decades. Many factors have contributed to efficiency gains, including operating practices that have greatly reduced engine idling and improved train pacing, lighter weight cars and new locomotive technology, and abandonment of light density and circuitous routes.

Passenger Car and Light Truck Market Trends and Fuel Economy

The boom in light truck[2] sales since 1980 is often cited as a major reason for the continued growth of motor fuel use. Light trucks, which get three-quarters the miles per gallon (mpg) of passenger cars, went from a low of 16.5 percent of light-duty vehicle[3] sales in 1980 to 40.4 percent in 1996, because of the success of minivans, sport utility vehicles, and larger pickup trucks. While passenger car mpg was 80 percent higher in 1996 than in 1975 (28.5 mpg v. 15.8 mpg), light truck mpg was up only 50 percent (from 13.7

[2] As defined here, a light truck includes pickup trucks, vans, and sport utility vehicles of less than 8,500 pounds manufacturer's gross vehicle weight rating.
[3] Light-duty vehicles are light trucks and passenger cars.

Figure 4-4.
Changes in Highway Passenger Use: 1972–94
Efficiency, Occupancy, and Vehicle Type Effects



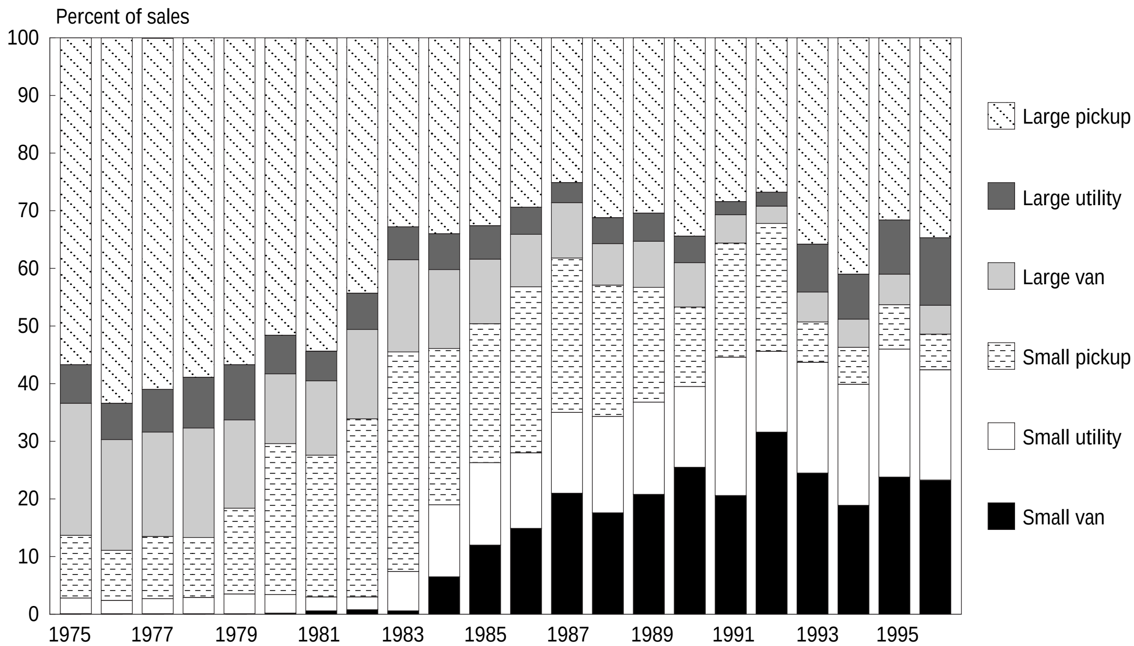
SOURCE: S.C. Davis and D.N. McFarlin. 1996. *Transportation Energy Data Book, Edition 16,* ORNL-6898. Oak Ridge, TN: Oak Ridge National Laboratory. Methodology found in D.L. Greene, and Y. Fan. 1994. *Transportation Energy Efficiency Trends, 1972–1992.* Oak Ridge, TN: Oak Ridge National Laboratory. December.

mpg to 20.5 mpg). (Heavenrich and Hellman 1996, table 1)

A detailed analysis of recently published fuel economy and sales data, however, reveals that the big move to light trucks played a very minor role in overall light-duty vehicle mpg trends. (Heavenrich and Hellman 1996) This is due primarily to two factors: fleet average mpg is relatively insensitive to market share; and as consumers switched from cars to light trucks, they chose predominantly smaller, "car-like" light trucks, such as minivans and smaller sport utility vehicles. Thus, changes in the market shares of vehicle size classes within the passenger car and light truck market segments, combined with the shift from passenger cars to light trucks, have had a negligible effect on overall light-duty vehicle mpg.

Light trucks comprise six classes: small and large categories of pickups, vans, and sport utility vehicles. In 1975, small pickups, vans, and sport utility vehicles accounted for only 13.6 percent of the light truck market. In 1996, however, small light trucks accounted for nearly half of all light truck sales (see figure 4-5). Had the sales mix of light trucks remained constant at 1975 levels, light truck mpg would have been only 18.3, instead of the 20.5 actually achieved. At the same time, shifts among passenger car size classes had a small but positive effect on average new car mpg. Had the sales mix among size classes not changed, average new passenger car mpg would have been 28.3 instead of 28.5. Considering all changes (among passenger car classes, among light truck classes, and between cars

Figure 4-5.
Light Truck Market Shares by Size Class: 1975–96



SOURCE: R.M. Heavenrich and K.H. Hellman. 1996. *Light-Duty Automotive Technology and Fuel Economy Trends Through 1996,* EPA/AA/TDS/96-01. Ann Arbor, MI: U.S. Environmental Protection Agency, Office of Mobile Sources.

and trucks), the net effect of sales mix shifts turns out to be very small and slightly beneficial. Without any sales mix shifts among vehicle classes new light-duty vehicle mpg would have been 24.3 in 1996. In fact, it was 24.5 mpg.

In recent years, potential mpg gains from new, more efficient technologies have been offset by increased vehicle weight and performance. (Heavenrich and Hellman 1996, table 1) Average light-duty vehicle weight increased from 3,200 pounds in 1982 to nearly 3,700 pounds in 1996. Over the same period, horsepower per pound increased by 40 percent, resulting in a 25 percent faster acceleration time for vehicles going from 0 to 60 miles per hour. Without the increases in weight and performance, 1996 model year cars would have averaged 33.3 mpg instead of 28.5 mpg, and light trucks would have gotten 25.3 mpg instead of 20.4 mpg. Overall, light-duty vehicle fuel economy would have been 4.9 mpg (20 percent) higher than it was in 1996. (Heavenrich and Hellman 1996, 10)

Alternative and Replacement Fuels

The Energy Policy Act of 1992 and the CAAA gave a boost to AFVs and greatly increased the use of replacement fuels (alcohols and ethers) in gasoline. Since 1992, the number of AFVs on America's highways has grown by two-thirds, and blending of nonpetroleum components in gasoline has doubled. As discussed below, the small but notable change in the composition of modern gasolines has decreased (albeit by a small amount) the transportation sector's dependence on petroleum for the first time since 1960 (USDOE EIA

1996b, table 2.1), and may point the way to reducing future petroleum dependence.

The number of AFVs, other than those running on liquefied petroleum gases (LPG), tripled in the three years from 1992 to 1996 (see table 4-1). Despite this growth, AFVs account for less than 0.2 percent of the 193 million cars and light trucks (pickup trucks, minivans, and sport utility vehicles) in the United States in 1995. LPG vehicles have always been the most prevalent type of AFV. Their popularity antedates policies to promote alternative fuels in the United States. A relatively small percentage of predominantly light trucks have taken advantage of the lower cost of LPG, their numbers waxing and waning with the relative cost advantage of the fuel. Among the other AFVs, compressed natural gas (CNG) vehicles are the most popular to date. CNG vehicles accounted for more than two-thirds of all non-LPG AFVs in 1995. Vehicles running on M85 (a mixture of 85 percent methanol and 15 percent regular, unleaded gasoline) have historically been the second most popular non-LPG AFV type. (USDOE EIA 1996a)

Alternative fuel use has grown in proportion to the expansion of the vehicle fleet. From 1992 to 1996, alternative fuel use increased from 229.6 million gallons of gasoline equivalent energy (GGE) to 300.0 million GGE (see table 4-2). Most of this was LPG, 91 percent in 1992 and 80 percent in 1996. Still, alternative fuels comprise a tiny fraction of total motor vehicle fuel use: 0.17 percent in 1992 and 0.21 percent in 1996, LPG included. (USDOE EIA 1996a)

Replacement fuels—alcohols and ethers (oxygenates) blended with gasoline to meet the requirements of the 1990 Clean Air Act—comprise a far larger proportion of the motor fuel market than

Table 4-1.
Alternative Fuel Vehicles by Fuel Type: 1992–96

	Number of vehicles				
Fuel used	**1992**	**1993**	**1994**	**1995**	**1996**
Total	251,352	314,848	324,472	333,049	356,533
Liquefied petroleum gases[1]	221,000	269,000	264,000	259,000	266,000
Non-LPG subtotal	30,352	45,848	60,472	74,049	90,533
Compressed natural gas	23,191	32,714	41,227	50,218	62,805
Liquefied natural gas	90	299	484	603	715
Methanol, 85%[2]	4,850	10,263	15,484	18,319	19,636
Methanol, 100%	404	414	415	386	155
Ethanol, 85%[2]	172	441	605	1,527	[3]3,575
Ethanol, 95%	38	27	33	136	341
Electricity	1,607	1,690	2,224	2,860	3,306
Fuel unknown	U	140	U	U	U

[1] The Energy Information Administration (EIA) rounds its liquified petroleum gases estimates to the nearest thousand.
[2] The remaining part of 85 percent methanol and ethanol fuels is gasoline.
[3] EIA estimate, based on the planned introduction by General Motors of a line of flexible-fuel pickup trucks designed to use ethanol 85 or gasoline.

KEY: U = data are unavailable.

SOURCE: U.S. Department of Energy, Energy Information Administration. 1996. *Alternatives to Traditional Transportation Fuels 1994,* DOE/EIA-0585(95). Washington, DC. December. Table 1.

Table 4-2.
Estimated Consumption of Vehicle Fuels in the United States: 1992–96

(Thousand gallons of gasoline-equivalent energy)

Fuel	1992	1993	1994	1995	1996
Total fuel consumption[1]	**134,230,631**	**135,912,964**	**139,847,642**	**143,019,659**	**145,634,964**
Traditional fuels					
Total	**134,001,000**	**135,619,630**	**139,566,490**	**142,741,750**	**145,334,920**
Gasoline[2]	110,135,000	111,323,000	113,144,000	115,943,000	117,768,000
Diesel	23,866,000	24,296,630	26,422,490	26,798,750	27,566,920
Alternative fuels					
Total	**229,631**	**293,334**	**281,152**	**277,909**	**300,044**
Liquefied petroleum gases	208,142	264,655	248,467	232,701	238,681
Compressed natural gas	16,823	21,603	24,160	35,162	58,884
Liquefied natural gas	585	1,901	2,345	2,759	3,233
Methanol, 85%[3]	1,069	1,593	2,340	3,575	3,832
Methanol, 100%	2,547	3,166	3,190	2,150	360
Ethanol, 85%[3]	21	48	80	190	436
Ethanol 95%[3]	85	80	140	709	1,803
Electricity	359	288	430	663	815
Replacement fuels (oxygenates)					
Total	1,876,000	2,829,200	2,864,700	3,592,900	3,522,000
MTBE	1,175,000	2,069,200	2,018,800	2,682,200	2,709,100
Ethanol in gasohol	701,000	760,000	845,900	910,700	812,900

[1] Total fuel consumption is the sum of alternative and traditional fuels. Replacement fuel consumption is included in gasoline consumption.
[2] Includes ethanol in gasohol and MTBE.
[3] Includes the portion of the fuel that is conventional gasoline. This is 15 percent for M85 and E85, and 5 percent for E95.

NOTE: Totals may not equal sum of components due to rounding.

SOURCE: U.S. Department of Energy, Energy Information Administration. 1996. *Alternatives to Traditional Transportation Fuels 1995*, DOE/EIA-0585(95). Washington, DC. December. Table 7.

alternative fuels, as shown in table 4-2. Unlike petroleum, which is composed entirely of hydrogen and carbon atoms, alcohols and ethers contain oxygen. In areas where CO (a product of incomplete combustion of hydrocarbon fuels) is a chronic problem, fuel providers have been required since 1992 to add oxygenates to gasoline. The presence of oxygen in fuels promotes more complete combustion of hydrocarbons to form carbon dioxide (CO_2) and water vapor.

Beginning in December 1994, areas failing to attain air quality standards for ozone were required to use reformulated gasoline (RFG).[4] RFG must contain 2 percent oxygen, by weight. These clean air requirements have had a major impact on modern gasoline. In 1992, oxygenates comprised 1.7 percent of the gasoline pool, and in 1996, they made up 3.0 percent. (USDOE EIA

[4] Gasoline is reformulated by changing the amounts of various compounds present in gasoline in order to reduce emissions.

1996c, 21) Moreover, preliminary analysis of the impacts of oxygenate use on transportation sector petroleum dependence indicates that at least 10 times more petroleum is displaced by blending alcohols and ethers with conventional gasoline than by all motor vehicles powered by alternative fuels.

From zero in 1993, RFG production increased to 688 million barrels in 1995, 24 percent of total U.S. gasoline consumption. At the same time, demand for alcohols and ethers for motor fuel skyrocketed. Use of methyl-tertiary-butyl-ether (MTBE), the most popular oxygenate, by U.S. refineries increased from just over 3 million barrels in 1992 to nearly 80 million in 1995. Also, ethanol use grew from 2 million barrels in 1981 to 23 million in 1995, due to an increase in the federal excise tax exemption of 5¢ to 5.4¢ per gallon beginning in 1983, as well as further exemptions from many state motor fuel taxes. (USDOT FHWA 1983, table FE-101; USDOT FHWA 1995, table FE-101A) Because gasohol contains 10 percent ethanol, a 5¢ subsidy to gasohol equates to a 50¢ per gallon subsidy to ethanol.

Alcohols and ethers are predominantly derived from energy sources other than petroleum. MTBE is produced via chemical combination of 33.6 percent methanol and 66.4 percent isobutylene, by volume. Although both can be synthesized in a number of ways, nearly all the refinery inputs of methanol and isobutylene used to make MTBE in the United States are obtained from natural gas. In the United States, ethanol is produced via fermentation of corn.[5] Natural gas liquids (NGLs) (e.g., pentanes, butane, and isobutane) are hydrocarbons co-produced during the extraction of natural gas, and are significant inputs to the production of gasoline. By convention, NGLs are usually counted as petroleum. (USDOE EIA 1996b) Interestingly, use of NGLs in gasoline appears to have decreased proportionately as the use of oxygenates has increased.

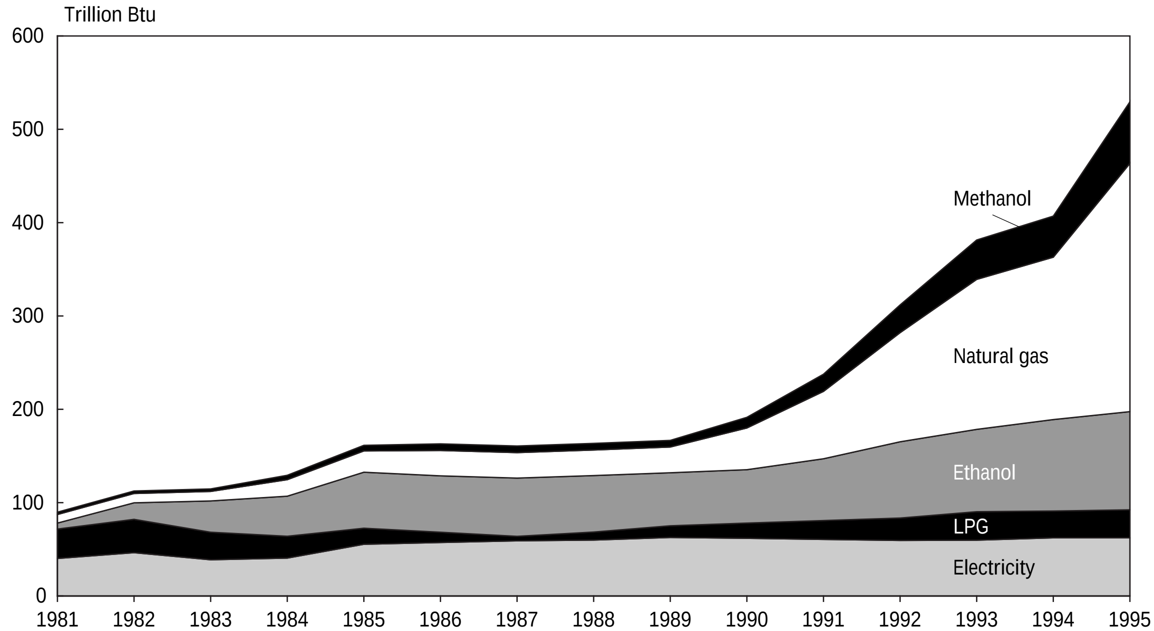
Based on available information, the nonpetroleum energy content of gasoline increased from 0.2 percent in 1981 to 3.3 percent in 1995. Primarily as a result of this, the nonpetroleum content of energy for all of transportation (excluding pipelines) increased from 0.6 percent to 2.6 percent over the same period. An initial increase from 1981 to 1985 can be attributed to the growing use of ethanol to produce gasohol (see figure 4-6). A second expansionary period from 1990 to 1993 can be attributed to mandated use of oxygenates to control CO emissions. As a result, MTBE use in refineries grew from 8.5 million barrels in 1989 to almost 80 million barrels in 1995. The RFG mandate can be credited with the final jump in 1995. Once again, MTBE was the oxygenate of choice. (USDOE EIA 2996h)

Oil Dependence

In 1996, the United States imported 46.2 percent of the petroleum required for transportation and other uses. (USDOE EIA 1996g, table 1.8) This is within 0.3 percent of the highest year of imports on record, 1977, having risen steadily from a recent low of 27 percent in 1985 (see figure 4-7). Petroleum dependence remains a concern because the world's oil reserves continue to be concentrated in relatively few countries. More than two decades after the oil price shock of 1973–74, member states of the Organization of Petroleum Exporting Countries (OPEC) still hold two-thirds to three-quarters of the world's proven oil reserves (USDOE EIA 1996d) and more than half of the world's estimated petroleum resources. (Masters et al 1994) World dependence on OPEC

[5] Significant amounts of petroleum are used in the cultivation and transportation of corn and ethanol. Upstream oil use is not considered in our calculations here.

Figure 4-6.
Sources of Nonpetroleum Transportation Energy: 1981–95



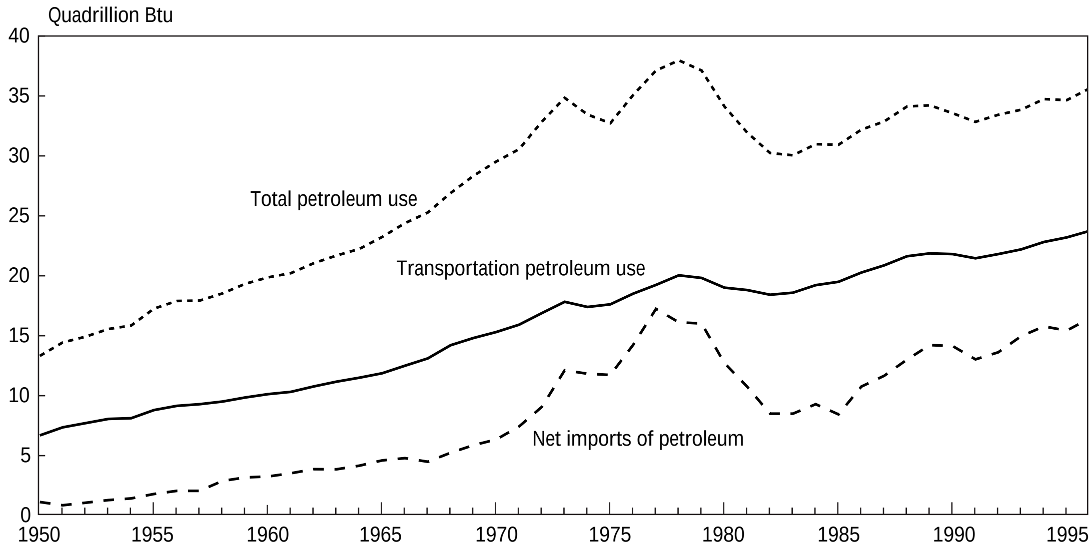
SOURCES: Methods of estimation developed by D.L. Greene. Oak Ridge National Laboratory.
Data from: 1) U.S. Department of Energy, Energy Information Administration. 1982–85 (annual volumes). *Petroleum Supply Annual,* DOE/EIA-0340(95)/1. Washington, DC. Vol. 1, tables 16 and 17.
2) U.S.Department of Energy, Energy Information Administration. 1996. *Alternatives to Traditional Fuels 1994,* DOE/EIA-0585(94)/1. Washington, DC. February. Vol. 1, table 14.
3) S.C. Davis and D.N. McFarlin. 1996. *Transportation Energy Book, Edition 16,* ORNL-6898. Oak Ridge, TN: Oak Ridge National Laboratory. July. Tables 2.10 and 5.14.

oil is expected to grow from its present level of 40 percent to 52 percent by 2010 and 56 percent by 2015 (see figure 4-8). (USDOE EIA 1996e, table 13) With an increased market share, OPEC may have greater influence on the world oil market.

Although the importance of strategic and political factors should not be underestimated, the economic threat from oil dependence is primarily a function of OPEC's market share, the importance of oil to the U.S. economy, the quantity of oil imported, and the ability of oil supply and demand to respond to price increases. The indicators discussed earlier shed light on each of these factors except the price responsiveness of supply and demand. If supply and demand are unresponsive to price, even a small supply shortage will cause prices to rise significantly. Some indication that petroleum supply and demand remain inelastic[6] is provided by the recent increase in U.S. gasoline prices in spring 1996. Although this single event is not conclusive, it suggests that over a short period of time even relatively minor supply shortfalls can cause significant increases in motor fuel prices. This appears to have happened to gasoline prices in early 1996.

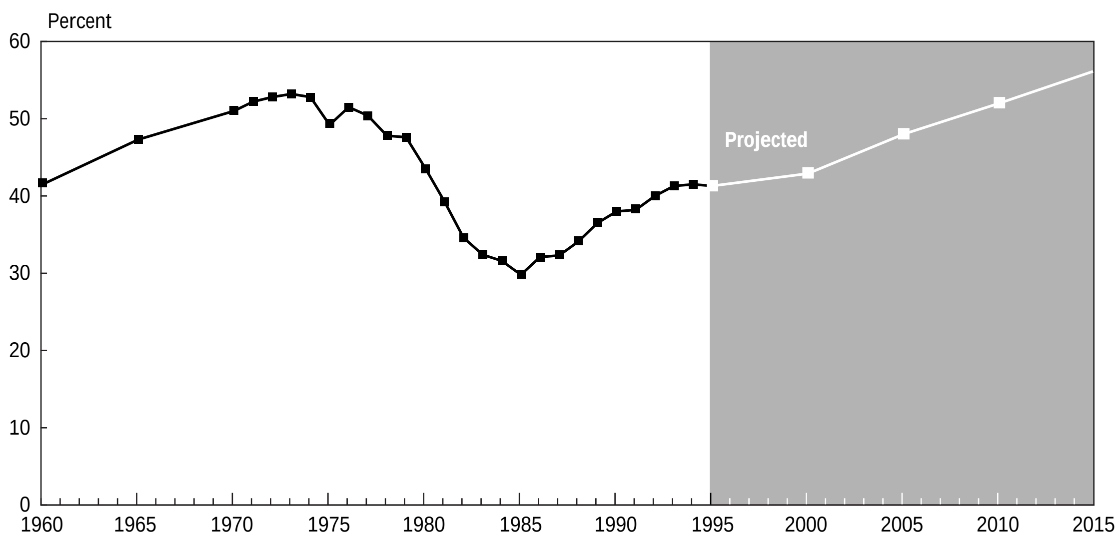
[6] Price elasticities are dimensionless measures of the price responsiveness of supply or demand. Precisely, they describe the percentage change in the quantity supplied or demanded that can be expected as a consequence of a 1 percent change in price. If supply and demand are inelastic, a large change in price will produce only a small change in quantity. Conversely, a small change in quantity supplied would cause a large increase in price.

Figure 4-7.
U.S. Petroleum Use and Imports: 1950–96



SOURCE: S.C. Davis and D.N. McFarlin. 1996. *Transportation Energy Data Book, Edition 16,* ORNL-6898. Oak Ridge, TN: Oak Ridge National Laboratory. Table 2.16

Figure 4-8.
OPEC World Oil Market Share: 1960–2015



KEY: OPEC = Organization of Petroleum Exporting Countries.

SOURCES: Data are from the following U.S. Department of Energy, Energy Information Administration documents:
1993. *Annual Energy Review 1993,* DOE/EIA-0384(93). Washington, DC. August. Tables E1, 5.18, 5.20, and 11.5.
1994. *Historical Monthly Energy Review,* DOE/EIA-0035(73-92). Washington, DC. August. Tables 10.1a and 10.1b.
1995. *Annual Energy Outlook,* DOE/EIA-0383(95). Washington, DC. Tables C1 and C20.
1996. *International Petroleum Statistics Report,* DOE/EIA-0520(96/05). Washington, DC. May. Tables 1.1 and 1.3
1996. *Monthly Energy Review,* DOE/EIA-0035(96/06). Washington, DC. June. Tables 9.1, 10.1a, and 10.1b.

Gasoline Prices in Spring 1996

U.S. average monthly gasoline prices climbed from $1.16 per gallon in December 1995 to $1.38 per gallon by May 1996, before falling to $1.28 per gallon in November 1996. Although average U.S. gasoline prices normally increase by 5¢ per gallon or so during this seasonal change, the 22¢ per gallon jump caught the public, press, and government by surprise. The Department of Energy (DOE) published a detailed analysis explaining the confluence of factors behind the price increase, from higher world crude oil prices to low stocks to a late-winter cold spell. (USDOE OPIA 1996) This section reviews these factors to provide a full picture of what happened and why.

Four principal components determine the price of gasoline:

1. the **cost of crude oil** purchased by refineries;
2. the **resale spread**, which is the difference between the refiners' price of crude oil and wholesale prices charged to distributors for gasoline;
3. the **retail spread**, which is composed of marketing and distribution costs and retail mark-ups; and
4. federal, state, and local taxes.

The cost of crude oil has a significant effect on gasoline prices. Average prices of crude oil to U.S. refineries increased from $17.57 per barrel in December 1995 to $21.60 and $20.63 per barrel in April and May 1996, respectively. The crude oil price component rose from 41.8¢ per gallon in January to 51.4¢ in April and 49.1¢ in May.[7]

The Energy Information Administration (EIA) attributes the increase in crude oil prices to an imbalance of oil supply and demand precipitated by a combination of low stocks and speculation about Iraq's return to the world oil market. (USDOE OPIA 1996, 3–4) It is believed that widespread, sustained cold winter weather caused an initial drawdown of crude oil stocks among the Organization for Economic Cooperation and Development countries. The resulting 251 million barrel reduction in stocks was the largest drop during the previous five years. At the same time, OPEC countries were producing close to their self-imposed quotas, causing a tightening of world oil markets and a slight rise in prices, from $17.57 in December 1995 to $19.71 in March 1996. Despite a late cold wave in February and March, buyers did not rebuild stocks, probably because they expected Iraq to be allowed to resume selling oil on world markets at the rate of perhaps 1 million barrels per day (mmbd) early in 1996. (USDOE OPIA 1996)

According to EIA, the world oil market expected a further increase in supplies from the North Sea region (Norway and Great Britain), but this did not occur. North Sea production declined slightly from 5.89 mmbd in the last quarter of 1995 to 5.82 mmbd in the first quarter of 1996. (USDOE EIA 1996f, table 1.1) The combination of low inventories and the surge in demand brought about by persistent winter weather is believed to have been responsible for driving prices to $21.60 per barrel in April. This change in world oil markets accounted for 44 percent of the increase in retail gasoline prices in that month.

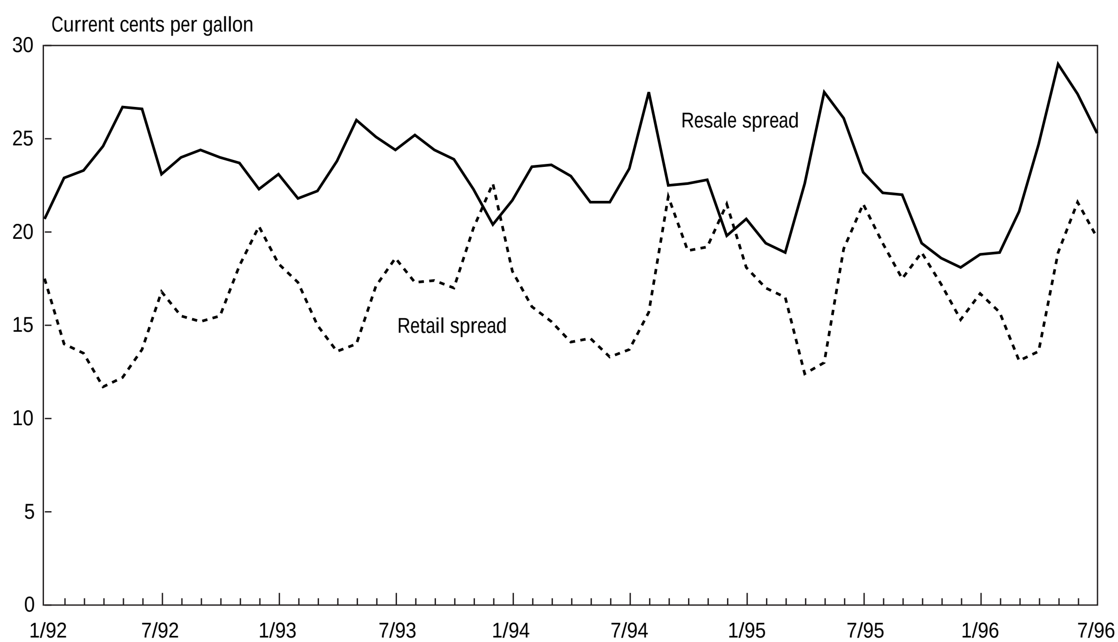
A second factor that changed significantly from December to May was the resale spread—the difference between refiners' cost of crude oil and wholesale prices charged to distributors. In December 1995, the resale price was 59.9¢ per gallon, and the cost of crude was 41.8¢, resulting in a spread of 18.1¢. Between December 1995 and May 1996, the resale price rose to

[7] One barrel of crude oil contains 42 gallons, and although there is some gain in volume during the refining of crude into products, dividing crude price by 42 gives a reasonably accurate estimate of the cost of crude as a component of gasoline price.

78.1¢ and the spread increased by an additional 10.9¢. Typically, resale spreads follow a seasonal pattern, increasing from a low point in December to a high point in May. Demand for the two principal petroleum products—gasoline and distillate fuel—causes this pattern. Demand for distillate, which includes home heating oil, peaks in winter, while gasoline demand peaks in summer. Because refinery outputs of these products cannot be adjusted at will without cost, refiners build stocks of gasoline in the winter (by producing a surplus) and draw them down in the spring and summer. This produces a cycle of low gasoline prices in the winter (when there is surplus production) and higher prices in the spring and summer. The normal cycle accounts for all but 3¢ to 4¢ of the change in resale price spreads.

Retail price spreads, a third component, are the difference between the price refiners charge to distributors and the price consumers pay at the pump, minus taxes. The costs of transportation, storage, handling, and retailing, plus profits made by businesses engaged in those activities, make up the retail price spread. Retail spreads increased from 15.3¢ in December 1995 to 19.0¢ in May 1996, a total of 3.7¢ per gallon. Retail spreads also show a seasonal pattern, with lows in the early spring, a rebound in late spring and early summer, and typically reaching a high point in December (see figure 4-9). Retail markups were unusually low in December 1995, making the increase in May seem relatively large when, in fact, the level of retail spread is well within the range of historical variability.

Figure 4-9.
Refiner and Retail Gasoline Price Markups: January 1994 to July 1996



NOTE: Resale spread is the difference between refiners' cost of crude oil and wholesale prices charged to distributers. Retail spread is the difference between the price refiners charge to distributors and the price consumers pay at the pump, minus taxes.

SOURCE: U.S. Department of Energy, Energy Information Administration. 1996. *Monthly Energy Review, October 1996,* DOE/EIA-0035(96/10). Tables 9.1, 9.4, 9.6

Taxes remained constant over the period. Congress considered but did not lower the 18.4¢ per gallon federal excise tax on gasoline. State taxes averaged 18.5¢ per gallon. (USDOT FHWA 1994, table MF-121T) The addition of local taxes brought the national average tax rate to 40.8¢ per gallon. (USDOE OPIA 1996, 2)

Analysis of the components of gasoline price shows that the sudden 21.8¢-per-gallon jump in the national average gasoline prices in the spring of 1996 was the result of: 1) increased world crude oil prices, 2) increased refiner markups, and 3) higher retail price markups (see table 4-3). DOE's analysis of this issue partially attributes the higher than normal increases in refiners' markups to supply problems unique to California and its very large share of the national gasoline market (11 percent). In spring 1996, California introduced Phase 2 gasoline, which was designed to pollute less and help California's cities meet national air quality standards. Refiners were required to produce the new fuel by March 1, and deliver it to California terminals by April 15. By June 1, retail outlets could sell only the new fuel. Because of mechanical problems and accidents at West Coast refineries, at one point 100,000 barrels of capacity were out of production. (USDOE OPIA 1996, 50) California's new RFG is significantly different from the fuel sold in other gasoline markets, and thus the loss of supplies could not be made up by gasoline production in other regions.

As a result, from December 1995 to April 1996, average gasoline prices in California increased by 25¢ per gallon, from $1.15 to $1.40. (USDOE OPIA 1996, 51) Over that same period, prices in the rest of the nation increased by 15¢ per gallon. Since the chief problem in California appears to have been supply from refiners, it is very likely that the additional price increase took place in the resale spread (i.e., refiners margin). Given its 11 percent share of the nation's gasoline market, California's fuel shortage caused a 1¢ increase in national gasoline prices. This still leaves 2¢ to 3¢ unaccounted for in the 21.8¢ per gallon price hike in spring 1996. An increase in resale spread appears to explain the remaining 2¢ to 3¢.

One lesson of the gasoline price increases of 1996 is that petroleum markets remain volatile. Even without a major loss of crude oil supply, weather-related swings in inventory, inaccurate expectations about future supplies from Iraq and the North Sea, and problems with domestic refinery capacity in California caused roughly a 10 percent jump in retail gasoline prices. Normal sea-

Table 4-3.
Components of the Retail Price of Gasoline: December 1995 v. May 1996

	December 1995 (price per gallon)	May 1996 (price per gallon)	Change (¢ per gallon)
Total	$1.160	$1.378	+21.8
Refiners' cost of crude oil	.418	.491	+ 7.3
Resale spread	.181	.290	+10.9
Retail spread	.153	.189	+ 3.6
Taxes	.408	.408	—

SOURCE: U.S. Department of Energy, Office of Policy and International Affairs. 1996. *An Analysis of Gasoline Markets: Spring 1996,* DOE/PO-0046. Washington, DC.

sonal variations in refiner markups together with a smaller amount of "unexplained" increase added almost another 10 percent to gasoline prices. Last spring's experience also raised the issue of whether the greater number of gasoline types required for air quality purposes may result in reduced flexibility in reallocating regional gasoline supplies and, thus, increased price volatility.

The Environment

The benefits of the U.S. transportation system are great, but they come at a substantial cost to our environment. Thus, our nation's challenge is to achieve a balance between transportation's numerous benefits and the need to protect and preserve our environment. Part II of the *Transportation Statistics Annual Report 1996* (TSAR 1996) provided a comprehensive discussion of transportation-related environmental issues. It described national-level impacts of air and water pollution, solid waste production, noise, and land use, and quantified these impacts where possible. Environmental regulations and controls intended to alleviate or eliminate negative impacts were also discussed. (USDOT BTS 1996)

The following section continues the discussion of transportation-related impacts presented in TSAR 1996. The section begins with an update of recent trends in the emissions of pollutants and greenhouse gases, as well as overall air quality changes. Next, it discusses other media impacts not covered in TSAR 1996. Finally, the section details air pollution control initiatives, either newly initiated since TSAR 1996 or for which there is new information.

Environmental Trends Update

Air pollution is the transportation-related environmental impact that is most closely monitored by the federal government. TSAR 1996 discussed this topic in some length from national, metropolitan, and international perspectives. Over the past two decades, national emissions of the six key transportation-related pollutants have steadily decreased despite continued growth in transportation activity, and lead emissions from transportation have been almost eliminated. (USDOT BTS 1996, figure 7-2, 133)

Significant strides also have been made in understanding, quantifying, and reducing other impacts. For example, federal noise standards for commercial aircraft certification have reduced the number of people exposed to unacceptable levels of aircraft noise, and the government continues to monitor underground storage tank releases and cleanup efforts. Other impacts, such as land use and habitat fragmentation, are less well understood and, therefore, more difficult to assess or quantify.

Box 4-1 discusses the role of indicators in measuring transportation-related environmental impacts. The recent Environmental Protection Agency (EPA) study on indicators is also highlighted.

Air Pollution

The Clean Air Act of 1970 (CAA) represented the first all-encompassing step in our nation's efforts to reduce harmful air emissions and improve air quality. Emissions refer to the amount of pollution released into the atmosphere from sources (e.g., vehicle tailpipes), while air quality is a measure of the concentration of pollutants in the atmosphere.

Pursuant to the Act, National Ambient Air Quality Standards (NAAQS) were set for six criteria pollutants—CO, ozone, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), lead, and particulates (total suspended particulates and particulate matter of 10 microns in diameter or smaller, or PM-10). The concentration of these pollutants within the ambient air is monitored at 4,000 sites across the country. EPA estimates emissions of

Box 4-1.
Measuring Impacts—The Role of Environmental Indicators

An ability to quantify impacts is essential in assessing transportation's effects on the environment and the success of regulations and programs established to offset these effects. Researchers can use indicators[1] as a tool for analyzing environmental trends and approximating results of transportation-related regulations. For example, researchers can assess the effect of transportation activity and mitigating environmental regulations by monitoring air quality. Since many other factors influence air quality, such measures cannot be used to directly link changes in air quality to specific regulations or changes in activity. Still, they give an *indication* of impact. Thus, indicators, or metrics, are most useful for approximating general improvement or deterioration in the environment and can aid in overall policy assessment and in setting broad-based policies.

The Environmental Protection Agency (EPA) recently published a comprehensive report, *Indicators of the Environmental Impacts of Transportation,* which identifies, describes, and categorizes indicators for the environmental media impacts of major modes of transportation. This study presents a framework for thinking about and categorizing indicators. It also discusses applications and limitations of these environmental yardsticks.

EPA divides indicators into four categories based on the kind of phenomena they describe.

- *Root-cause indicators* provide information on underlying factors that influence transportation activity, such as land use, demographic, and economic measures.
- *Activity indicators* provide information on infrastructure use and transportation-related actions, such as vehicle travel, vehicle manufacture, and congestion levels.

Neither root-cause nor activity indicators quantify transportation effects.

- *Output indicators* quantify the amount of pollution that is produced or is present in the environment, such as emissions, air quality, and exposure to pollutants, but they do not quantify the effects of pollutants on humans, flora, and fauna.
- *Outcome indicators* quantify the resulting effects of exposure, such as health, ecological, and economic impacts. Outcome indicators are the most desirable type of indicator, since they represent the environmental end result of transportation activity. Unfortunately, they are the most difficult to quantify. Furthermore, it is difficult and often impossible to directly connect these measures to specific activities and policies.

[1] Indicators are metrics used to quantify the magnitude or severity of environmental impacts.

SOURCE: U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation. 1996. *Indicators of the Environmental Impacts of Transportation,* Final Report. Washington, DC. June.

these and closely related classes of pollutants from transportation vehicles and other sources using a complex modeling process. The most significant transportation emissions are CO, volatile organic compounds (VOC), NO_X, and PM-10.

It is evident that the CAA reduced the overall quantity of air pollution generated by transportation and other sources and improved the quality of air in urban areas. This progress in emissions reductions and air quality improvements has had many benefits, but also has come at considerable cost to businesses, taxpayers, and consumers. Thus, it is logical to ask whether the health and environmental benefits of the CAA and its Amendments have been worth the costs incurred from their implementation. To address this question, Congress required EPA to perform a retrospective analysis of the costs and benefits to the public health, economy, and environment of the CAA from its inception in 1970 to 1990. In 1996, EPA made a draft report available for public review. The draft attempts to quantify the direct capital, operations and maintenance, abatement, regulatory, and research and development costs of CAA measures; emissions reductions; air quality improvements; visibility improvements; human health effects in both reduced cases of illness and the corresponding monetary benefits; and agricultural effects resulting from the CAA and its 1977 Amendments. The draft estimates that Americans invested $523 billion in air pollution abatement and control from 1970 to 1990 and received an estimated $23 trillion in health and welfare benefits. Of the $523 billion invested, nearly $179 billion (approximately 34 percent) were used toward control of mobile sources, while approximately $334 billion was used for stationary sources.[8] (USEPA 1996)

► Air Emissions Trends

As was detailed in TSAR 1996, the effort to control air pollution from highway vehicles has been an environmental success story. Although some emissions from transportation increased in 1992, 1993, and 1994, in 1995, according to the most recent EPA data, CO emissions decreased significantly—the largest reduction since 1989, VOC emissions decreased for the first time since 1992, and PM-10 emissions were down from 1994 estimates (see figure 4-10). NO_X emissions remained level. Lead emissions from transportation have been almost completely eliminated. (USEPA OAQPS 1996)

For all pollutants, reductions in onroad vehicle emissions accounted for the lion's share of the most recent improvements, even though emissions from other sources such as aircraft and airport services vehicles also generally decreased. In contrast, marine vessel (both commercial and recreational) and railroad emissions continued to climb steadily, and recreational nonroad sources showed increases in emissions.

Air quality results for 1995 were mixed. Of those pollutants tied most closely to transportation (i.e., CO, NO_2, lead, ozone, and PM-10), only ozone showed increased national average concentrations (see figure 4-11). Despite a slight increase in national average ozone concentrations, the number of areas designated as nonattainment for ozone dropped from 77 in 1994 to 68 in 1995. CO nonattainment dropped from 36 areas to 31; lead decreased from 11 to 10; and PM-10 decreased from 82 to 81. Los Angeles is still the only area in nonattainment for NO_2.

► Greenhouse Gases

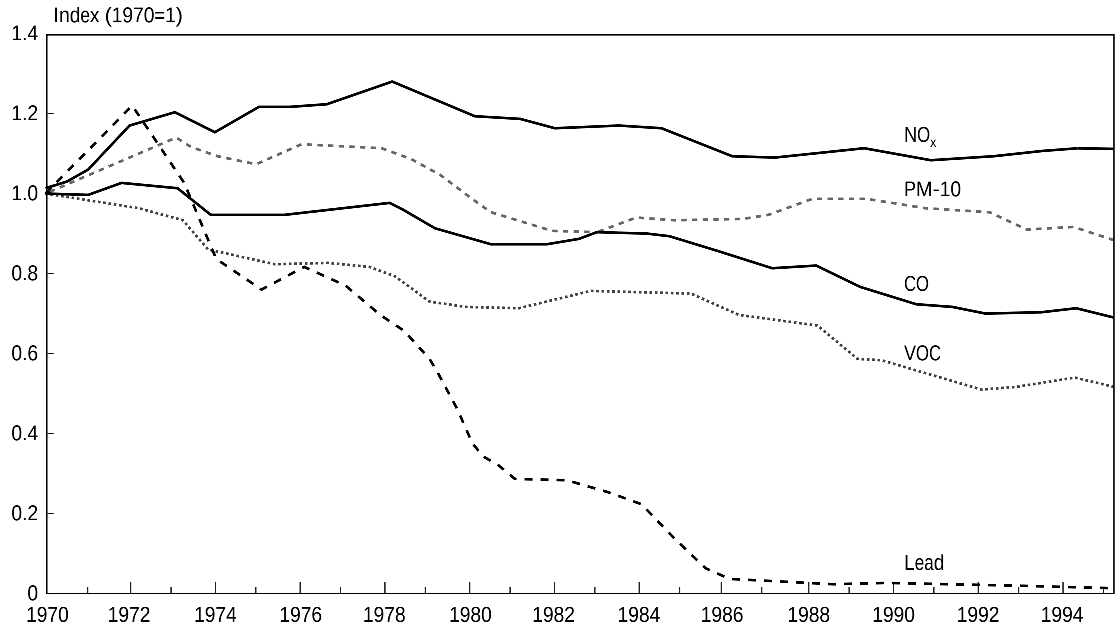
Transportation-related greenhouse gas emissions—CO_2, methane, and nitrous oxide (N_2O)—continue to follow trends prevalent over the past several years. CO_2 emissions produced by the transportation sector continue to rise due to increased energy use. In 1995, the transportation sector emitted 457.2 million metric tons of carbon in the form of CO_2, a 1.5 percent increase over 1994. According to EIA, transportation emissions accounted for nearly 40 percent of the national increase in CO_2 from end-use sectors since 1990. (USDOE EIA 1996f, 13, 16, 99)

Methane emissions from transportation dropped from 239,000 metric tons (263,452 tons) in 1994 to 230,000 metric tons (253,532 tons) in 1995, continuing a moderate decline over the past several years. All of this reduction was due to the use of catalytic converters in passenger cars. This trend is expected to continue in the near future as older autos are replaced by newer ones. (USDOE EIA 1996f, 25)

Nitrous oxide emissions have decreased slowly over the past several years, mostly due to reduction in highway vehicle emissions. This reduction reflects greater use of newer catalytic

[8] Costs were calculated by converting current dollars to 1990 dollars, annualizing capital costs at 5 percent, and then discounting expenditures to 1990 values assuming a 5 percent rate. Calculations were based on EPA data. Stationary and mobile source cost shares are calculated based on the assumption that abatement, regulations, monitoring, and research and development costs were distributed evenly between the two source categories.

Figure 4-10.
U.S. Transportation-Related Air Emissions: 1970–95



KEY: NO_x = oxides of nitrogen; PM-10 = airborne particulates of less than 10 microns; CO = carbon monoxide; VOC = volatile organic compounds.

NOTE: Transportation emissions include all onroad mobile sources and the following nonroad mobile sources: recreational vehicles, recreational marine vessels, airport service equipment, aircraft, marine vessels, and railroads. Lead estimates include onroad mobile sources only.

SOURCE: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1996. *National Air Quality and Emissions Trends, 1900 to 1995.* Research Triangle Park, NC. October.

converters that emit less N_2O than older models. Highway emissions in 1995 accounted for 128 million of the 145 million metric tons (159.8 million tons) of N_2O emissions in 1995.

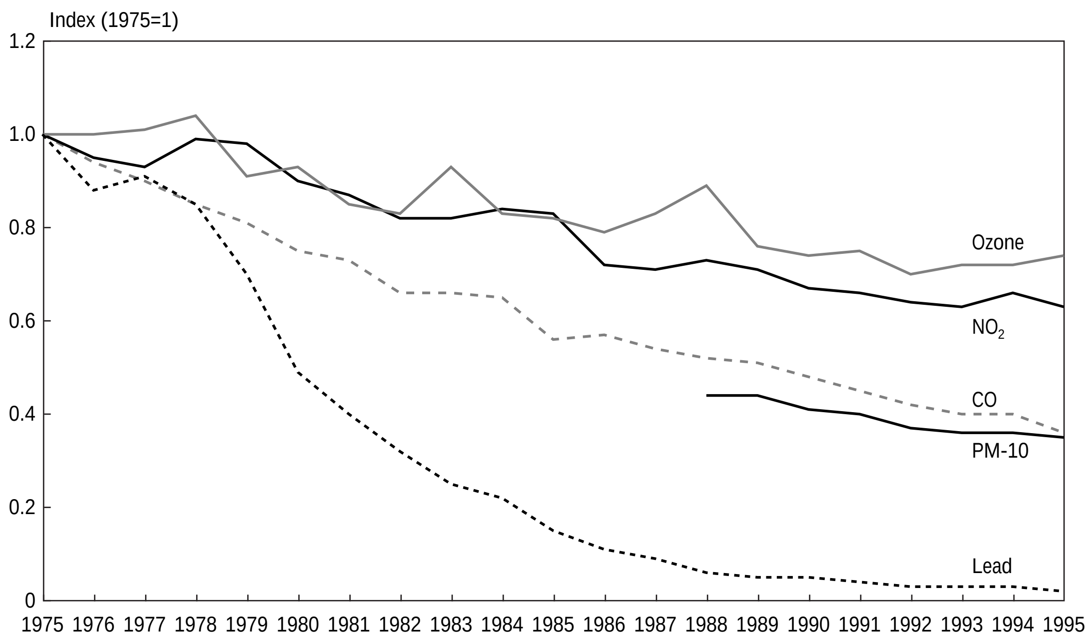
► Stratospheric Ozone Depletion

While ozone in the air is harmful to health, a layer of ozone in the upper atmosphere protects the earth from harmful ultraviolet rays. When released to the atmosphere, chlorofluorcarbons (CFCs), substances that until recently were widely used in many consumer and industrial applications, can migrate to the stratosphere and deplete the protective ozone layer. Recognition of this problem led the United States and most other countries to agree to phase out and eventually eliminate CFC production.

CFC-12 (dichlorofluoromethane) was once widely installed in newly manufactured mobile air conditioners. Although a substitute (HFC) is now used in air conditioners of new vehicles, leakage of CFC-12 from older vehicles continues. CFC-12 emissions from all sources dropped from 71,000 metric tons (78,264 tons) to 66,000 metric tons (72,753 tons) between 1994 and 1995.

CFCs are potent greenhouse gases. Because they destroy ozone, which is also a potent greenhouse gas, their net effect on climate change is uncertain. The HFC replacement is also a greenhouse gas.

Figure 4-11.
National Air Quality Trends: 1975–95



KEY: CO = carbon monoxide; NO_2 = nitrogen dioxide; PM-10 = airborne particles of less than 10 microns.

SOURCE: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1996. *National Air Quality and Emissions Trends Report,1995.* Research Triangle Park, NC. Table A-9, p. 76.

Water Pollution

Leaking petroleum storage tanks and spills from vessels transporting crude oil or petroleum products contribute to the degradation of water and groundwater supplies. Other transportation-related sources of pollution include highway and airport runoff of leaked oil, fuel, deicing agents, and other chemicals. Improper disposal of used motor oil and other fluids is also a significant source of water contamination.

► Airport Runoff

Runoff from airport runways is gaining attention as a major source of water contamination, mostly from aircraft and runway deicing solutions used during winter operations. Aircraft deicers are typically formulated with ethylene or propylene glycol; those used on runways are typically formulated with urea or glycols. Urea degrades into ammonia and nitrate. Urea is highly toxic to aquatic life, and nitrate can be hazardous to humans if excessive amounts are present in drinking water. Glycols are biodegradable, but this process takes place so rapidly and demands so much oxygen that they can affect oxygen-dependent aquatic life. Furthermore, some deicers contain trace elements of 1,4-dioxane, which is an animal carcinogen.

An estimated 11.5 million gallons of deicing products are used each year. (USDOE EIA 1996f, 126–127) Of this total, 49 to 80 percent of the deicing solution applied to an aircraft is estimated to fall to the apron, as does all of the solution applied to the runway. The amount of deicer used on a single airplane can range from 10 gallons to several thousand, and large airports can use over 150,000 gallons of deicer in a single storm. A recent survey found that 46 percent of airports discharge runway runoff directly into public waterways without treatment or monitoring, and another study showed that 64 to 100 percent of applied urea may discharge to surface waters through land overflow. (USDOE EIA 1996f, 126–127) Currently, there is no established procedure for measuring and recording annually the quantity of runoff or its constituents on a national basis.

▶ Oil Spills

The median quantity of reported oil spilled annually in U.S. waters is about 9 million gallons or about 0.004 percent of the total amount used. The reported volume spilled trended downward from 1973 to 1993, despite gradually increasing consumption and imports. While the trend is down, periodic spikes occur in years with large tanker spills. On a cumulative basis from 1973 through 1993, tankships accounted for 30 percent of the volume of total reported oil spills, only 5 percent of reported spill incidents. Tank barges and other vessels accounted for 22 percent of the volume of reported oil spills, and pipelines for 18 percent. The remaining 30 percent was from facilities or other nonvessel sources, or was attributed to unknown sources. (USDOT USCG 1995)

The Interagency Coordinating Committee on Oil Pollution Research, established by the Oil Pollution Act of 1990 developed a research, development, and demonstration plan to address oil spills. The plan was recently updated based on recommendations of the Marine Advisory Board of the National Research Council. The Committee analyzed the overall oil production and transportation system and concluded that the waterborne transportation component poses the greater risk of spills.

The plan identifies four broad categories of research and development (R&D) needs: spill prevention; spill response planning, training, and management; spill countermeasures and cleanup; and monitoring and restoration. Spill prevention R&D was found to have the most significant potential benefits, especially in the areas of human factors (on vessels) and offshore and onshore facility and pipeline design, inspection, and monitoring.

▶ Leaking Storage Tanks

Both underground and aboveground leaking storage tanks, most of which are used by the transportation sector, contribute to groundwater contamination. EPA estimates that nearly 1,000 releases from underground tanks occur each week, and as many as 20 percent of the 2 million regulated tanks may be leaking. (USEPA 1993c, 14–15) The federal government established the Leaking Underground Storage Tank program to monitor and respond to releases from these storage tanks. The rate of increase in the number of annual confirmed releases is slowing. Cleanup efforts, however, are also proceeding at a slow pace (see table 4-4).

Sediment Dredging in U.S. Ports

Dredging and dredged material disposal is a key issue facing the U.S. port industry. (USDOT MARAD 1996) Most ports and harbors are not naturally deep enough for modern vessels, and require periodic dredging to maintain depths. As world trade increases and shipping practices and technologies evolve (see chapter 9), many ports have also needed to deepen and broaden their channels and harbors. Conflicts have arisen between the need for port expansion and the need to address environmental problems in coastal areas and oceans. Dredged sediments contaminated with heavy metals and other pollutants must be

Table 4-4.
Leaking Underground Storage Tank Releases and Cleanup Efforts: 1990–96

Year	Confirmed releases	Cleanups initiated	Cleanups completed	Releases not cleaned up	Cleanups not initiated
1990	87,528	51,770	16,905	70,623	35,758
1991	127,195	79,506	26,666	100,529	47,689
1992	184,457	129,074	55,444	129,013	55,383
1993	237,022	171,082	87,065	149,957	65,940
1994	270,567	209,797	107,448	163,119	60,770
1995	303,635	238,671	131,272	172,363	64,964
1996	317,488	252,615	152,683	164,805	64,873

NOTE: Numbers are cumulative. "Cleanups initiated" plus "Cleanups not initiated" total to "Confirmed releases." "Cleanups completed" and "Releases not cleaned up" also total to "Confirmed releases."

SOURCE: U.S. Environmental Protection Agency, Office of Underground Storage Tanks. 1996. *Strategic Targeting and Response Systems (STARS) Data.* Washington, DC.

handled and disposed of in special ways (such as confined upland disposal sites) that raise the costs of dredge management. New rules on sediment management are increasing the percentage of sediments deemed contaminated. (Environmental problems posed by sediments in harbors are discussed in more detail in TSAR 1996.)

Regional differences and uncertainties in national dredging data complicate environmental analysis at the national scale. The U.S. Army Corps of Engineers (Corps) and others, such as port authorities, conduct dredging operations. The Corps is responsible for federally maintained channels and harbors, while others dredge their own facilities. Although the Corps maintains a dredging database of its work, others do not. Port authority dredging, for instance, is only captured in occasional surveys.

According to the Corps database, it dredged an average of 273 million cubic yards of material annually between 1991 and 1995. Actual volumes ranged from 244 million to 302 million cubic yards per year.[9] Some estimates suggest that Corps operations result in an average of 300 million cubic yards per year, but these appear to be based on older data. In recent years, dredging by the Corps has declined, reflecting environmental concerns, budget reductions, and changes in operations (such as dredging to closer tolerances). Corps dredging costs (1991 through 1995) averaged $514 million per year.[10]

Recent estimates of port authority dredging include: 1) 100 million cubic yards annually, cited by the Maritime Administration in 1996; and 2) a "lower bound" estimate for 1993 of 24 million cubic yards, cited in an EPA report. (USEPA OPPE 1996) The latter estimate, from a survey conducted by the American Association of Port Authorities, was based on responses from less than 70 percent of ports. In 1994, ports spent 3.4 percent of their capital expenditures ($24 million) on dredging. In proposed expenditures for 1995 through 1999, dredging would increase to 8.4 percent.

The Corps and the port authorities do not maintain aggregate records on the amount of

[9] This includes amounts dredged by the Corps and through Corps contracts with private sector dredging firms.

[10] Under provisions of the Harbor Maintenance Trust Fund, Corps projects are cost-shared with local authorities.

dredged material that is contaminated. Moreover, it is difficult to estimate this figure on a nationwide basis, because contaminants in dredged sediments vary by location and even by the nature of dredging operations. Dredging is classified as either new work (such as increasing the depth of shipping channels) or maintenance work (re-dredging to established depths). Maintenance tends to generate more contaminated sediments than new work projects, because the deposits are more recent. Maintenance also results in higher volumes of sediments than does new work (217 million v. 34 million cubic yards according to 1995 Corps data), but the proportions vary from year to year. While maintenance was 86 percent of total volume in 1995, it was 91 percent in 1991.

In 1996, the Maritime Administration reported that an often-used estimate for contaminated sediments (5 percent of the volume of total dredged sediments) was obsolete. New testing protocols were put in place by the Corps and EPA in the early 1990s. The protocols increase the sensitivity of detection limits and include more stringent criteria for assessing chronic impacts, thus the volume of sediments that must be managed as contaminated has risen.

The Port of New York and New Jersey (naturally shallow, with average depths of 18 feet) is one of the most heavily dredged areas, resulting in about 6 million cubic yards per year. Under the earlier protocol, less than 5 percent of its dredged material required any special handling. Dredging, transport, and capping costs for the uncontaminated sediments at an ocean dumping site were $5 to $10 per cubic yard. Now, only an estimated 25 percent of dredged material is suitable for management that way, and costs for the balance using existing options could range from $35 to $118 per cubic yard.

To maintain dredging and management costs below the benefits of harbor usage, a Corps interim report stresses the importance of establishing long-term, cost-effective disposal alternatives for contaminated sediments. (Corps 1996) It also suggests that reasonable alternatives exist (at a cost of $5 to $30 per cubic yard).

Other studies are underway that may help address the issue of balancing port growth with environmental concerns. A National Research Council report on decontamination of sediments was released in March 1997. (NRC CCS 1997) The Corps' Institute for Water Resources study, "Need for Changes in Dredged Material Disposal Policy for the Nation's Harbors," is developing strategies for federal and nonfederal responsibilities and financing on dredged material management.[11] The interagency National Dredge Team, established to refine the sometimes lengthy dredging review process, is preparing guidance documents for Dredged Material Management Plans that identify viable options and costs for proposed dredging projects.

Solid Waste: Rail Infrastructure

TSAR 1996 discussed several ways that worn highway vehicles and infrastructure were reused and recycled. (USDOT BTS 1996, 154–160) The railroad industry also reuses and recycles much of its old infrastructure. Almost all rails removed from mainlines are reused on secondary lines, branch lines, or yard tracks. Other track materials such as fasteners, tie plates, spikes, and anchors are reused when possible, and components such as switch stands, joint bars, and switch plates are repaired and used or sold to short lines that need lower cost products. Materials that are not reusable are sold to brokers or directly to steel mills for recycling.

Wooden ties are often repaired with a chemical plugging agent to fill holes and are then

[11] This study is in response to Section 216 of the Water Resources Development Act of 1992.

reused. Those that cannot be reused are sold as landscape materials, parking bumpers, fence posts, and retaining walls, or sold to powerplants. Only the worst ties are placed in landfills. Like wooden ties, treated timber from bridges and other structures are either reused or disposed of. Used concrete ties and most plastic rail-tie components are placed in landfills. Fine materials removed from cleaning ballasts are occasionally reused on roads. (TRB 1996, 28–31)

New Strategies for Reducing Air Pollution

Increasingly stringent emissions standards for light-duty highway vehicles have been instrumental in reducing transportation-related air pollutants. Several efforts to reduce emissions further have been or will soon be implemented. Discussed here are four that resulted from the CAAA:

- oxygenated fuels and reformulated gasoline programs in areas with persistent air quality problems;
- new emissions standards for heavy-duty highway and nonhighway vehicles;
- revised Federal Test Procedures (FTP) for measuring emissions from newly manufactured vehicles; and
- measures to ensure that in-use vehicles meet emissions standards, such as inspection and maintenance (I/M) programs and onboard diagnostic systems.

► Oxygenated Fuels Programs

The CAAA required 31 metropolitan areas that exceeded NAAQS for carbon monoxide to implement oxygenated fuels programs. (Other areas with CO problems may “opt-in” to the program.) During the winter months, gasoline sold within these areas must contain a minimum of 2.7 percent oxygen. This is accomplished by adding oxygenates, such as ethanol or MTBE, to conventional gasoline.

As noted earlier, oxygenated fuels reduce CO emissions, a product of incomplete combustion, by helping fuel burn more efficiently. At temperatures above 50ºF, results from dynamometer tests suggest that there could be a 5.4 to 27 percent reduction in CO for fuels with the required levels of oxygenate. An exhaust CO emissions model developed by EPA predicted reductions of 7 to 15 percent for oxygenated fuels containing required levels of MTBE and ethanol. (Rao 1996, table 8) A number of tunnel and remote-sensing studies also reported similar emissions reductions under real-world conditions, although others have not observed significant reductions.

EPA and other agencies conducted studies to determine how these emissions reductions affect air quality levels. An EPA analysis of CO concentrations from 1986 to 1994 concluded that the oxygenated fuels program implemented in 1992 reduced average CO concentrations by 3.1 to 13.6 percent, or an average of about 8 percent. (Cook et al 1996) Other studies showed similar results. (Dolislager 1993; Mannino and Etzel 1996)

In spite of emissions reductions observed in controlled tests and apparent air quality improvements due to the oxygenated fuels program, reservations exist about the benefits of oxyfuels and there are some concerns regarding the potential adverse effects of some oxygenates. Criticisms include:

- Actual CO reductions are uncertain. There is only limited test data on CO emissions from vehicles using oxyfuels at temperatures below 20ºF, even though many cities in the program experience winter temperatures this cold. Most emissions tests have been performed under an ambient temperature of 75ºF. (NRC 1996, 34–35) Also, large reductions in ambient CO concentrations have been observed in some areas without oxyfuels programs, while increases have been observed in some areas with these programs. (NRC 1996, 37–40)

- Some evidence suggests that oxyfuels may increase emissions of other pollutants, especially nitrogen oxides. NO_X is a major ozone precursor, and many areas participating in the oxyfuels program are also in nonattainment of the ozone NAAQS. (NRC 1996, 42–43)
- Controversy exists over possible health effects from the use of MTBE, one of the most commonly used oxygenates. Studies indicated a 26-percent increase in formaldehyde and an 8-percent increase in benzene and 1,3-butadiene emissions because of MTBE. These substances are toxic. The National Research Council reported increased incidents of headaches, coughs, and nausea in some areas with oxygenate programs, although toxicity studies indicate that MTBE is not harmful at probable exposure levels. (NRC 1996, 18–19)
- The possibility of groundwater being contaminated by gasoline containing MTBE is also a concern, as MTBE is more water soluble than gasoline. As yet, this chemical has only been found in very low concentrations in groundwater. Since MTBE levels are rarely monitored, it is difficult to determine whether this is currently a problem. (NRC 1996, 54–60)

► Reformulated Gasoline Program

The CAAA required nine areas that exceeded ozone NAAQS to implement an RFG program as of January 1995, and allowed other areas with ozone problems to “opt-in” to the program. Reformulation changes the amounts of various compounds present in the gasoline so that less criteria and toxic pollutants are emitted when it is burned.

The program will be phased-in in two stages. Phase I began in January 1995 and required that VOC and toxic air pollutants be reduced by 15 percent, and that NO_X emissions not increase over 1990 baseline rates. Phase II, starting in the year 2000, will require a 25-percent reduction in VOC and a 20-percent reduction in toxics, as well as a 5.5-percent reduction in NO_X. Both phases place a limit on the amount of benzene, a known carcinogen, allowed in fuel.

EPA estimates that Phase I of the RFG program will reduce VOC emissions by 90,000 to 140,000 tons during the summer period for all areas involved in the program. Phase II RFG standards are expected to reduce annual VOC emissions by an additional 42,000 tons, NO_X emissions by about 22,000 tons, and total toxic emissions by 1,000 tons. (*Federal Register* 1994, 7810; USEPA 1993b)

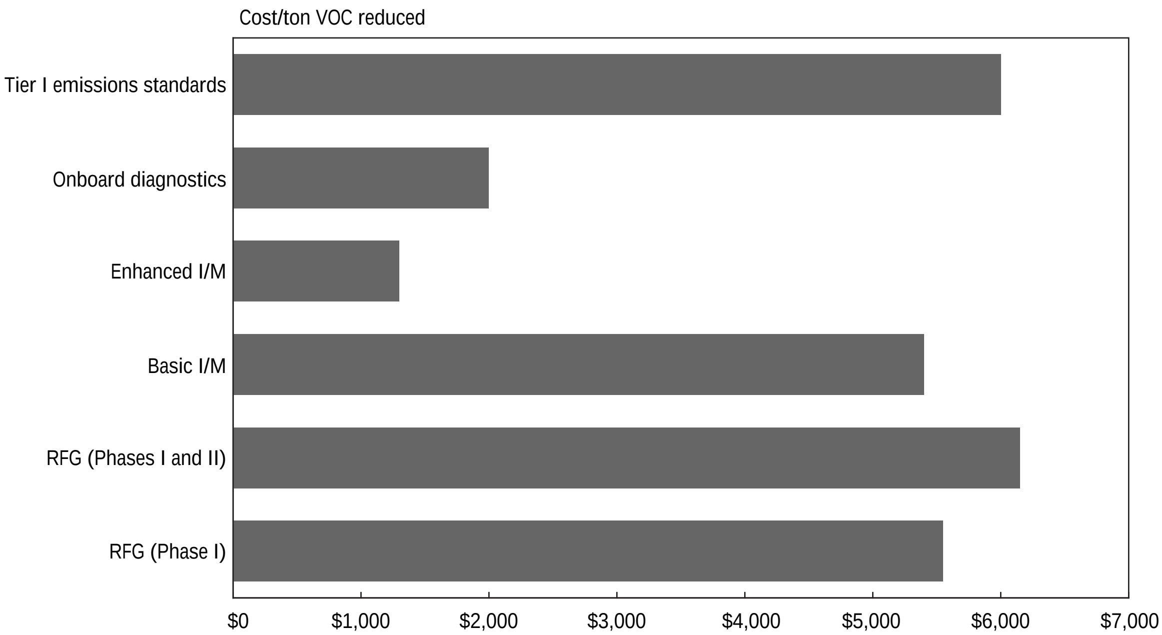
According to EPA, Phase I is projected to cost $700 million to $940 million annually for those areas participating, while Phase II will cost an additional $133.4 million annually.[12] Several studies have assessed the cost-effectiveness of the RFG program, and the general consensus seems to be that the program is comparable to other programs with similar objectives. (USGAO 1996, 4) Figure 4-12 shows EPA cost-effectiveness estimates for VOC.

To date, no national study has been completed that demonstrates the impact of RFG on ozone levels. EPA has noted, however, that a greater proportion of sites in RFG-required areas showed significant decreases in average benzene and other highlighted mobile-related VOC concentrations than did sites in areas that did not use RFG.

Because of severe air pollution problems, California requires even cleaner blends of RFG than those required by federal standards. Preliminary findings by the California Air Resources

[12] Phase I estimate: 59 *Federal Register* 7810; Phase II estimate based on EPA cost-effectiveness estimates and estimated emissions reductions.

Figure 4-12.
Cost-Effectiveness of VOC Pollution Control Measures



KEY: Tier I = new standards for certifying light-duty trucks and vehicles; I/M = inspection and maintenance; RFG = reformulated gasoline; VOC = volatile organic compounds; Phases I and II—see text.

NOTE: Average value used for estimated cost ranges.

SOURCE: U.S. Environmental Protection Agency estimates cited in U.S. General Accounting Office. 1996. *Motor Fuels: Issues Related to Reformulated Gasoline, Oxygenated Fuels, and Biofuels,* GAO/RCED-96-121. Washington, DC. June. p. 4.

Board (CARB) indicate a significant improvement in ozone and benzene concentrations coinciding with the use of federal Phase I gasoline in 1995. CARB reported that, in the South Coast Air Basin, average ozone levels on the smoggiest days in June and July were 18 percent lower in 1996 than in 1994 and 1995, after adjusting for differences in weather. (CARB 1996) Similar reductions were noted in Sacramento (11 percent) and in the San Francisco Bay area (10 percent). In Southern California, Stage 1 episodes,[13] which are characterized as high ozone concentrations, decreased from 23 in 1994, to 14 in 1995, to 7 in 1996. Benzene levels also decreased by 36 percent in 1995 and an additional 14 percent in 1996. (Hirsch 1996)

► New Standards for Heavy-Duty Vehicles

Federal regulation of highway vehicles has proven effective in reducing transportation-related emissions. Although emissions from these vehicles have been regulated for many years—light-duty passenger vehicles since 1970 and heavy-duty trucks since 1980—those of many nonroad vehicles have only recently come under scrutiny. Over the past few years, EPA has been developing emissions standards for nonroad mobile sources such as locomotives, marine vessels, aircraft, and heavy-duty on- and off-highway vehicles. Many of these standards are now finalized and will go into effect around the turn of the century.

[13] Stage 1 episodes occur when the maximum daily 1-hour ozone concentration exceeds 0.2 parts per million. These levels are considered very unhealthful to hazardous on EPA's Pollutant Standard Index.

Highway Vehicles. EPA is currently proposing more stringent NO_X and HC emissions standards for both diesel- and gasoline-powered highway trucks and buses. Starting with model year 2004, these standards would be implemented in the form of a combined nonmethane hydrocarbons (NMHC) and NO_X standard in grams per brake horsepower-hour (g/bhp-hr). Manufacturers would have a choice of meeting one of two optional sets of standards: 2.4 g/bhp-hr combined NMHC and NO_X or 2.5 g/bhp-hr combined NMHC and NO_X with a limit of 0.5 g/bhp-hr on NMHC. EPA estimates that these standards would reduce NO_X emissions by heavy-duty highway vehicles by 50 percent over the previously established standard for 1998. In addition, in 2020, ozone precursors would be reduced by 1.2 million tons and 50,000 tons of secondary nitrate particulate matter annually.

EPA estimates that these standards initially would increase vehicle retail prices by $200 to $500 per vehicle, but these additional costs would decrease by 50 percent within five years. For such vehicles, this represents less than 1 percent of the new-vehicle cost. (USEPA OAR 1996c)

Locomotives. According to EPA, locomotives are one of the largest remaining unregulated sources of NO_X emissions. Locomotives produced about 10.9 percent of the total NO_X emitted from transportation sources and about 4.5 percent emitted from all sources in 1995. EPA is currently in the process of developing national emissions standards, expected to be finalized by the end of 1997, for all locomotives manufactured after 1973, including those that are currently unregulated. EPA regulations would go into effect in the year 2000 and require locomotives originally manufactured between 1973 and 1999 to meet emissions standards at the time of the first remanufacture after January 1, 2000. Locomotives are typically remanufactured 5 to 10 times during their life, which is often more than 40 years. For new locomotives, emissions standards would first be applied to those manufactured from 2000 through 2004, with more stringent standards being applied to those built after 2004. When fully phased in, the new standards are expected to reduce NO_X emissions rates from locomotives by nearly two-thirds. (USEPA OAR 1996d)

Marine Vessels. Gasoline marine engines are one of transportation's largest nonroad emitters of hydrocarbons, accounting for about 30 percent of such emissions. In August 1996, EPA published a final rule regulating emissions from spark-ignition marine engines. This ruling applies to new outboard engines and gasoline engines manufactured during or after 1998; it does not apply to sterndrive or inboard gasoline engines, which have relatively low emissions compared with 2-cycle engines. (Inboard engines are very similar to those used in automobiles.)

The new regulations will tighten HC emissions standards over a nine-year phase-in period. By the final phase of the program, each manufacturer must meet a composite HC and NO_X corporate average emissions standard that represents a 75-percent reduction in HC compared with unregulated levels. EPA estimates that this program will result in a 50-percent reduction in HC emissions from such engines by 2020 and a 75-percent reduction by 2025. (USEPA OAR 1996a; USEPA OAR 1996b)

► Initiatives To Reduce Highway Vehicle Emissions

Research shows that the potential emissions improvements expected from light-duty vehicle regulations are not being fully realized due to several factors: 1) the inability of the "conventional" Federal Test Procedure to represent real-world driving conditions (or driver behavior) and the effects of air conditioner use; 2) emissions control devices become less efficient as vehicles age; 3) emissions control devices are tampered with by owners; and 4) some vehicles, even new ones, emit much higher levels of pollutants than expected. Thus, a number of programs are in effect to ensure that vehicles meet emissions standards under real-world driving conditions and continue to meet them after they enter the national fleet.

A New Federal Test Procedure. For several years now, many researchers have questioned whether or not the FTP adequately represents actual driver behavior.[14] The CAAA directed EPA to review and revise FTP regulations to ensure that they accurately reflect current driving conditions in the areas of fuel, temperature, acceleration, and altitude. A series of driving behavior studies conducted by EPA indicated that the FTP did not accurately reflect some key aspects of real-world driving conditions. (USEPA 1993a, 7)

In August 1996, EPA established a Supplemental Federal Test Procedure (SFTP) for light-duty vehicles and trucks operating on gasoline and diesel fuel. The SFTP simulates aggressive driving behavior (rapid acceleration or high speed), speed fluctuations, driving behavior following startup, and more realistic use and modeling of air conditioning impacts. The SFTP includes speeds of up to 80.3 miles per hour (mph) (rather than the previous 56.7 mph maximum), as well as accelerations of 8.46 mph per second and decelerations of –6.9 mph per second (rather than 3.3 and –3.3 mph per second, respectively, under the FTP). The SFTP also calls for improved dynamometer simulation of the road forces that act on tested vehicles. These SFTP and dynamometer requirements are to be phased in from model year 2000 to model year 2002 for light-duty vehicles and trucks. Phase-in for heavier, light-duty trucks has been delayed two years.

[14] See TSAR 1996. (USDOT BTS 1996, 184, 185)

EPA expects use of the SFTP to reduce emissions from light-duty vehicles and trucks by 435,000 tons of NO_X, 5 million tons of CO, and 82,000 tons of NMHC annually by 2020. This represents a 2.4 percent reduction in NMHC, 11.1 percent in CO, and 9.3 percent in NO_X. EPA estimates that the new regulations will cost a total of $198.9 million to $244.5 million annually, or $13.26 to $16.30 per vehicle.[15] (40 CFR Part 86)

Inspection and Maintenance. EPA-required state inspection and maintenance programs address a number of problems, such as emissions control devices that work less effectively as vehicles age and vehicles that emit more pollutants than expected. EPA requires these programs in states unable to meet NAAQS for CO and ozone. By 1996, 92 urban areas were required to implement either “basic” or “enhanced” I/M programs, depending on the severity of their air quality problems. Still, the concerns about frequency of testing, enforcement, and regulatory loopholes are generating debate about the potential effectiveness of I/M programs.

Onboard Diagnostic Systems. EPA issued regulations requiring manufacturers to install onboard diagnostic systems in all new light-duty vehicles and trucks beginning in the 1994 model year. These systems monitor emissions control components for any malfunction or deterioration causing certain emissions thresholds to be exceeded and alert vehicle operators to the need for repair. The regulations also require that these systems store diagnostic information in the vehicle’s computer to assist mechanics in diagnosis and repair. (*Federal Register* 1996)

[15] This estimate is based on annual sales of 15 million vehicles.

Data Needs

The demise of EIA's Residential Transportation Energy Consumption Survey (RTECS), following publication of the 1995 results, means that fleet fuel economy estimates and household vehicle use data will no longer be available. RTECS data are unique in that they provide odometer-based travel estimates for a statistical sample of U.S. household vehicles, and because they match make and model mpg estimates to each vehicle in the sample. RTECS mpg estimates are not actual in-use fuel economy estimates, but are rather EPA test numbers adjusted to better represent actual operating conditions. Actual in-use fuel economy estimates based on odometer readings and fuel purchases would facilitate evaluation of the real-world impacts of the Federal Automotive Fuel Economy Standards over time. RTECS data were the next best thing.

The Bureau of Transportation Statistics (BTS) recommends filling the RTECS gap by expanding the Truck Inventory and Use Survey (TIUS) to include passenger cars and other types of vehicles. An expanded Vehicle Inventory and Use Survey would improve on the RTECS by including vehicles owned by businesses, as well as households, but the current TIUS survey methods would have to be adapted to allow odometer-based vehicle-miles traveled (vmt) estimates. Additional processing of the survey results would also be required to add mpg estimates. The 1995 Nationwide Personal Transportation Survey (NPTS), for the first time, will provide odometer-based vmt estimates for household vehicles. The NPTS will not permit accurate estimates of fleet fuel economy, however, since it will not identify vehicles in sufficient detail to allow them to be matched with their EPA mpg values.

Vehicle occupancy rates for cars and light trucks and heavy truck load factors indicate the overall energy efficiency of the U.S. transportation system. Trends in these variables are key determinants of future growth in vehicle travel. Currently, both of these numbers are greatly in need of improvement. For any year other than that of the survey, vehicle occupancy levels are based on extrapolation from the NPTS rather than actual observations. Even in the survey year, vehicle occupancy during business travel, in general, is not measured.

Truck ton-miles are based on similar extrapolations from the TIUS. Although the TIUS is currently the best available source of load factor information, it is based not on actual measurement of truck loads but on survey respondents' estimates of their average annual loads. BTS's 1993 Commodity Flow Survey, provides useful information about truck ton-miles that, together with TIUS data, permits new estimates and analysis of load factors.

There is a continuing need to improve the credibility of estimates of vmt by type of vehicle. Such data have a variety of applications, such as measuring exposure for safety studies or estimating cost responsibility for highway revenue analyses. In the energy arena, data on vmt by vehicle type are essential to estimating overall efficiency trends and the sensitivity of vehicle travel to fuel price and fuel economy, and for understanding how vehicle type choice and use affect energy demand.

This chapter presented estimates of the composition of transportation energy use based on utilization of nonpetroleum blending components in gasoline. As the importance of replacement and alternative fuels grows, methods of estimating the composition of transportation energy by source should be refined and validated.

Historically, the primary focus of transportation-related environmental impacts has been on air pollution. Since 1970, the Clean Air Act and its Amendments required extensive data collection and control of mobile source emissions.

Environmental laws controlling other forms of pollution do not have as pervasive requirements for the collection of national trend data on emissions by source and on resultant media quality. Thus, knowledge of other transportation impacts, such as water contamination, hazardous and nonhazardous waste generation, noise, and land use, is less complete.

There are accurate, annually updated output indicators for air pollution, but few studies have produced outcome indicators. Fairly accurate data are available on the annual amount of petroleum spilled in and around U.S. waters by vessels. Little is known, however, about the net amount of contaminants released into the environment (after cleanup efforts), the amount of water contaminated by spills, exposure to contaminants, and ultimate health effects to humans and wildlife. Spills from leaking underground storage tanks are monitored—at a minimum, their frequency and cleanup status—while spills from aboveground storage tanks are not. Also, only limited studies have been performed to quantify highway and airport runoff and its impact on the environment.

There is general knowledge about solid wastes produced from scrapped vehicles and worn infrastructure. According to the data available, recycling plays a significant role in reducing waste from highway vehicles and highway and rail infrastructures. Due to the slow scrappage rate of rail, marine, and air vehicles and their material content, it is reasonable to assume that these components of the transportation system may have a relatively small impact on solid waste production.

At present, there are no comprehensive indicators of the exposure of Americans to transportation noise. The localized nature of noise, as well as its characteristics of attenuation, makes national exposure difficult to quantify. Exposure to aircraft noise around commercial airports has been estimated, but there are no recent estimates for exposure to highway and rail noise.

Land use and habitat degradation are topics about which very little is known on a national scale. Accurate trends of land area occupied or affected by the four major transportation modes are not available, although the amount of infrastructure in place has been quantified. Furthermore, understanding of the extent to which habitat fragmentation and depletion affect wildlife species as a whole is limited—although a few studies on specific kinds of wildlife have been conducted. Destruction of wetlands is a topic that has recently received much attention from both private and public organizations concerned about the environment, and an inventory of wetlands in the United States is currently being produced by the U.S. Fish and Wildlife Service of the U.S. Department of the Interior. The amount of wetlands degraded or destroyed due to the construction of transportation infrastructure is unclear, however. Also, it is unclear whether wetlands banking programs[16] replace wetlands satisfactorily

[16] Mitigation banks have been set up to offset losses of wetlands from construction or other forms of development. Using a system of credits and other marketable instruments, mitigation banking makes it possible for developers to convert wetlands to other uses if corresponding activities take place elsewhere to restore, protect, or create other wetlands of comparable value.

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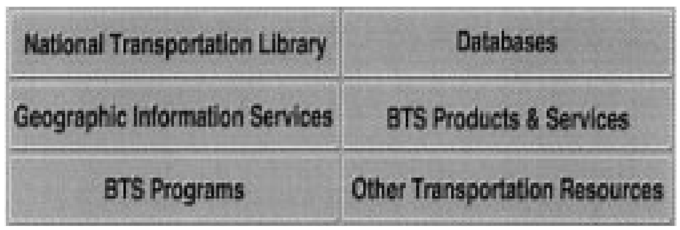
The State of Transportation Statistics



Congress created the Bureau of Transportation Statistics (BTS) to establish a policy-relevant knowledge base for decisionmakers, and to inform the public about transportation and its consequences. Toward these ends, Congress called for BTS to assess both the state of the transportation system and the state of transportation statistics in the *Transportation Statistics Annual Report* (TSAR). Specifically, the annual report is to include "documentation of the methods used to obtain and ensure the quality of the statistics presented in the report, and recommendations for improving transportation statistical information."

This chapter builds on previous TSAR assessments of transportation statistics. TSAR 1994 highlighted information needs expressed in congressional mandates, reports of the National Academy of Sciences, and customer responses to initial BTS products. TSAR 1995 outlined a comprehensive strategy of data collection and analysis for meeting the initial set of needs. In 1996, BTS articulated a more detailed list of information needs and described the progress made toward meeting those needs.

This 1997 assessment comes at a good time to step back, review the path followed by BTS and other information-producing agencies, and examine whether that path remains appropriate to follow into the 21st century. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), under which BTS was created, authorized federal spending on highways, transit, and statistics through fiscal year

Table 5-1.
A Brief History of Transportation Statistics

1808	The first national transportation policy study is produced by Secretary of the Treasury Albert Gallatin.
1861	Six decades of geographic data collection by the federal government are summarized in *Reports of Explorations and Surveys To Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean,* prepared by the Secretary of War for the U.S. Senate.
1887	The Interstate Commerce Commission is established, initiating the collection of data from carriers to support regulation.
1920–1921	The U.S. Army Corps of Engineers begins publishing data on water transportation commerce and ports.
1934	The Federal-Aid Highway Act authorizes funds to be spent by state highway departments on surveys and economic analyses.
1944–1970	The largest metropolitan areas conduct large-scale studies of urban travel and transportation capacity.
1945	The Bureau of Public Roads (predecessor to the Federal Highway Administration) publishes the first *Highway Statistics.*
1957–1963	The Census Bureau initiates the Census of Transportation, including surveys of trucks, unregulated motor carriers, commodity movements, and long-distance passenger travel.
1958	The Federal Aviation Administration Act establishes the current mandate for collection of airline financial and operating statistics.
1960	The Census Bureau begins to collect journey-to-work data as part of the Decennial Census of Population and Housing.
1962	The Federal-Aid Highway Act establishes a data-rich comprehensive planning process for metropolitan areas.
1966	The Department of Transportation (DOT) Act creates DOT and requires the Secretary of Transportation to “promote and undertake the development, collection, and dissemination of technological, statistical, economic, and other information relevant to domestic and international transportation.”
1968	The Federal Highway Administration begins publishing a biennial highway needs report.
1969	The Federal Highway Administration initiates the first Nationwide Personal Transportation Survey. DOT summarizes the state of statistics in *Transportation Information: A Report to the Committee on Appropriations, U.S. House of Representatives, from the Secretary of Transportation* (the Red Book).
1970–1971	DOT publishes the first edition of *National Transportation Statistics*. Passage of the National Environmental Policy Act and Clean Air Act highlight the need for environmental data related to transportation. The Census Bureau significantly expands the content and geographic detail of journey-to-work data collected under the Decennial Census of Population and Housing.
1972–1974	DOT publishes two *National Transportation Reports* in which data are compiled on all modes.
1974	The National Urban Mass Transportation Assistance Act mandates collection of data on the transit industry. Energy data becomes a major concern with the first oil embargo.
1975	The Fatal Accident Reporting System is initiated by the National Highway Traffic Safety Administration. The Census Bureau conducts a survey of domestic transportation of foreign trade.
1976–1986	DOT annual spending on multimodal transportation data shrinks from approximately $4.5 million to less than $0.5 million (in 1982 dollars).
1977	A national transportation atlas and the last DOT *National Transportation Report* is published under the title *Trends and Choices.* The Census Bureau conducts the last quinquennial Commodity Transportation Survey and National Travel Survey.
1978–1980	Airlines, railroads, and motor carriers undergo significant economic deregulation, and most data-collection programs by regulatory agencies are subsequently reduced or terminated.

Table 5-1.
A Brief History of Transportation Statistics *(continued)*

1979	The National Transportation Policy Study Commission calls for a continuing commitment to the development of transportation statistics in the last comprehensive assessment of transportation published by a federal agency until 1990.
1982	The Census Bureau terminates the quinquennial collection of data on commodity flows and passenger travel due to funding and methodological problems.
1990	DOT publishes *Moving America: New Directions, New Opportunities—A Statement of National Transportation Policy Strategies for Action,* which calls for a renewed commitment to transportation statistics.
1991	The Transportation Research Board completes its recommendations in its report, *Data for Decisions: Requirements for National Transportation Policy Making*. The Intermodal Surface Transportation Efficiency Act (ISTEA) is passed mandating the establishment of the Bureau of Transportation Statistics (BTS).
1992	The Federal Highway Administration begins work with the Census Bureau on the Commodity Flow Survey. The DOT management order implementing the ISTEA mandate for BTS is signed in December, and management of the Commodity Flow Survey is transferred to BTS.
1993–1995	BTS and the Census Bureau conduct the Commodity Flow Survey, the American Travel Survey, and the Transborder Surface Freight Transportation program. BTS publishes its first *Transportation Statistics Annual Report.* BTS receives the surviving data functions of the Civil Aeronautics Board from the Research and Special Programs Administration.
1996	BTS receives the motor carrier financial and operating statistics program from the Interstate Commerce Commission.

1997. ISTEA reauthorization will set the course for these programs in the years ahead. At this juncture, it is important to establish whether the information needs reflected in the ISTEA have been met, and, if there are new needs emerging, how they will be addressed. This chapter highlights BTS's progress, how the world of information may change, and what future directions decisionmakers might consider for transportation statistics programs.

How Far Have We Come?

When the ISTEA was enacted, transportation statistics had passed through two strikingly different eras (see table 5-1). A long period of increasing interest in transportation statistics reached its zenith in 1977 with major data-collection activities in all modes of transportation, the publication of comprehensive analyses of national transportation needs and a national transportation atlas, and a joint program of multimodal data collection by the Department of Transportation (DOT) and the Census Bureau of the Department of Commerce. After 1977, transportation statistics entered a period of decline as deregulation and shrinking budgets brought many federal programs to an end. No comprehensive national analyses of transportation were conducted by the federal government between 1979 and 1989. No national multimodal data on commodity flows were collected between 1977 and 1993. Although the supply of transportation data declined, the demand for this information remained strong.

Reports issued at the beginning and end of these two eras in transportation statistics emphasized the need to maintain information on commodity and passenger flows to understand transportation system performance. Two assessments, in particular, helped to shape subsequent ISTEA mandates related to data. The first assessment, *Transportation Information: A Report to the Committee on Appropriations, U.S. House of Representatives, from the Secretary of Transportation*, was published in 1969; the second assessment, *Data for Decisions: Requirements for National Transportation Policy Making*, was published by the Transportation Research Board of the National Academy of Sciences in 1991. Both emphasized the importance of developing new technology for data collection to improve accuracy and reduce respondent burden. The 1991 assessment added the need for a National Transportation Performance Monitoring System, anticipating the Government Performance and Results Act (GPRA) and a blossoming interest in performance measurement by all levels of government. As indicated in table 5-2, the ISTEA responded to the ongoing needs for information articulated in both assessments and set a course that BTS continues to follow.

Many ISTEA sections relevant to BTS can be characterized as a mandate to recapture past capabilities and understanding, demonstrating that the establishment of a knowledge base for transportation requires continuous investment. The Intermodal Transportation Database called for in Section 5002 of the ISTEA is largely fulfilled by the Commodity Flow Survey and the American Travel Survey, both of which are direct descendants of the 1977 Census of Transportation. The requirements in Section 6006 of the ISTEA for a *Transportation Statistics Annual Report* reestablish many aspects of the old *National Transportation Report* (although the latter report went beyond the state of the transportation system to include policy recommendations and estimates of investment needs). The ISTEA emphasis on data dissemination reinforces a similar mandate in the Department of Transportation Act of 1966, and the ISTEA focus on the promulgation of internal guidelines and external coordination requires BTS to do what the former Office of Information Policy attempted within the Office of the Secretary of Transportation in the 1970s.

BTS has made significant progress in most areas specified in the ISTEA. Specifically, BTS has:

- published four comprehensive TSARs, and continued to annually compile and publish *National Transportation Statistics* (NTS);
- completed surveys of commodity and passenger flows by all modes and intermodal combinations;
- initiated joint efforts with Canada and Mexico to create a continental view of transportation in North America;
- established the Standard Classification of Transportable Goods and participated in other statistical standard-setting activities;
- become a leader in developing geographic databases and geographic information systems (GIS) technology; and
- established an aggressive data dissemination program through CD-ROMs and an award-winning Internet site.

Box 5-1 shows the breadth of BTS accomplishments in responding to ISTEA mandates over the course of the four years between the start of operations and January 1, 1997.

Information Needs and Resources Beyond ISTEA

The ISTEA fueled major initiatives to meet the longstanding demand for data by the transportation community, but some needs identified in *Data for Decisions* remain to be filled. In addition, new data demands are arising from the rapidly evolving worlds of information technology and transportation.

Ongoing Demands for Information

Most needs for basic transportation statistics persist over time. For example, information about the quantity and distribution of travel, commodity movements, and vehicle activity has been relevant for decisionmaking throughout the history of U.S. transportation policy. Timely, reliable data to meet decisionmakers' needs are always important.

Domestic transportation of international trade. This information is increasingly critical given the dramatic growth in international freight movements, the increasing dependence of domestic businesses on global markets, and competition among transportation service providers throughout North America as U.S. borders with Canada and Mexico become less restrictive for goods movement. In the mid-1970s, the Census Bureau conducted surveys to confirm or complete key information on a sample of import and export documents. This information included the inland destination of imports and origin of exports, the means of transportation between the inland locations and the port or border crossing, and the weight of the shipment. Although the 1993 Commodity Flow Survey (CFS) captured much information about exports, it only surveyed what domestic establishments shipped, and thus did not capture imports. The Transborder Surface Freight Transportation Data Program only covers truck, rail, and pipeline movements, and like other foreign trade data, is limited to identifying inland geography.

Time and reliability statistics. From the perspective of travelers and shippers, time and reliability are as basic as cost for measuring the performance of transportation. Customer-oriented service providers and investors share this concern. National information on scheduled travel time and on-time performance is limited to major air carriers and Amtrak. Journey-to-work travel times are also reported in the Decennial Census of Population and Housing. Only anecdotal information exists on travel time and reliability of other passenger trips, which account for the majority of travel, or about freight transportation.

Costs of transportation. Cost data are essential to understanding transportation's performance, measuring productivity, estimating the impacts of public policies and private sector actions, and forecasting future trends and reactions to policies and programs. Before economic deregulation, carrier filings provided cost data specific to individual services and segments of the transportation network. These data have largely disappeared, reflecting the loss of reporting requirements after deregulation, extensive replacement of published tariffs by contract rates, and market innovations, which blur traditional cost accounting. The most detailed remaining information is for commercial aviation.

Motor vehicles. The numbers of motor vehicles and how they are used are a key concern when looking at their relationship to congestion, highway cost allocation, energy consumption, environmental pollution, and exposure to safety risks. While reliable inventory and use statistics for all classes of vehicles are not yet available, some progress can be seen. For example, major improvements have been made in the Truck Inventory and Use Survey, and alternatives for improving the quality of data provided by the states to the Federal Highway Administration are being assessed. Such promising data sources as the International Fuel Tax Agreement and the International Registration Plan remain to be mined, however.

Railroad geography and condition. Because most railroads are private companies, publicly available information on location and connectivity lacks adequate details, and is largely nonexistent on capacity and condition. Better information is needed to assess mergers, aban-

Table 5-2.
The Demands for Statistical Programs and the ISTEA Response

U.S. Department of Transportation (DOT), ***Transportation Information: A Report to the Committee on Appropriations, U.S. House of Representatives, from the Secretary of Transportation*****, May 1969**	**Transportation Research Board,** ***Data for Decisions: Requirements for National Transportation Policy Making,*** **Special Report 234, National Research Council, 1991**	**Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)**
NA	Establish a Transportation Data Center within the Department of Transportation.	Established the Bureau of Transportation Statistics (BTS).
National survey of total tripmaking by household characteristics; surveys of air travelers to learn trip purpose, airport access, mode choice variables, and general aviation use; resurrect the Interstate Commerce Comission's rail waybill origin-destination data-collection program and expand to rail shippers; data-collection program for regulated and nonregulated truck origin-destination patterns; air cargo waybill survey.	Collect passenger and freight flow data to provide basic system information on origin-destination, who or what is moving, and by what mode.	Called on BTS to establish an intermodal transportation database, including commodity and passenger flows, and public and private investment in facilities and services.
Link-specific data on highway and rail network facilities, including location, speed, traffic volumes, capacity, operating rights, and accidents.	NA	NA
International ocean and air travel, international freight flows, transportation facilities, and foreign demographic and economic characteristics affecting demand.	NA	NA
NA	Develop a national transportation performance monitoring system	Compile and analyze statistics and publish in the *Transportation Statistics Annual Report.*
Develop a uniform commodity coding system.	Improve the comparability of data collected on individual transportation modes to enhance intermodal comparisons and provide an assessment of overall system performance.	Develop guidelines to improve the quality and comparability of DOT's statistics.
NA	Integrate and supplement existing data to enhance the capability of DOT to determine the contribution of the transportation system to other national objectives such as economic growth, national security, environmental quality, and energy use.	Economic productivity and collateral damage on the human and natural environment are among the topics required for BTS's *Transportation Statistics Annual Report.*

Table 5-2.
The Demands for Statistical Programs and the ISTEA Response *(continued)*

U.S. Department of Transportation, *Transportation Information: A Report to the Committee on Appropriations, U.S. House of Representatives, from the Secretary of Transportation,* May 1969	**Transportation Research Board, *Data for Decisions: Requirements for National Transportation Policy Making,* Special Report 234, National Research Council, 1991**	**Intermodal Surface Transportation Efficiency Act of 1991**
NA	NA	Represent transportation interests in the statistical community.
Develop data integration, analysis, and dissemination media, software, and hardware.	NA	Make data accessible.
NA	Explore opportunities for using data that are gathered by the private sector, or collaborate with the private sector in data collection.	Identify data needs.
Research new methods of data collection with a particular emphasis on reduction of respondent burden.	Explore advances in data-gathering and information-processing technologies that have the potential to reduce costs and reporting burdens while improving the speed and reliability of data collection and analysis (e.g., automated surveying methods, electronic linking of records through electronic data interchange, automated vehicle and traffic monitoring through intelligent transportation systems technologies, and integration of data into geographic information systems for analysis).	NA
Develop geo-coding systems, working with the Census Bureau in urban areas and expanding to rural areas.	NA	NA
Establish best methods for passenger travel and urban goods data-collection efforts by local agencies and find ways to ensure use of the methods.	NA	Work with states and metropolitan planning organizations to create an intermodal transportation database.
Develop forecasting and explanatory models.	NA	NA

KEY: NA = not addressed.

Box 5-1.
BTS Responses to the ISTEA Mandate

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 outlines five core elements of the Bureau of Transportation Statistics's (BTS's) mission.

1. BTS is mandated to compile, analyze, and publish a comprehensive set of statistics on the following topics specified in 49 USC 111(c)(1):

■ ***Productivity of the transportation sector***. BTS work on productivity measurement with the Bureau of Labor Statistics was highlighted in the 1995 *Transportation Statistics Annual Report* (TSAR). BTS is extending this work through joint research with the Bureau of Economic Analysis (BEA), and aims to provide a broader picture of transportation performance by establishing Transportation Satellite Accounts. These accounts will more accurately measure transportation's contributions to the economy by for-hire and private service providers, equipment manufacturing and related services, and facility construction.

■ ***Traffic flows***. Previous TSARs summarized mode-specific flows. To enhance this information, BTS initiated the Commodity Flow Survey (CFS) and the American Travel Survey (ATS), which measure multimodal flows. BTS is also developing programs to measure the significant and growing flows of international trade and visitors through the U.S. domestic transportation system.

■ ***Travel times.*** BTS work in this area has focused on air travel for all trip purposes and on journey-to-work by all modes, reflecting availability of data. Increasing interest of decisionmakers on system performance will require a greater emphasis on time and cost aspects of transportation, which in turn will require additional data collection.

■ ***Vehicle weights.*** TSAR 1996 included an analysis of trends from the Truck Inventory and Use Survey (TIUS). Additional analyses will be conducted in the future based on integration of results from the TIUS and the CFS.

■ ***Variables influencing travel behavior, including mode choice.*** Basic trends have been highlighted in the TSAR, and will be explored in greater detail as data become available from the ATS and the 1995 Nationwide Personal Transportation Survey. BTS-sponsored research on the consequences of the Northridge earthquake also provided insights on urban travel behavior. BTS published the Census Transportation Planning Package on CD-ROM, making the largest national database on journey-to-work available to the entire transportation planning and travel behavior research community.

■ ***Travel costs.*** The Consumer Expenditures Survey has been analyzed to measure average costs to households, and results have been reported in the TSAR. Additional work on passenger travel costs needs to be done once data are available from the ATS and can be combined with data from other sources. On the freight side, aggregate estimates are being made from a joint program with the BEA for determining the role of transportation in the economy. Extensive new data collection will be required to obtain shipper costs that are comparable across all modes.

■ ***Availability and use of mass transit.*** Transit statistics are summarized in each TSAR and accompanying editions of *National Transportation Statistics* (NTS). A more detailed analysis is included in chapter 1 of this report.

■ ***Frequency of repairs and service disruptions.*** Comparable data across all forms of transportation do not currently exist. Statistics compiled in the NTS show vehicle age, equipment, service availability, and reasons for delay in modes with available data. Reliability measures are a key element of system performance, and must be designed from the ground up.

■ ***Accidents.*** BTS publishes data from the National Highway Traffic Safety Administration on CD-ROM, and combines that data with other modes in the safety chapter of each TSAR and related sections of the annual NTS.

■ ***Collateral damage to the human and natural environments.*** This topic was featured in the 1996 TSAR, which lists a number of specific data needs. Environmental and energy trends are discussed in each TSAR and data are presented in related sections of the NTS.

■ ***System condition.*** BTS summarizes information developed by the modal administrations in each TSAR and NTS.

2. BTS is mandated to implement a long-term, intermodal, intergovernmental data-collection program.

Title 5 of the ISTEA requires BTS to develop an intermodal transportation database on commodity and passenger flows, and public and private investment in intermodal transportation facilities and services. The CFS and the ATS are direct responses to this mandate. Future initiatives include surveys of the domestic transportation portion of international trade and travel, and surveys of costs to shippers and travelers associated with domestic transportation activity. BTS compiles location and connectivity data on intermodal facilities and services for all

Box 5-1.
BTS Responses to the ISTEA Mandate *(continued)*

forms of transportation as part of its National Transportation Atlas Database (NTAD).

These efforts are primarily federal. BTS is beginning to work with states and metropolitan planning organizations to encourage local data collection that can be integrated with national statistics. Federal-state-local cooperation for data collection is particularly emphasized in the NTAD project, which is part of the National Spatial Data Infrastructure under Executive Order 12906, Coordination of Geographic Data Acquisition and Access.

3. BTS is mandated to issue guidelines for the collection of information by the Department of Transportation (DOT) to ensure that information is accurate, reliable, and relevant.

BTS participates in a variety of standard-setting activities, representing DOT on committees that establish or revise the Standard Industrial Classification system, the Standard Occupational Classification system, the Standard Classification of Transportable Goods, the Standard Land Use Coding Manual, and ground transportation elements of geographic data under the National Spatial Data Infrastructure. BTS is represented in departmentwide efforts to measure safety, and successfully established a standard definition of fatal accidents across all modes.

BTS also reviews survey designs for data collection that must be submitted by DOT to the Office of Management and Budget for approval under the Paperwork Reduction Act.

Appropriate and effective methods of coordination for BTS are being studied by the Committee on National Statistics of the National Academy of Sciences as required by Section 6008 of the ISTEA, with a report due in 1997.

4. BTS is mandated to make information accessible to users.

BTS is widely recognized for its successes in making information from throughout DOT and from other government agencies accessible to the transportation community through publication of directories of data sources and telephone contact lists, release of data products and data access software on CD-ROM, and an award-winning Internet site. The Bureau's decision not to charge for data and interpretive products developed with ISTEA funds was based on a philosophy of removing all barriers to information.

The challenge ahead is to provide effective technical assistance in the use of data. Microcomputers and CD-ROM technology have made dissemination of and access to very complex databases possible by a wide range of users. The transportation community needs help in understanding how to use the data (e.g., the TIUS characterizes vehicle weights in several ways; BTS can help users decide which of the given applications is appropriate for them).

5. BTS is mandated to identify information needs.

BTS continually monitors customer reactions to BTS products and holds outreach meetings with allied organizations to better understand the community's information needs. BTS also established the Advisory Council on Transportation Statistics as mandated under Section 6007 of the ISTEA for this and other purposes.

donments, safety concerns, and proposals to invest in railroad capacity improvements and intermodal facilities.

Transportation, economic development, and land use. Data on economic and land-use impacts of transportation are required to understand the relationship between public policy and the ability of transportation to serve businesses and the public. The skeletal and circulatory functions provided by the transportation system are powerful influences on economic activity, encouraging development in some places while discouraging development in others. With development comes economic opportunity and environmental concerns, which vary significantly across regions. Understanding the interactions among transportation, economic development, and land use is central to appreciating the long-term consequences of infrastructure investment. Yet, the regional economic database to support this understanding has been diminished by budget cuts at the Bureau of Economic Analysis. In addition, a consistent scheme for classifying land uses by type of economic activity within developed areas and a vehicle to collect land-use data on a national scale needs to be developed.

Evolving Information Needs

Throughout this report, there is discussion of how various aspects of transportation have changed over time. In freight transportation, public agencies and private businesses must be able to respond quickly to rapidly shifting needs. In passenger transportation, a greater number of people are traveling more frequently to increasingly dispersed destinations. The demand for transportation is rising: faster, cheaper, and more reliable service is expected rather than desired. Forecasts of volume and capacity are no longer enough; statistics on cost, time, and reliability are also in demand.

Transportation policy is also changing quickly. Fiscal, environmental, and other concerns are limiting opportunities to build new transportation systems and major public facilities. Economic regulation of transportation service providers has largely been eliminated at the federal and state levels of government, while safety regulation in many instances has become more extensive. With encouragement from the ISTEA, the number of players in transportation policy continues to increase. There has been significant growth in the number of metropolitan planning organizations (MPOs), private sector interests, and citizen organizations now at the table once dominated by federal and state agencies. All are demanding data and the tools to use the data.

Although the number of players and instruments of policy have changed, many fundamental questions remain the same. How can growth in the demand for transportation be accommodated? Are users paying their fair share of public investments? Can transportation's negative effects on safety and the environment be reduced further? Can the needs of transportation-disadvantaged groups be met? What are the opportunities for new technology?

Decentralization of decisionmaking, first from the public sector to the private sector through deregulation, and second from the federal government to state and local governments, is the biggest potential change in the world of transportation policy to be informed by transportation statistics. Completion of the Interstate Highway System, ISTEA mandates, and other forces have shifted considerable decisionmaking to states and MPOs, and have encouraged greater public participation in those decisions. Some proposals call for a more dramatic reduction of federal involvement.

Although such changes would reduce the federal role in financing, regulating, and operating transportation facilities and activities, the need for publicly available transportation statistics would be likely to grow. According to the axioms of economics, the free flow of information is a prerequisite to properly functioning private markets. In the public sector, state and local officials would need to relate conditions in their states and localities to national trends and interstate commerce. After 1977, when the federal government temporarily stopped providing such data, state and local governments and the private sector began to ask for restoration of a federal presence in transportation statistics, leading to the ISTEA mandate for BTS and its programs.

A mandated transportation policy change to be informed through statistics is explicit accountability. The GPRA requires that all federal agencies begin to measure their outcomes, and not just their inputs (typically money) and outputs (typically contracts, grants, and permits). In effect, agencies are being asked to explain whether their actions have had a beneficial impact. The GPRA will be the basis of budget decisions by the Office of Management and Budget and will be monitored by Congress.

The GPRA's focus on outcomes forces many agencies to become aware of the conditions being measured by BTS and other statistical agencies (see box 5-2). Performance measurement is not just a federal preoccupation: most state departments of transportation and some local agencies are undertaking similar activities. Several states have expressed interest in sharing experiences with performance measurement, but all have been opposed to involvement by federal funding or regulatory agencies in defining and applying state performance measures.

► Evolving Sources of Information

DOT obtains information from four basic sources: surveys and censuses, reports from service providers, reports from government agencies, and byproducts of management and control systems. Surveys and censuses are often expensive, obtrusive, and the least timely way to collect data, but may be the only means available in some cases. For example, few people keep consistent records of their household travel unless they are participating in a survey. Reports from service providers, such as filings by carriers for regulatory purposes, also can be burdensome, because the cost of data collection is shifted from the data-collection agency to the respondent. The least obtrusive source of data is byproducts of management and control systems, such as counting vehicles on a turnpike based on toll collections.

Box 5-2.
Performance Measures: Data Issues

Performance measures in transportation are typically composites of variables based on direct observation (such as traffic counts and lane-miles) and on estimates (such as vehicle-miles traveled). For a performance measure to be effective:

- the observations underlying the variables must be accurate, reliable, and have adequate coverage;
- the estimation methods must be demonstrably unbiased; and
- the composite measure must be relevant, transparent, and devoid of spurious accuracy.

Many performance measures in transportation fail the relevancy test, either because the measure is not readily linked to real-world experience or because the measure does not capture the desired concept. The commonly used measure of ton-miles illustrates the former; few decisionmakers can readily visualize a ton-mile and relate it to an understood quantity. The ratio of the “transportation bill” to gross domestic product as a measure of transportation’s share of the economy illustrates the latter; the numerator and the denominator are based on entirely different forms of accounting and should not be combined.

Whether applied to program administration or general decisionmaking by executive agencies and legislative bodies, performance measurement should respond to the basic questions:

- Are things getting better or worse?
- What is meant by better or worse?
- What is contributing to the improvement or decline?
- What can be done to maintain or improve conditions?

To answer these questions, performance measures must translate inputs and outputs into outcomes.The focus on outcomes is a fundamental shift from traditional measurement activity by public agencies. Programs and program managers have been graded most typically on measures of inputs (e.g., how much money was spent and how quickly were regulations promulgated). Programs and program managers are sometimes graded on output measures (e.g., how many vehicles were purchased or how much highway was repaved). Neither input nor output measures are sufficient to determine whether the shippers and the traveling public have been served effectively and efficiently. Outcomes such as a change in congestion or air pollution must be measured to determine whether an investment, regulation, or service has made a difference and should be maintained or changed.

As information technologies advance, unobtrusive measurement is improving in both sophistication and coverage. (Chapter 11 discusses in-depth the role of information technologies in transportation.) Airline flights are tracked through the skies, trains are dispatched from central traffic control centers, trucks are weighed without stopping, and courier services tell customers where their parcels are at each step of the intermodal movement.

When monitoring and control systems can be tapped, the quantity and quality of data increase dramatically while costs and burden to the respondent plummet. For example, every ticket collected by the airlines is processed through a clearinghouse to allocate revenues when the ticketed travel is not completed on the originating airline. The clearinghouse is a superior source of commercial passenger air travel geography and data on price: BTS is working with industry to tap the clearinghouse as a replacement for the current data-collection system.[1] If the clearinghouse could be used, the burden on the carrier disappears because data collection is fully automated, and errors from sampling or changes in itineraries disappear because 100 percent of the travel is measured directly, and only after the travel is completed.

Switching to unobtrusive forms of data collection is not a panacea. Set-up costs, both fiscal and institutional, can be high, and the nature of data being collected may change, as illustrated by truck data. Formerly, much of this data was obtained for highway planning purposes by stopping trucks at temporary roadside stations and weighing the trucks with portable scales. The operating expenses of temporary weigh stations and the time burden placed on drivers limited the number of observations that could be made and encouraged some drivers to avoid the scales and compromise the representativeness of the data. By switching to weigh-in-motion sensors in the pavement, costs of data collection fell, the number of observations increased by orders of magnitude, truckers were no longer inconvenienced, and bias from scale avoidance was eliminated. The only information obtained, however, was the weight and spacing of each axle. In the past, the driver could be asked about the load, trip origin and destination, and other characteristics. This additional information must now be obtained through surveys or other intrusive data-collection strategies.

A fully developed vision for intelligent transportation systems (ITS) offers the potential to replace most surveys and carrier reports in the future, particularly if traffic control, shipment management, and other systems can be integrated. All of the information obtained in roadside interviews of truck drivers, plus other freight information, could be captured from monitoring systems used by public agencies to manage congestion and collect user fees, and from monitoring systems of carriers to track their vehicles, shipments, and drivers for the company's own logistics, marketing, and safety purposes (see chapter 9, box 9-3).

Such a fully developed vision of ITS has not yet been pursued for two reasons. First, most systems are being designed with an overriding concern for managing day-to-day or minute-to-minute conditions, which in itself is a challenge. Additional requirements for integration and archiving of data are often secondary, especially if integration must be across organizations. (Airlines have developed some remarkably integrated systems within their individual companies, using real-time and time-series data to coordinate everything from ticket revenue yield maxi-

[1] The BTS Office of Airline Information currently collects the data by sampling every 10th airline ticket sold. Airlines submit computerized ticket images or special data files. The results can be distorted by sampling error and by changes in passenger itineraries after buying the ticket.

mization to meal selection to fuel allocation for individual flights.) A much greater problem is concern about proprietary, privacy, and legal issues. Private companies are reluctant to share information with their competitors. Individuals are concerned that personal information provided to a government agency may be available to others. Public agencies are worried that data could be used against them in court; for example, observation of an unsafe condition obtained by an agency before a crash could possibly be used by a victim to sue later for failure to correct the problem.

For these and other reasons, enormous amounts of data are being generated, but not saved. The transportation community must continue to depend on the more costly, more burdensome, and lower quality sources of information until the technological and institutional issues can be resolved.

Improvements are possible in the traditional, obtrusive forms of data collection. The use of computers in telephone and personal interviews can reduce costs and respondent burden by speeding up the interview, improve data quality by providing immediate feedback for unlikely answers, and improve timeliness by automating the compilation of field data. The Census Bureau is experimenting extensively with computer-aided interviewing, and the Federal Highway Administration has sponsored research on the use of inexpensive, handheld computers for data collection.

Such improvements are essential given budget constraints and increasing resistance by respondents to answer traditional surveys. Most statistical agencies' budgets for data collection are being reduced significantly, potentially undermining key data sources for the transportation community. The Energy Information Administration eliminated its Residential Transportation Energy Conservation Survey, the Bureau of Economic Analysis curtailed its regional economic analysis program, and the Census Bureau is under pressure to eliminate or find sponsors for large parts of the quinquennial census. The Census Bureau is also under pressure to find sponsors for the journey-to-work questions on the year 2000 census, which alone would cost far more than the rest of the annual federal budget for major statistical programs related to transportation.

Evolving Uses and Dissemination of Information

Information technologies affect more than data collection. Rapidly evolving computational power, data-integration methods, analytical tools, and dissemination technology are improving the ability to address policy and other questions, which in turn changes the demand for information.

Sophisticated models, complex analysis, and large data sets are no longer restricted to the largest public agencies and private firms. Microcomputers and CD-ROMs allow the smallest MPO, small motor carriers, local citizen's groups, and individual consultants to manipulate data sets that required multimillion dollar mainframe computers just two decades ago.

Much of the requisite data analysis and integration can be accomplished with off-the-shelf spreadsheet, database, and project management software packages. The major statistical packages and some travel demand forecasting programs have been transferred from mainframes to microcomputers. The development of GIS packages to integrate geographic data and provide a platform for analysis and modeling has especially large potential for transportation analysts. The full potential of GIS is not realized because most of these packages are designed primarily to manipulate area data (in which roads and railroads are just boundaries) rather than network data (in which roads and railroads are the major objects of interest), and do not handle transportation problems adequately as a consequence. Also, most GIS packages require extensive training to use, and will not enter the mainstream until they are as easy to use as spreadsheets.

The shift of transportation analysis to microcomputers results in two problems, however. First, traditional methods are frequently applied inappropriately to new issues and data. For example, it is now relatively easy to apply the classic four-step urban travel demand forecasting process to estimating local, statewide, or national commodity movements. This straightforward application may result in misleading estimates, because shippers and carriers respond to very different forces in freight transportation than do households and individuals in passenger travel. New models are needed to make effective use of the data now available from the Commodity Flow Survey and local data-collection activities.

The second problem stems from the ease in which users can obtain and manipulate sophisticated data sets without understanding the basis of the data. In the world of mainframe computers and nine-track tape, analysts had to understand the structure of the data before they wrote the program to use the data. Now the analyst can load and tabulate large data sets from CD-ROMs with off-the-shelf database packages without looking at the documentation, creating results that look good but may be entirely wrong. For example, vehicle weight is characterized several different ways in the Truck Inventory and Use Survey. The appropriate measure depends on the application. Novice users might use the first weight variable they encounter—which may or may not be appropriate—when accessing the data with its built-in tabulation software on the BTS CD-ROM *Transportation Data Sampler Number 3*.

These problems create a significant challenge for BTS and other data providers to accelerate research on alternative forms of modeling and analysis, and to place significant emphasis on training. The training challenge is particularly daunting, because customers are no longer limited to a few large agencies.

The growth in analytical capabilities is fueled—and perhaps exceeded—by the revolution in data delivery technology. BTS was fortunate to begin operations just as CD-ROM technology was becoming popular. Each CD-ROM contains up to 630 million numbers or letters and costs less than $1 to reproduce. The next generation disc, based on digital video disc technology, will hold four to eight times as much data, and should be commercially available in 1997.

BTS's Internet site has become an ever more important means of data dissemination and communication with BTS customers. Internet's potential is illustrated by the National Transportation Library, described in box 5-3.

The new technologies of data dissemination and use have reduced the cost of delivering data and tools to each customer, but have resulted in the explosive growth in the number of customers and the demands they place on BTS for service. Many customers are looking for more than data files and format statements: they are demanding help in analyzing and interpreting the data. The Bureau is seeking ways to support wider audiences with technical assistance and analysis in addition to the traditional niche markets of experienced data users served by older DOT agencies.

Evolution of Transportation Organizations

Transportation organizations in both the public and private sectors must adapt to rapidly changing environments. Flexible manufacturing, cus-

Box 5-3.
The National Transportation Library

Libraries are a major component of knowledge bases for most professions. They provide archives for data and reports, and serve as platforms for disseminating information throughout the field. The importance of libraries is underscored by the budgets of the National Library of Medicine (at $152 million per year, estimated for fiscal year 1997) and the National Agricultural Library (at $18 million per year, estimated for fiscal year 1997). By contrast, the national library function has received far less support in transportation, about $3 million in fiscal year 1997.

Historic collections of transportation material are deteriorating with age and neglect. The Department of Transportation (DOT) library, once a national asset for the entire transportation community, is now a limited, in-house service for the Department after two decades of inadequate support. The Association of American Railroads gave away much of its collection in recent years because it duplicated the holdings of the Interstate Commerce Commission. The Commission's library became orphaned by the agency's sunset, and neither DOT nor the Library of Congress had the resources needed to identify and keep materials worth saving. (While the worthwhile historic documents can then be digitized for electronic storage and dissemination, the originals should still be preserved as today's standards for quality digitization will be increased inevitably by better technology in the future.) Instead, the Commission's collection was sent to a warehouse in Denver.

State DOTs, universities, and others are looking at ways to increase the effectiveness and reduce the costs of sharing material. For example, the Minnesota DOT has an excellent library collection, but must use interlibrary loans to fulfill 30 percent of its customer's requests for material. Although many librarians recognize that Internet, CD-ROMs, and related technology offer cost-effective ways to meet the growing demand for information, no one has asserted leadership to develop and implement the technology throughout the transportation community.

Recognizing the importance of dissemination, the Bureau of Transportation Statistics (BTS) established an electronic National Transportation Library (NTL) as a major component of the Bureau's Internet site. The NTL contains electronic documents and other information provided by the transportation community. Most of the current collection comes from state agencies, metropolitan planning organizations, and universities.

The NTL performs two functions: it is a place where DOT can compile and disseminate its own reports; and it is a shared resource available to all members of the transportation community. For example, local planners or their consultants can browse the NTL, see what colleagues in similar places have done to design local travel surveys, and then make copies of the material they want to adapt for their own use. If the user has a question or comment, the NTL provides electronic mail addresses for individuals at all levels of government and in the private sector who have volunteered to help.

Congress recognized the value of the library function when it directed BTS to establish a collection of material on high-speed rail transportation as part of the NTL. BTS is working with the Special Libraries Association and others to improve the content and organization of the electronic collection, and to consider options for establishing an effective archive of printed material (especially maps and other illustrations). BTS is also working with the Secretary of Transportation to resurrect a requirement that all DOT reports be provided to the Department's library so that users do not have to search the 10 operating administrations to find valuable information.

tomer responsiveness, and accountability all require extensive and timely information.

Decisionmaking is increasingly decentralized. Many activities of the federal government have shifted to state and local governments or to the private sector. Within many public and private organizations, decisionmaking authority is shifting from central offices to the "front lines."

Decentralized decisionmaking does not lessen the core activity of DOT: to identify transportation needs and problems and to advocate solutions. This function remains no matter how many investment, regulatory, or other programs are devolved to state and local governments or the private sector. BTS supports this core activity by:

- making Congress and the public aware of the nation's transportation resources, the interaction of transportation with society and the economy, and the consequences of transportation systems; and
- providing information and analytical tools to support public and private decisionmaking.

In effect, BTS provides feedback for DOT and the transportation community on how well the system is serving the nation. This function will be increasingly difficult and more important to perform as traditional sources of information from other federal statistical agencies decline.

Future Directions

Since the Bureau's formal establishment one year after passage of the ISTEA, BTS has worked within DOT and with other organizations to create a national knowledge base covering all modes of transportation through a range of products and services. In response to customer demands, BTS proposes to build on its initial products and services with three major initiatives. These initiatives are part of the administration's proposal for reauthorization of the surface transportation program.[2]

Transportation in a Globalized Economy

The initial BTS focus on domestic transportation needs to be expanded to reflect the increasing importance of international trade to the economic health of the nation and its individual communities. This expansion includes:

- *The domestic side of international trade and travel.* BTS proposes to work with the Customs Service and the Census Bureau to determine where and how international trade and travel passes through the domestic transportation system. Such data are key to understanding the impact of trade policies on the demand for domestic transportation facilities and services, and for identifying regional and local opportunities to compete in world markets. BTS has assessed major shortcomings in existing data on these topics as part of the *Transportation Statistics Annual Reports.*
- *The condition, performance, and use of transportation links to other nations.* BTS proposes to assemble information on transportation facilities and services that link the United States to other nations, paralleling DOT's ongoing efforts to measure the condition, performance, and use of transportation in this country. The requisite work involves acquiring commercial data sources, maintaining data programs that may be lost with institutional change, and data integration.
- *An international transportation database.* BTS proposes to build a database to support understanding of international issues, that provides comparative data to inform domestic policy on the transportation experience of other countries, and that contains basic information on international markets for U.S. economic interests.

Enhancing Relevance of National Statistics for State, Local, and Private Sector Transportation Decisions

The DOT budget is less than one-quarter of all government spending in transportation, and only 5 percent of spending by the public and private sectors combined. For BTS to enhance the effectiveness of transportation decisions, the Bureau's national programs must be made more relevant to the state, local, and private sectors that are the dominant stakeholders. The Bureau proposes to improve the geographical specificity and timeliness of its data programs through increased sample sizes of data collections, the

[2] Section 6002 of S. 458, the proposed National Economic Crossroads Transportation Efficiency Act of 1997.

development of monthly transportation indicators, and the development of innovative analytical and information-sharing programs.

To improve timeliness and minimize the burden of responding to government requests for information, BTS proposes to develop methods of capturing data from traffic control systems, electronic data interchange systems, and other forms of ITS. BTS recognizes that emerging technology makes instantaneous and unobtrusive measurement of transportation activity possible, but that a number of technical and institutional issues must be resolved first. In particular, ways to archive massive amounts of data in a reasonably accessible form need to be devised. In addition, privacy and confidentiality need to be protected.

BTS proposes to provide technical and financial assistance to organizations that can help enhance the relevance of national transportation statistics for state, local, and private sector decisions. These organizations include state agencies, MPOs, universities, and others who integrate local data collection and analyses among themselves and with national counterparts. The proposed grant program would allow BTS to work with nonfederal professionals as they begin to collect data using ITS technologies, with universities and others as they begin to build repositories of transportation data and information on the Internet, and with the private sector to ensure that DOT provides American businesses competing in the global economy with useful and necessary information when it is needed, in an easily accessible format.

The demand for these activities is underscored by the Bureau's participation in the White House Economic Briefing Room, and by a policy statement passed unanimously by the Board of Directors of the American Association of State Highway and Transportation Officials that states:

> . . . the U.S. Department of Transportation should encourage and support the further development of the Bureau of Transportation Statistics, a continuation of the dialogue between the Bureau and the states, and an exploration of the Bureau's services to the states, including the potential for increased technical assistance.

Performance Indicators

BTS recognizes that significant work is needed to measure outputs and outcomes of transportation programs as required by the GPRA and similar initiatives by state and local governments. Since performance measurement reflects a new user-focused and output-oriented approach, the concepts, specific measures, and supporting data are in the early stages of development. BTS has been assigned to work with other DOT modal administrations to evaluate the data necessary for performance measurement under the GPRA. BTS has also been asked by states and MPOs to help with the development of performance measures for their own purposes.

BTS proposes to develop a program of research, technical assistance, and data quality enhancement to support performance measurement. Research is needed to update and extend past studies of program evaluation methods to transportation. BTS needs to establish a performance measurements methods clearinghouse and other forms of technical assistance if it is to help states and MPOs develop their own performance measures. Data quality enhancement is needed in several programs sponsored by BTS and other DOT modal administrations to assure the validity and precision of performance measurement.

Beyond Reauthorization

Whatever specific directions are set by Congress, BTS and the other statistical agencies will continue to evolve. The Bureau focused much of its early energy on restoring the knowledge base in transportation statistics after a long period of decline, and must maintain that investment in information capital. BTS will also continue to develop the knowledge necessary to deal with emerging transportation technologies, dynamic economic and social forces that alter transportation demand, and the unintended consequences of transportation for safety, energy, and the environment. This knowledge base is essential to guide transportation investments and services that account for 11 percent of gross domestic product, 19 percent of household expenditures, and the physical links that hold the nation together.

Part II

Mobility, Access, and Transportation

chapter six

Transportation, Mobility, and Accessibility: An Introduction

The transportation system exists to help individuals and firms overcome the friction of distance. The performance of the system should therefore be judged by the degree to which it achieves that end. Individuals must overcome distance to commute from home to work, reach recreational and shopping facilities, visit friends and relatives, and perform a variety of other day-to-day activities. Firms must overcome distance to obtain their material inputs, distribute their finished products, exchange business documents such as contracts and proposals, and move personnel to places where they are needed for sales, negotiation, and general management functions.

The ease with which transportation users overcome distance may be addressed by three interrelated questions: how far must they travel, how long will it take, and how much will it cost? These questions may be addressed on a case-by-case basis, but in order to assess overall transportation system performance it is useful to devise indicators that incorporate elements of distance, time, cost, and ease of movement. Two fundamental concepts—mobility and accessibility—provide the foundation for devising such indicators. Both concepts refer to the potential created by the transportation system and both are attributes, not of the transportation system itself, but of the people, places, and firms that it serves.

Mobility, as defined here, refers to the *potential for movement*. Accessibility, a more comprehensive concept, refers to the *potential for spatial interaction with various desired social and economic opportunities* (i.e., the ease with which activities can be reached from a specific point in space). (Morris et al 1979)

A variety of statistical indicators could be used in assessing mobility and accessibility trends over time. For example, to assess the contribution of a new or expanded highway to mobility, a throughput indicator, such as the number of vehicle-miles, passenger-miles, or ton-miles occurring on a new route, might be used. This is a more useful indicator of mobility than physical capacity (e.g., lane-miles), because the potential for movement depends not only on the new and existing infrastructure, but also on its use by individuals and firms.

Movement, however, is not generally an end in itself. Transportation services are seldom consumed for their direct benefit, but instead for the indirect benefit of facilitating the various activities of those who use them. Measures of service throughput may not show much about the indirect benefits, so measures of the outcome of service are needed. (Sherwood 1994, 11–19)

Accessibility indicators are essentially outcomes measures that take into account not only mobility but also the ease by which locations of desired activities can be reached from other places. If applied to the above example, they should tell something about how a new highway makes it easier for people and firms to participate in a range of activities. To do this, accessibility indicators must integrate information on a highway, and its use by firms and people and their activities.

Subsequent chapters assess the role the U.S. transportation system plays in providing mobility and accessibility to Americans and their businesses. Before proceeding to that assessment, this chapter reviews the concepts of mobility and accessibility and the principles for devising empirical indicators.

The Concept of Mobility

This section focuses on mobility as it relates to the day-to-day movement of people and materials. A number of factors affect personal mobility, including the availability and cost of transportation and public infrastructure. Mobility in the business world is affected not only by availability of vehicles and infrastructure, but also by knowledge of available transportation and logistical options. Firms able to take advantage of transportation innovations, such as intermodal shipping, may have greater mobility. It is important to note that all these enabling factors also affect accessibility.

Other factors affect the potential for movement. For example, natural events, such as blizzards and floods, can reduce mobility temporarily. Physical restrictions, such as poor eyesight, narrow the transportation options of some people, thereby reducing their mobility.

The concept of mobility as defined here is not easy to quantify. Given the variety of factors that affect mobility, proxy measures such as availability of a car can give only a partial indication. Empirical studies usually rely on the concept of revealed mobility, which is defined as the number of miles traveled or trips taken, over some unit of time such as a day, week, or year.

The justification for using revealed mobility is that, other things being equal, people with high mobility will travel more than people with low mobility. In economic terms, we can think of high mobility as indicating a low cost of travel, measured in either dollars or time. Since travel generally confers some benefit, people will travel more as it becomes cheaper. One can think of examples, however, that reveal inconsistencies between the pure concept of mobility and revealed mobility. If a person who commutes by car moves to a new house that is closer to work, the number of miles traveled per week will go down, and revealed mobility declines. But has that person really become less mobile? Despite these inconsistencies, trends in revealed mobility can show a lot about the ability of people to travel and firms to move materials.

The Concept of Accessibility

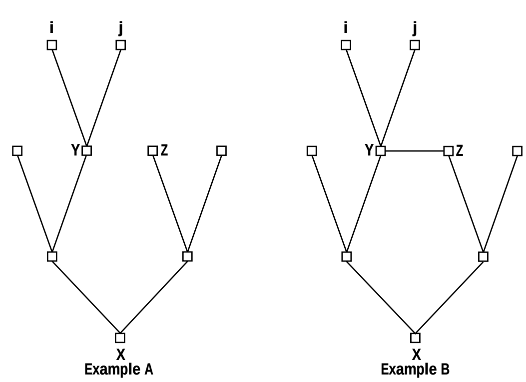
Although accessibility is an important concept in transportation and in urban and regional studies, it is not easy to define and measure. (Pirie 1979) Several useful measures of accessibility have been developed, however, including the two discussed below.

The accessibility of a person's workplace from home can be evaluated by determining the length of time it takes to commute. This is an example of *relative* accessibility because it evaluates one point relative to another. Alternatively, a newcomer to an area who has yet to find a job might want to know how accessible a neighborhood is to the area's major employment centers. In this case, accessibility can be measured by summing up the travel times from the residential neighborhood to major employment centers within a reasonable commuting range. (Such a measure is only meaningful if it is used to compare two or more points.) This is an example of *integral* accessibility because it integrates information about activities at a number of locations. In a similar way, integral measures may be created for shopping, recreation, and a range of other activities.

Both relative and integral accessibility depend on the locations of the point of evaluation and of the activities that can be reached from it. They also depend on the structure of the transportation network that connects the points. To take an extreme example, suppose a person lives directly across a river from her place of work, but has to drive several miles upriver to the nearest bridge. If a bridge is built adjacent to her home, her access to her workplace will improve greatly even though her revealed mobility, as measured by vehicle-miles traveled, will decline. This example illustrates that accessibility is not an immutable characteristic of a spatial pattern of activities. Transportation networks help to create accessibility.

To illustrate this point further, consider the two networks shown in figure 6-1. The first (example A) is a typical "branching network" where all links branch out from a central point X. This type of network is typical of transportation systems in early stages of development. (Robinson 1977) Here, point X is readily accessible from points Y and Z, but travel from Y to Z requires a highly indirect route passing through X. In the second network (example B), a single link is added to close the circuit connecting X, Y, and Z, as is typical in the later stages of network development. This improves the accessibility of point Y to point Z, thus enhancing the potential for interaction between them. The ability of networks to provide accessibility depends not only on the structure and length of links, but also on

Figure 6-1.
Accessibility of Transportation Networks



their capacities. If capacities are not sufficient to handle the traffic flow, congestion may set in, resulting in poor accessibility even between points that are well connected.

Accessibility measures are often adjusted to account for differences in the potential benefits that could be realized on reaching various destinations. In our simple network example, the number of shopping, recreational, and employment opportunities at point X may be greater than the number at point Y. Thus, even if the transportation cost from point Z to points Y and X were equal, the accessibility of point X is of more value because it provides a larger number of opportunities.

Another factor to consider is that not all trips made by the same individual begin from the same point. Someone who lives at Z may make a trip to point Y and then make another trip, perhaps for a completely different purpose, from Y to i or j. The benefit of reaching Y is therefore increased by the possibility of making further trips as part of a "trip chain." (Richardson and Young 1982)

The discussion above highlights location as it relates to accessibility. It also is useful to evaluate accessibility in terms of transportation options or other personal circumstances. For example, if two people have the same residential location, but one person has a car and the other does not, each person's access to employment and shopping activities may be very different. (Black and Conroy 1977; Martin and Dalvi 1976) Thus, mobility is a critical component of accessibility. Accessibility, however, takes the concept of mobility a step further by incorporating information on relative locations and the structure of networks.

The notion of accessibility may also be extended to incorporate a time element. A person with a wide variety of stores located within a half-hour's drive from his home may appear to have good access to shopping opportunities. If, however, he commutes by public transportation and does not arrive home until 5:30 p.m., and the shops close at 6:00 p.m., his access is curtailed. Access could be increased by changes in his work schedule that allow him to arrive home earlier or by extended store hours. It could also be increased by transportation system improvements that allow him to commute faster or to reach stores from his home faster. Thus, a broader concept of access, defined as the ability to participate in a variety of activities, must take account of time as a finite resource. (Burns 1979)

The concept of accessibility also can be applied to firms. Manufacturing firms benefit from accessibility of sources of inputs, markets for their outputs, and labor forces. Retail and other service firms may seek to be in locations where they are highly accessible to a large number of potential customers.

Many firms, especially those involved in nationwide or international business, are dependent on the ability to move freight long distances on a regular basis. For some firms, accessibility may depend on the location of specialized national or even global networks.

A retail store receives its merchandise by truck and sells to a residential market. For such a firm, accessibility depends on its location on the same road networks that are convenient for households to use. By contrast, firms that produce or use bulky materials (e.g., coal, iron ore, grain, and crude oil) can achieve high accessibility only at locations on networks providing transportation at low cost per ton, such as along railways, inland waterways, or at ocean ports. Where transport time, rather than cost, is the critical variable, locations close to major airports provide greater accessibility.

Although accessibility can be a critical determinant of where businesses locate, other factors, such as low wages, tax breaks, and local amenities, can induce firms to locate facilities in relatively inaccessible places.

The Relationship Between Mobility and Accessibility

Accessibility is an indicator of potential spatial interaction, while revealed mobility is an indicator of achieved movement. The proposition that people with good access to desired activities also have high revealed mobility has been the subject of a great deal of empirical investigation. Some studies find a positive relationship (Koenig 1980), while others conclude that the link is either weak or nonexistent. (Hanson and Schwab 1987)

This lack of consensus may arise from differences in the types of data used, differences in the behavior of different social groups, and the difficulty of devising meaningful indicators of mobility and accessibility. It may also suggest that other factors are at play, and the relationship between the two is more complex than initially imagined. In the case of urban residential real estate markets, a family can generally afford to own a larger and better house if it moves to a more remote area where real estate prices are lower. The household would be likely to travel more as a result of the move, because distances to work, shopping, and other related activities may be longer. Thus, its access goes down while revealed mobility goes up.

In light of this, it is best to think of accessibility and mobility measures not as opposite sides of the same coin, but rather as distinct and complementary indicators, which taken together provide a comprehensive picture of the outcomes of the transportation system.

The Importance of Mobility and Accessibility

Mobility and accessibility affect our lifestyles and economic well-being in many ways. They affect the evolution of the urban landscape, the livelihood of various social groups, and the growth and decline of regions.

Since before the industrial revolution, urbanization has been a pervasive trend in human social organization. The transition from an agrarian economy to one based on manufacturing and services brought the benefits of accessibility, which in turn increased the rate of urbanization. Cities bring complementary activities into close proximity, provide the infrastructure to connect them to major transportation networks, and create an environment conducive to the efficient exchange of goods and information.

In the 20th century, urbanization has been accompanied by increasing decentralization within cities—a phenomenon known as urban sprawl. This decentralization was supported by a succession of transportation innovations (e.g., streetcars, automobiles, and subways) that made longer intracity trips possible on a daily basis.

As early as the 1950s, accessibility measures were shown to be good predictors of the rate of land development around major metropolitan areas. (Hansen 1959) Examples are shopping and employment centers that tend to spring up around the junctions of major commuter roads, beltways, and Interstate highways.

Different socioeconomic groups often have different levels of mobility and accessibility. Mobility is necessary to take advantage of many benefits of economic growth. Many innovations in provision of services are based on the assumption that consumers have cars. For example, the new “big box” style of retailing makes it possible to provide goods at lower prices through high-volume, low-overhead operations.[1] Every aspect of these stores—from their locations, to their site designs, to their

[1] Big box retail refers to chain discount retail outlets housed in very large, single-story buildings. Typically a big box store contains 100,000 square feet or more of retail space.

interior layouts—caters to a highly mobile, automobile-oriented clientele.

How to make suburban jobs more accessible to inner-city residents—especially the urban poor—has become an important concern. The concentration of the poor in central cities coupled with the suburbanization of employment has created a spatial mismatch between low-skilled workers and low-skilled jobs. This is exacerbated by the fact that relatively few suburban jobs are located near public transit and many inner-city residents are without cars. (Simpson 1992)

A major focus of urban transportation planners has traditionally been accessibility of employment sites. In recent years, however, the number of nonwork trips has overtaken the number of commuting trips. Rising incomes and the suburbanization of the population have led to increased travel demand for shopping, a broad variety of personal services, and for recreational activities. Most of this travel is by car. The results of these trends include increased use of road networks for nonwork trips, therefore increasing congestion during offpeak periods.

On a broader scale, accessibility is a critical determinant of the economic growth and decline of regions. Historically, accessibility of resources afforded by the construction of the Erie Canal contributed to the importance of New York City. The establishment of Chicago as the main hub in a network of railroads gave it an advantage in accessibility that was unmatched in the Midwest. More recently, a major impetus to growth in west coast port cities has been their accessibility for shipments to and from burgeoning Pacific Rim economies.

Accessibility and Mobility in the Information Age

The emergence of new information technologies has a number of implications for the role that mobility and accessibility play in the economy and in our day-to-day lives. To the extent that spatial transfer of information can substitute for movement of people and goods, some transportation services may be displaced. Telecommunications networks and the Internet give rise to a kind of *virtual accessibility* that is largely divorced from physical distance and the structure of transportation networks.

In fact, this is hardly a recent phenomenon. From its first introduction, the telephone has reduced the need for mail communications and passenger travel. The effect of the telephone on mobility has intensified in the past 20 years, however. The dramatic growth of catalog sales was made possible by reductions in the cost of long-distance telephone calls and intercity parcel delivery. Technologies such as fax machines and computer modems have expanded the scope of information that can be transferred by telephone.

The Internet has made communications on a global scale very inexpensive and provides formats for the transfer of large digital files. The Internet is already used to transfer huge volumes of information from educational and other institutions and from government agencies to users scattered around the globe.

Practices like telecommuting and distance education could potentially displace millions of work and school trips. The barriers to further penetration of these innovations are now more institutional than technological, as conventions about working and teaching will first need to adjust to reduced face-to-face contact.

It is no simple matter, however, to assess the full impact of telecommunications on revealed mobility. Telecommuting will reduce the number of work trips, but it may result in workers choosing to live in ever more remote areas and making more and longer nonwork trips. (Nilles 1991) Also, technologies such as cellular phones, which release workers from the need to be near hardwired infrastructure, may lead to more travel occurring during the work day as opposed to during commute times.

Information technologies have also contributed to the evolution of an increasingly global economy. Ease of communication and coordination over long distances is part of the reason for growing regional specialization and trade, which ultimately requires more long-distance goods movement. A related trend is the *dematerialization* of the economy, whereby fewer bulky materials and more high-value components are transported. This trend should lead to slower growth in ton-miles of freight movement than would otherwise occur. At the same time, the need to coordinate production on a global scale should lead to demand for transportation services of ever higher quality.

Measuring Accessibility and Mobility

Assessments of mobility and accessibility require the development of quantitative indicators based on transportation and other statistics. The mobility indicators used in this report are measures of revealed mobility, so they are based on observed transportation activity. At an aggregate level, mobility can be measured as the total number of vehicle-, passenger-, or ton-miles traveled, or trips in the United States as a whole or in different regions. Such gross measures, however, fail to distinguish between increased travel due to overall population and economic growth and increased travel that reflects a greater propensity to consume transportation services—that is, an increased transportation intensity. To reflect intensity, transportation activity must be measured on a per-capita, per-household, per-vehicle, per-employee, or per-dollar of output basis.

Considerable insight can be gained by disaggregating mobility measures in various ways. For example, personal mobility, which may be measured as passenger-miles per capita, can be evaluated separately for different social groups based on age, sex, race, and income. Disaggregation can reveal differences in mobility among different groups of people. In a similar way, mobility measures can reveal differences in travel behavior between regions (e.g., the Northeast Corridor and high growth areas of the southwest). Calculating mobility by mode can show not only how much we travel, but also how we travel.

Measuring accessibility is more complicated than measuring mobility, because it requires information not only on travel but also on the location of destinations. Simple measures of relative accessibility may be based on distance, travel time, or travel cost of various places from a single important location. An example is travel time from the central business district (CBD), which may be evaluated as a measure of relative accessibility at different points in a metropolitan area. Such a measure, though, was more relevant in an era when opportunities for shopping, employment, and many other activities were predominantly found in the CBD. In present-day metropolitan areas, several locations offer extensive opportunities for such activities, so indicators of relative accessibility that measure time, cost, or distance to the nearest facility are more useful. Thus, accessibility indicators for a residential location might include average travel time to the nearest hospital emergency room, shopping mall, public school, or park.

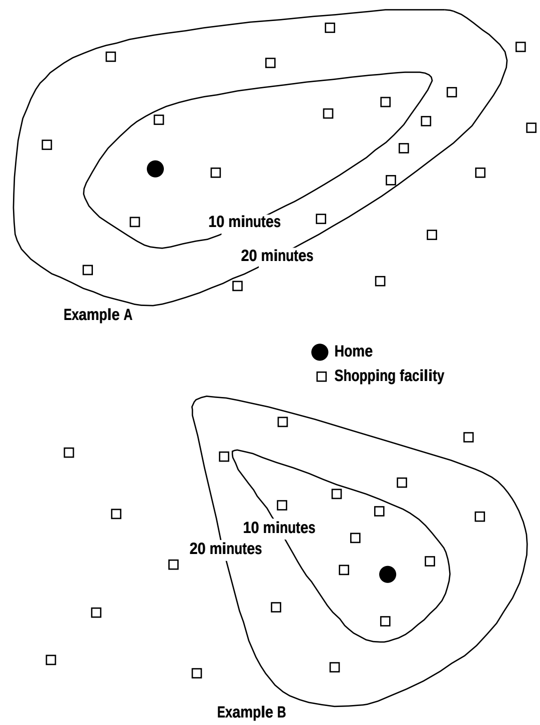
Given the variety of available opportunities and the fact that many people participate in the same activity (e.g., shopping) at different places at different times, measures of integral accessibility give a more realistic picture of the ability to reach desirable destinations. These measures can be complicated, as they must combine information about a variety of routes and destinations.

The simplest kind of integral accessibility indicator is called an *isochronic* measure. An isochrone is a line on a map that connects points of equal travel time away from a single reference point. If a person's home is used as the reference point, an isochrone may be drawn connecting points in all directions that can be reached in exactly 10 minutes (see figure 6-2). The isochrone will be irregularly shaped because the structure of transportation routes makes it possible to travel faster in some directions than in others. Also, the isochrone will depend on attributes of the person in question; if the individual does not have a car, the 10-minute isochrone will be smaller.

If an indicator of the individual's access to shopping opportunities is needed (the locations of shopping facilities are shown in example A), the number of facilities located within the 10-minute isochrone (in this case five) can be counted. If 20 minutes is considered a reasonable estimate of the time the individual is willing to travel for shopping, then a 20-minute isochrone is drawn. In figure 6-2, example A, doubling the travel time triples the number of shopping opportunities to 15.

In general, accessibility measures are most useful when they are evaluated at more than one point and compared. Example B in figure 6-2 shows the location of a second person's home in the same area. Drawing isochrones again, it is apparent that 7 shopping facilities are within 10 minutes and 13 within 20 minutes. Comparing these two cases points up one of the main weaknesses of isochronic measures. The second person has superior access based on the 10-minute isochrone, while the first person has superior

Figure 6-2.
Accessibility by Travel Time from Home to Various Locations



access based on the 20-minute isochrone. Thus, these measures are highly sensitive to the analyst's judgment about what constitutes reasonable travel time. It is important to note that there may be a point at which access to additional facilities has little value to an individual.

Despite the shortcomings, isochronic measures can be useful in evaluating accessibility from the standpoint of different socioeconomic groups. Average isochronic accessibility to locations of jobs for people of different income groups or residing in different parts of a metropolitan area can shed light on the dynamics of urban labor markets. Using this approach, one study arrived at the surprising conclusion that in Los Angeles accessibility was lower for middle-class people than either low- or high-income people. (Wachs and Kumagai 1973) Looking at the Newark metropolitan statistical area and using an approach that draws lines of equal distance rather than time, another study found that the proportion of jobs within 10 miles of the central city declined from 62 percent in 1960 to 40 percent in 1988, indicating that accessibility of jobs for inner-city residents had declined relative to that of suburbanites. (Hughes 1991)

In order to overcome the sensitivity of isochronic measures to a single predefined travel time, alternative measures that incorporate the time, cost, or distance between the reference point and each of the potential destinations can be used. For example, to compare the access level of the people in figure 6-2, the travel time from their homes to all the shopping facilities could be measured separately and then an average taken. The person with the lower average travel time has the most access. This approach can be extended to incorporate information about individual destinations. For example, if shoppers value access to enclosed malls more highly than access to shopping plazas, a weighted average can be calculated by which travel times to malls have twice the weight as travel times to plazas. In this case, being close to a mall would contribute more to overall accessibility than being close to a plaza.

There are a number of other ways to refine measures of accessibility. It may be better to weight the importance of different destinations on a continuous scale (based on, say, retail floor space or the number of goods available for sale). Corresponding measures of attractiveness can be devised for accessibility to employment. It may be better to incorporate travel time in a nonlinear way—increasing the importance of the nearest destinations and discounting the importance of those that are more remote.

Similar types of accessibility measures can be calculated for firms, but the relevant information that goes into these measures will vary for different industries. In general, accessibility of sources of inputs and markets is important for manufacturing firms. If both of these are good, then the firm has a favorable location in terms of transportation. For a steel works, accessibility of the bulky inputs of coal and iron ore is important, as well as accessibility of major industrial users such as automotive plants and centers of construction activity. An appliance manufacturer's transportation costs will depend on the accessibility of companies that produce components, such as electric motors, compressors, and tubing, and on accessibility to the major centers of population that provide its markets.

There are many firms for which transportation makes up only a small fraction of total costs. For them, accessibility of suppliers and markets may be of less concern. Location relative to universities and research centers, to pools of highly skilled labor, and even to the locations of their competitors is of great concern, so accessibility indicators based on these factors are more relevant.

Another important issue for the calculation of accessibility indicators is the geographical scale at which they are measured. By definition, accessibility is evaluated at a single point. By calculating accessibility at different points it is possible to map patterns at a national or regional scale. An accessibility measure that applies to an entire zone or region may also be useful. This can be done by taking an average over a number of points within the zone. An interesting example of this type of measure is a recent study that calculates an indicator of the average accessibility of points within U.S. metropolitan areas (see box 6-1.)

Box 6-1.
Internal Accessibility Within U.S. Metropolitan Areas

Accessibility is usually defined as an attribute of a point in space. The concept may be extended to a region, if it is defined as the ease of moving from one destination to another within its borders; this is a measure of internal accessibility. For example, two metropolitan areas may have a roughly equal population and an equal number of workplaces, shopping centers, and recreational facilities. One area has higher internal accessibility than the other if the trips between important origins and destinations are shorter.

An evaluation of this type was recently conducted by the Wharton School and the University of Pennsylvania. For the 60 largest U.S. metropolitan statistical areas (MSAs), a number of points representing residential or activity locations were chosen. For each point, the travel time to each point was estimated based on the existing road network, taking account of different average speeds on different classes of road. An average was calculated for each origin and then an average of the averages was calculated. The resulting figure is the estimated average travel time from point to point within the MSA (see table). Variations in the values across metropolitan areas may be attributed to two factors: the dispersion of the reference points in space and the structure and quality of the road network.

SOURCE: W.B. Allen, D. Liu, and S. Singer. 1993. Accessibility Measures of U.S. Metropolitan Areas. *Transportation Research B* 27B:439–449.

Internal Accessibility Measures for the 60 Largest MSAs

MSA	Average travel time (minutes)	MSA	Average travel time (minutes)
Sacramento, CA	69.72	Cleveland, OH	48.32
Houston, TX	69.45	Indianapolis, IN	47.16
Phoenix, AZ	67.79	San Antonio, TX	46.86
Tulsa, OK	67.76	Allentown, PA	46.84
Dallas. TX	65.49	Kansas City, MO	46.63
Los Angeles, CA	62.53	Tampa, FL	46.62
Detroit, MI	62.00	Dayton, OH	46.59
Pittsburgh, PA	61.52	Buffalo, NY	46.41
Rochester, NY	60.42	Honolulu, HI	46.37
St. Louis, MO	59.43	Orlando, FL	46.05
San Diego, CA	58.24	Ft. Lauderdale, FL	45.76
Greensboro, NC	57.73	Cincinnati, OH	45.50
Denver, CO	57.42	Toledo, OH	45.39
Nashville, TN	57.18	Columbus, OH	44.51
Birmingham, AL	56.71	Seattle, WA	44.45
Miami, FL	56.59	San Francisco, CA	42.46
Atlanta, GA	56.19	Louisville, KY	42.26
New York, NY	55.23	Charlotte, NC	40.09
Minneapolis, MN	55.08	Richmond, VA	40.50
Hartford, CT	54.97	Philadelphia, PA	40.17
Syracuse, NY	54.88	Milwaukee, WI	39.53
Albany, NY	54.14	New Orleans, LA	39.39
Providence, RI	52.95	Baltimore, MD	36.64
Chicago, IL	52.72	San Jose, CA	35.92
Oklahoma City, OK	51.42	Youngstown, OH	34.87
Salt Lake City, UT	50.95	Gary, IN	34.33
Memphis, TN	50.49	Anaheim, CA	34.16
Boston, MA	50.17	Grand Rapids, MI	32.97
Portland, OR	49.44	Newark, NJ	30.46
Washington, DC	48.68	Akron, OH	30.00

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Personal Mobility in the United States

The United States, quite possibly the world's most mobile society, is more mobile now than ever before. A small but growing number of people elect to live in places that require them to travel over 50 miles one way to work each day. (Ball 1994, 23) Many others think nothing of hopping on a plane for a day trip or a long weekend excursion of hundreds or thousands of miles, not only for business, but for pleasure. Between November and December 1994, one airline offered day-trip service from 55 cities to a gigantic shopping mall located close to the airport in Minneapolis, Minnesota. (Pressler 1994) From Washington, DC, one of the cities served, the one-way distance to Minneapolis is more than 1,000 miles, further than traveling from London to Budapest. The fact that ordinary citizens can routinely traverse great distances is one of the great triumphs of American society, one often taken for granted, and one rarely matched anywhere else (see chapter 10).

This chapter focuses on the household-based transportation of people in the United States. It examines revealed mobility, a term discussed in detail in chapter 6, using such measures as the number of trips taken and the number of miles traveled per person. Several questions are considered here: what is the overall level of personal mobility now and how has it changed; why do people travel; what modes of transportation do they use and at what cost in time and money; and how does personal mobility vary among people according to income, sex, age, and location (e.g., rural/

metropolitan, central city/ suburb, or region of the country)? For the most part, the quality of mobility is not examined, but box 7-1 outlines its importance.

Personal Mobility Trends

By all indications, revealed mobility has risen appreciably over the past quarter century. This trend has been influenced by, among other things, changes in the labor force, income, and the makeup of households and metropolitan areas. As baby boomers and women poured into the labor force, the civilian labor force increased by 50 million people between 1970 and 1995, reaching 132 million people. Overall, the population increased by 59 million over this period. The number of women working outside the home nearly doubled, from about 32 million to 61 million. From 1970 to 1995, the number of households increased by 56 percent, partly as a result of households declining in size from 3.14 people in 1970 to 2.65 in 1995. (USDOC Census 1996) More households translate into more trips for shopping, recreation, and taking care of children's needs.

Changes in locations where people, live, work, and shop increased travel and dependence on private vehicles. Between the 1970 and 1990 censuses, the population in metropolitan areas grew from 140 million to 189 million.[1] Between 1980 and 1990, the central cities lost 500,000 people, while the suburbs gained 17.5 million. At the same time, the suburban share of jobs rose from 37 percent to 42 percent. The shift in the location of jobs changed travel patterns. In 1990, 43 percent of all metropolitan commutes were from suburb to suburb, while suburb-to-downtown commutes made up only 20 percent. (Pisarski 1996) As metropolitan areas expanded and low-density suburbs spread into rural areas, mass transit struggled to provide the same level of service as in higher density city cores. Thus, private vehicle trips soared, as they offered the most direct connections for many suburb-to-suburb commutes.

Increases in the number of motor vehicles also contributed to the growth in passenger-miles traveled. The number of automobiles grew from 89 million in 1970 to 146 million in 1993.[2] (USDOT FHWA Various years) This increase is partly related to income growth. Disposable personal income per capita rose from about $12,000 in 1970 to $18,800 in 1995 (in chained 1992 dollars). (USDOC Census 1996) When people have more money to spend, they spend more on transportation, particularly on personal vehicles and long-distance travel. Growth in personal vehicles goes hand in hand with the ability to drive which, not surprisingly, has an enormous impact on mobility.

Detailed information about mobility and the mobility of specific groups within society is available from four national surveys, the Nationwide Personal Transportation Survey (NPTS) conducted in 1969, 1977, 1983, and 1990 (described in box 7-2). The NPTS conducted in 1990 revealed that on average each person made 3 trips a day, covering almost 29 miles, in that year.[3] (USDOT FHWA 1992, 6) That was an increase from 26 miles a day in 1977, but only a slight increase in the trip rate (see table 7-1). Daily vehicle-miles and daily vehicle-trips per

[1] Figures for 1990 are calculated using 1980 metropolitan area definitions and therefore differ from figures based on current U.S. census definitions. (Pisarski 1996, 18)

[2] Until 1994, the Federal Highway Administration counted some minivans, pickup trucks, and sport utility vehicles as automobiles. Beginning in 1994, however, these types of vehicles were reclassified as trucks. As a result, the number of private passenger vehicles after 1994 is difficult to compare with earlier data. In 1995, if the number of private automobiles is added to pickups, vans, sport utility vehicles, and other light vans, the total is 193 million.

[3] This section uses travel-day unadjusted figures.

Box 7-1.
The Quality of Mobility

Mobility contributes to the well-being of people by expanding their geographic range of choices, whether for meeting basic needs (e.g., health care) or broader social needs (e.g., visiting friends and attending community meetings). Moreover, people's sense of well-being can be affected by their ability to choose their mode of transportation and their perception of its comfort (including the level of stress), safety, security, reliability, and personal control. (Leinbach et al 1994; Carp 1988) These quality factors affect whether an individual looks forward to travel, tolerates it, dreads it, or tries to avoid it. As some of these factors are subjective—tolerance of discomfort, for example, varies among people—the quality of mobility is difficult to measure.

The popularity of automobiles derives, in part, from the general perception that they are relatively secure, give a high degree of personal control, and are often more comfortable than other modes of transportation. In surveys of the elderly, the absence of a car, resulting in dependence on friends, relatives, or public transit, was associated with a less satisfactory lifestyle and loneliness, as well as lower activity levels. Being able to drive was reported as making one feel free and independent. (Carp 1988) On the other hand, driving can be a high stress experience. This is particularly true in congested metropolitan areas. High speeds, traffic, and confusing road signs are a source of stress for many people, especially the elderly. Furthermore, people are more likely to be injured or killed in an automobile crash than in a train, plane, or bus.

Choice among different modes of travel is another dimension of mobility that can affect well-being. Currently, in the United States, the passenger car and the airplane allow most people a high level of mobility in reasonable comfort at generally affordable prices. People have more limited options if their travel preferences involve trains or buses.

The quality of mobility may also affect mobility patterns. If people perceive the available transportation options to be uncomfortable or unsafe, some may choose not to travel at all, or may limit the number of trips they take. This is particularly true for discretionary trips. In a world that offers many communications alternatives—from mail and the telephone to home videos and the Internet—there are many ways to stay in touch with others that do not require travel. By contrast, if people think travel is safe, comfortable, and affordable, they will take more trips and may also use transportation itself as a form of recreation, such as a drive along a scenic highway or an ocean cruise.

When individuals perceive one mode of transportation to be deficient in the qualities they value the most, they may use other transportation options even if they are more expensive or time consuming. Some people, for instance, are afraid to fly and will insist on using another means of transportation, even on very long trips. Some people fear parking their cars in unguarded lots or using transit because of the real or perceived concern about exposure to harassment and crime when walking to and from their vehicles. They may use a more expensive option such as a taxi, or elect to travel less.

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household increased by around 20 percent between 1969 and 1990.[4]

The 1990 data show that people who can drive (defined as those with licenses) take almost twice as many person-trips a day by all modes as those who do not drive (3.5 compared with 1.9), travel more than three times as far (33.8 miles a day compared with 11.1 miles a day), and make trips that are much longer (10.2 miles compared with 6.5 miles). (USDOT FHWA 1993a, 4-18) Identifying those who do not drive is, therefore, an important task when discussing personal mobility problems (see below).

Furthermore, as will be discussed in more detail below, people have very different levels of mobility (see figure 7-1). Men, particularly white

[4] Trip-length calculations are based only on observations with valid trip-length data. (USDOT FHWA 1993a, 4-4)

Box 7-2.
The Nationwide Personal Transportation Survey

One of the few detailed national data sources on personal mobility in the United States is the Nationwide Personal Transportation Survey (NPTS), sponsored by the U.S. Department of Transportation (DOT). First conducted in 1969, the survey was also carried out in 1977, 1983, 1990, and 1995. The 1995 survey was sponsored by several DOT agencies, including the Federal Highway Administration, the Bureau of Transportation Statistics, the Federal Transit Administration, and the National Highway Traffic Safety Administration. Data from the 1995 survey will not be released until late 1997 and, therefore, are not included in this report.

In 1990, data were collected from 22,000 households representing all residents of the 50 states and the District of Columbia. Because of budgetary constraints, only 6,500 households were surveyed in 1983, contributing to a larger sampling error in that year. The most recent survey in 1995 was conducted with approximately 21,000 households.

The NPTS data are collected and available in two sections. The travel-day section asks respondents about trips of any length on a designated day. The second part, the travel-period section, asks people about long-distance trips (trips of 75 miles or longer) completed in the preceding two weeks or ending on the travel day. Thus, the travel-day data include both short- and long-distance trips on the designated day and the travel-period data include all trips over 75 miles in a two-week period including the travel day. Because of the overlap, the travel-day and travel-period data cannot simply be added together to derive and estimate total travel. Some data in the NPTS reports subtract long-distance trips from travel-day trips and is labeled travel-day-adjusted. (USDOT FHWA 1993a, 2-1 to 2-18) Many of the detailed data in the NPTS are travel-day *unadjusted*. In 1990, information on 150,000 travel-day trips was collected. These data are the most widely used because of the rich detail this information provides, the great interest in average daily travel, and the fact that these data can be compared with those in urban travel surveys.

The NPTS collects information on commercial and institutional driving, such as driving a bus, taxi, airplane, or train, driving for goods delivery, and jobs that involve driving (e.g., a patrolling police officer). These data are reported separately from the estimation of personal travel found in the travel-day and travel-period data. As a result, estimates of personal travel made from the NPTS vary from estimates of passenger and vehicle travel found in other documents such as *Highway Statistics* and *National Transportation Statistics*. For instance, *Highway Statistics* estimated personal vehicle-miles traveled in 1990 at 1.9 trillion miles, whereas the 1990 NPTS estimate was 1.6 trillion. (USDOT FHWA 1993a) Estimates from the NPTS are subject to sampling and nonsampling errors. Therefore, care should be taken when interpreting small differences between sample estimates[1]

More detailed data on long-distance trips will soon be available from the 1995 American Travel Survey being conducted by the Bureau of the Census for the Bureau of Transportation Statistics. It will report on origins and destinations, long-distance commuting, all types of transportation used for a trip, how many nights away from home a trip involved, where people stayed, the reason for the trip, and whether there were any side trips. This information will be available by income, education, employment, and type of vehicle owned.

[1] Standard errors for selected summary statistics and an explanation of estimating sampling errors for the 1990 NPTS are contained in USDOT FHWA 1993b.

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U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA). 1993a. *Nationwide Personal Transportation Survey: 1990 NPTS Databook, Volume 1.* Washington, DC.
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men, have a very high level of mobility compared with women, especially women of color. For instance, white men (aged 16 to 64) who live in urban areas travel nearly two and a half times as much as Hispanic women (aged 16 to 64) in urban areas. Age has a very important impact on people's travel behavior, with those in the 40 to 49 age cohort traveling two and a half times more than people over 65. Income affects a person's ability to travel. People in households with income over $40,000 per year travel more than twice as much as those in households under $10,000 per year. Data also show that suburban residents travel about 30 percent more than

Table 7-1.
Average Daily Travel: 1969–90
(Travel day unadjusted)

Type of measure	1969	1977	1983	1990	Percentage change 1969–90
Daily person-miles traveled per person[1]	NA	25.90	25.00	28.60	NA
Daily person-trips per person[1]	NA	2.92	2.89	3.08	NA
Average person-trip length (miles)	9.67	8.87	8.68	[2]9.45	–2.3
Daily vehicle-miles traveled per household	34.00	33.00	32.20	41.40	21.8
Daily vehicle-trips per household	3.80	4.00	4.10	4.70	23.7

[1] Persons over five years old.
[2] Based on observations with valid trip-length data.

SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1993. *Nationwide Personal Transportation Survey: 1990 NPTS Databook, Volume 1.* Washington, DC. pp. 3-4 and 4-4.

those who live in the central city, and slightly more than those who in live in rural areas.

Why and How People Travel

Mobility is accomplished through local travel, made on a daily basis, as well as long-distance travel, typically made infrequently. Although the NPTS includes data on both types of travel, we know much more about the former than the latter. To rectify this situation the Bureau of Transportation Statistics sponsored the American Travel Survey (ATS) conducted by the Census Bureau in 1995, which focuses exclusively on long-distance travel (see box 7-2). ATS results should be available in 1997.

► Daily Travel

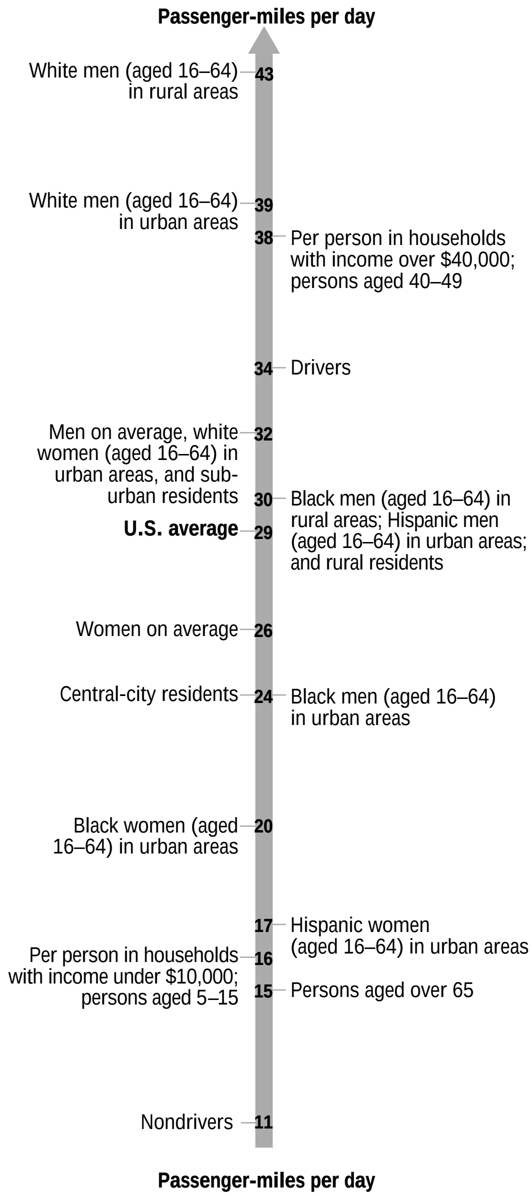
In 1990, more than one-third of the average person's travel-miles had a social or recreational purpose, including vacationing and visiting friends; another third involved family and personal business, including shopping and doctor and dentist visits (see table 7-2). Approximately one-quarter of the travel-miles were for earning a living. Work trips, however, are more important than their share of person-miles and person-trips suggest, because work trips tend to structure how and when other trips take place (see box 7-3 on trip chaining).

Between 1983 and 1990, person-miles increased in most trip categories (see table 7-2). Person-miles traveled for family and personal business increased by 50 percent, the greatest increase in any category. Smaller growth occurred in the number of miles traveled to earn a living (22 percent), for civic, educational, and religious reasons (14 percent), and social and recreational trips (3 percent).

In 1990, 87 percent of person-trips were made in privately owned vehicles (mostly cars and light trucks), up from 82 percent in 1983 (see table 7-3). Private transportation was more likely to be used for all types of trips in 1990 than in 1983, except for the category of "other."[5] One reason for the growth in tripmaking by automobile is that people are most likely to use them for the most rapidly growing type of trip, those made for family and personal business (see table

[5] These calculations are based on travel-day data and do not include most long-distance travel. Thus, the data ignore modes more likely to be used for long trips like airplanes.

Figure 7-1.
Miles of Daily Travel: 1990



SOURCES:
S. Rosenbloom. 1995. Travel by the Elderly. *1990 NPTS Report Series: Demographic Special Reports.* Washington, DC: U.S. Department of Transportation, Federal Highway Administration.
_____. 1995. Travel by Women. *1990 NPTS Report Series: Demographic Special Reports.* Washington, DC: U.S. Department of Transportation, Federal Highway Administration.
U.S. Department of Transportation, Federal Highway Administration. 1993. *1990 Nationwide Personal Transportation Survey: 1990 NPTS Databook, Volume 1.* Washington, DC.

7-2). Public transit accounted for only 2 percent of all trips. People are most likely to use public transit for work-related trips and least likely to use it for family and personal business (USDOT FHWA 1993a, 4-70). Other modes of transportation—including airplanes, trains, taxis, walking, bicycles, and school buses—accounted for nearly 11 percent of all trips (see box 7-4 for a discussion of nonmotorized mobility). Not surprisingly, more than one-third of civic, educational, and religious trips are made by these other modes, especially trips made by school bus.

► Long-Distance Travel

Many of the data discussed here reflect short trips, similar to information collected by urban travel surveys. This is only a piece of the total travel picture, because in 1990 approximately 30 percent of person-miles, 3,700 per person, took place on long-distance trips (defined as trips over 75 miles),[6] compared with nearly 8,300 on local travel.[7] Three-quarters of the person-miles made on long-distance trips in 1990 were made for social and recreational reasons (see table 7-4). Only 9 percent of long-distance travel was work related, mostly business travel, though some was commuter travel. Private vehicles were used for 70 percent of the person-miles traveled on long-distance trips (see table 7-5). Less than 1 percent involved public transit. The remaining 29 percent were made by "other" means, overwhelmingly by airplane (27 percent). One-fifth of person-miles made by airplane in 1990 were for business reasons. (USDOT FHWA 1993b, 8-23)

► International Travel

Globalization of the economy has resulted in a marked increase in Americans traveling abroad

[6] Data here are from the travel-period section of the NPTS (see box 7-2).
[7] Data here are from the travel-day section of the NPTS and are adjusted to remove long-distance trips.

Table 7-2.
Number of Person-Miles Traveled by Trip Purpose: 1983 and 1990
(Travel day unadjusted)

Trip purpose	1983 Person-miles (millions)	1983 Percent	1990 Person-miles (millions)	1990 Percent	Percentage change, 1983–90
Total	1,946,662	100	[1] 2,315,273	100	19
Earning a living	511,393	26	623,536	27	22
Family and personal business	484,358	25	724,112	31	50
Civic, educational, and religious	130,563	7	149,272	6	14
Social and recreational	778,459	40	799,675	35	3
Other	41,889	2	18,197	1	–57

[1] Includes miles of travel where trip purpose was unreported.

SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1993. *1990 NPTS Databook: Nationwide Personal Transportation Survey, Volume 1*. Washington, DC.

for both business and pleasure. Cheaper international airfares, large amounts of U.S. investment overseas, and direct foreign investment in the United States have contributed to this trend. For instance, between 1980 and 1995, the yield (passenger revenue divided by passenger-miles) on international flights by U.S. major, national, and large regional carriers declined by 30 percent from 12.5¢ per mile to 8.7¢ per mile (in constant 1987 dollars). Between 1986 and 1995, the number of departures of U.S. residents to international destinations increased by 38 percent, from 37 million to 51 million. (USDOC ITA 1996)

International travel is dominated by trips to Canada and Mexico. In 1995, nearly 19 million people, or 37 percent of all international travelers from the United States, journeyed to Mexico, while 13 million, 25 percent, visited Canada. Departures to overseas destinations made up the remaining 38 percent. The top 10 destinations of U.S. residents in 1995, after Mexico and Canada, were the United Kingdom, France, Germany, Italy, Jamaica, the Bahamas, Japan, Hong Kong, the Netherlands, Switzerland, and Spain. (USDOC ITA 1996)

Travel Time and Speed

Related to the concept of mobility is speed. If all else remains equal, an increase in speed means an increase in mobility. Clearly, one reason that people are able to travel further today than in the past is that, among other things, the quality of roads, the availability of personal automobiles, and the development of commercial aviation allows people to travel faster. Some researchers contend that mobility increases only when speed increases, based on the observation that people in advanced industrialized countries allot a fixed amount of time to traveling each day. (Hupkes 1982; Zahavi and Talvitie 1980; Walker and Peng 1991) Some support for this argument comes from a recent review of results from a household travel survey conducted in 1965, 1981, and 1990 in the San Francisco Bay area. (Purvis 1994) According to the survey, the average time per household spent traveling in the Bay area per weekday was 2.71 hours in 1965, 2.80 hours in 1981 and 2.68 hours in 1990.

Nationally the available evidence suggests that travel speed increased between 1983 and

Box 7-3.
Trip Chaining

A person-trip in the Nationwide Personal Transportation Survey (NPTS) is defined as "one-way travel from one place (address) to another by means of transportation." This is a valid method of measurement for simple trips from one place to another, but does not fully capture the complexity of journeys involving multiple stops know as trip chains. People often combine trips into more complicated journeys by, for instance, stopping at the supermarket on the way home from the fitness club or dropping off children at school on the way to work. It has been estimated that 46 percent of all person-trips in 1990 were made in these trip chains, with 16 percent involving work as an origin or destination and 30 percent not involving work. (Strathman and Dueker 1995)

Research (Strathman and Dueker 1995; Stratham et al 1994) based on NPTS data shows:

- Women are more likely to trip chain than men, especially with work-related travel. On work commutes, 31 percent of men's and 42 percent of women's trips involved another destination.
- Higher income households combine work and nonwork trips more often than do lower income households.
- Trip chains, both work and nonwork related, are more likely to occur during rush hours than unchained trips.
- Trip chains are more likely to be taken by automobile than simple trips. It is unclear whether automobile use encourages trip chaining or if the desire to trip chain encourages automobile use. Trip chaining behavior, however, appears to put other modes of transportation, like transit, at a disadvantage.
- Suburban residents are somewhat more likely to trip chain to or from work than are central-city residents or nonmetropolitan residents.
- Single persons and two-adult households in which both work are more likely to chain trips. The increase in such households is one reason for the growth in trip chaining.
- Because only the last leg of a trip chain to or from work is coded as a work trip in the NPTS, the distance between home and work is underestimated. If trip chaining is taken into account, it is estimated that the mean distance to work is 11.05 miles not 10.46 miles, a 5.6 percent difference. Likewise the time of a work trip is estimated to be 20.4 minutes not 19.3 minutes, a 5.3 percent difference.

Trip chaining suggests that the journey to work is a more important organizational element in people's daily travel than a simple proportion of total trips. Chaining also provides a plausible explanation for the rise in nonwork trips, often thought of as discretionary travel, scheduled during peak travel times. If trip chains involving work are added to simple work trips, then 30 percent of all person-trips are structured around the work schedule compared with only 22 percent when trip chains are ignored. Further, information is needed to determine the impact of trip chaining on the amount of travel done at peak times and its effect on congestion. It is possible, however, that because trip chaining with work travel encourages nonwork travel during peak hours, rescheduling work travel at nonpeak times would have a greater effect on congestion than simply decreasing work trips. Moreover, because trip chaining most often involves automobiles, getting people to shift to carpools or transit from single-occupant vehicles might reduce nonwork travel during the rush hour, which could have a larger impact on congestion than implied by the reduction in work trips alone. It is also likely, however, that it might be harder to induce people to reschedule work trips or switch to other modes if the work trip is coordinated with other trips, such as dropping off children at school.

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J.G. Strathman, K.J. Dueker, and J. Davis. 1994. Effects of Household Structure and Selected Travel Characteristics on Trip Chaining. *Transportation* 21:23–45.

1990, at least for commuting. The NPTS estimates that for the nation as a whole the average daily commute time rose by 10 percent between 1983 and 1990 from 18.2 to 20.0 minutes. The average commute distance, however, increased by 26 percent, from 8.5 miles to 10.7 miles. Thus, the average commute speed rose from 28.0 mph to 33.3 mph, a 20 percent increase. (USDOT FHWA 1993b, 6-21) Commute distances and speeds increased the most in non-

Table 7-3.
Person-Trips by Mode and Purpose: 1983 and 1990
(In percent, travel day unadjusted)

	Private		Public		Other[1]	
Trip purpose	**1983**	**1990**	**1983**	**1990**	**1983**	**1990**
Total	82.0	87.2	2.4	2.0	15.6	10.8
Earning a living	87.1	91.2	4.5	3.9	8.4	4.9
Family and personal business	87.9	92.6	1.1	1.0	11.0	6.4
Civic, educational, and religious	55.9	61.9	4.7	3.8	39.4	34.3
Socal and recreational	81.2	86.3	1.6	1.2	17.2	12.5
Other	83.7	81.4	0.8	1.9	15.5	16.7

[1] Includes trips by bicycle, walking, school bus, taxi, airplane, train, moped, and other modes.

SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1992. *Summary of Travel Trends: 1990 Nationwide Personal Transportation Survey.* Washington, DC. Table 19.

metropolitan statistical areas, by 72 percent and 40 percent, respectively. Commute speeds in suburban areas of metropolitan statistical areas (MSAs) increased about 16 percent, while commute distances increased by 27 percent. Commute speed in central city areas of MSAs increased by 26 percent and trip distance increased by 20 percent. (USDOT FHWA 1993b, 6-21) Although these data are hard to compare with data from earlier NPTSs, this increase in commute speed seems to confirm an earlier trend for the nation as a whole going back to 1969. Trip distance, on the other hand, declined between 1969 and 1977 before lengthening again in 1983 and 1990. (USDOT FHWA 1986, 7-6)

Speed is up for several reasons. Some of the increase is a result of the shift from relatively slow modes of transportation—such as transit, carpooling, and walking—to the relatively quicker mode of the single-occupant private vehicle. Speed has also increased with the shift of population and employment to the suburbs where, on the whole, speeds tend to be faster. For example, transit buses and trains run faster in the suburbs because of less frequent stops. Thus, despite evidence that congestion increased in most metropolitan areas in the mid- to late 1980s (see chapter 1), average trip speed has not declined.

Time spent commuting has, however, increased, because people travel farther to work. The increase in commuting distance suggests that the suburbanization of work has not resulted in a closer proximity between home and work, even though this is a possibility as people adjust their residences in response to the changing geography of employment. Urban sprawl is a potent force in metropolitan areas for several reasons. Large plots of cheap land on the urban fringe and beyond, often with less restrictive local government controls, are enticing areas for developers. The development of suburban concentrations of employment allow people to live great distances from the center of the urban region and has led to long-distance commuting, as people are more likely now to commute from suburb to suburb.[8] Moreover, households with two wage earners,

[8] One study demonstrates that the time for suburb-to-suburb commuting within the same metropolitan area (MA) is 19.4 minutes, while suburb-to-central city commuting within the same MA is 16.9 minutes. (Pisarksi 1996, 87) As commuting in the suburbs is faster than traveling in the central city, it is reasonable to assume that commutes are longer with the growth of suburb-to-suburb commuting.

Box 7-4.
Bicycling and Walking

Despite the dominance of motorized transportation in the United States, nonmotorized modes—primarily bicycles and walking—remain important. In 1990, nearly 8 percent of all trips were made by nonmotorized forms of transportation (7.2 percent on foot and 0.7 percent by bicycle), a drop from 9.3 percent in 1983.[1] (USDOT FHWA 1993a, 4-41) As pedestrian and bicycle trips are short, averaging 0.6 miles and 2.0 miles respectively, they accounted for less than 1 percent of all person-miles in 1990. Because of their low cost, benign impact on the natural environment, and positive impact on public health, research to seek new ways to encourage walking and bicycling to fulfill people's mobility needs was sponsored by the Department of Transportation. (USDOT FHWA 1994)

The Nationwide Personal Transportation Survey (NPTS) provides the most detailed data on nonmotorized transportation available. The definition of a trip excludes recreational bicycling and walking trips that begin and end at the same address with no intermediate destination. The data show men are more likely to make bicycle trips than women, accounting for 72 percent of all trips made by this mode in 1990. Women, however, made slightly more trips on foot than men, 53 percent of all walking trips in the same year. Both biking and walking decline with age. Trips on foot, for instance, decline rapidly between the ages of 16 and 29, with a slight increase for people over 50. Walking also declines as income increases, from 1.5 daily trips averaged by households with income under $10,000 to 0.5 daily walking trips by households with over $40,000 in income. Households in the income brackets between these end points all clustered around 0.6 daily walking trips. There seems to be no relationship between bike trips and income. Households in the $30,000 to $40,000 bracket were found to take, on average, slightly more bike trips (0.09 a day) than households under $10,000 (0.08 trips a day). Households with children make more nonmotorized trips than households without children. (Niemeier and Rutherford 1995)

Biking and walking trips tend to be "U-shaped" with regard to urban size. The fewest of both types of trips occur in metropolitan statistical areas (MSAs) with populations of 500,000 to 999,999, and the most occur in urban areas of 50,000 to 199,000 and in cities over 1 million. In addition, more walking trips occur in MSAs of over 1 million that have a subway. Walking trips tend to increase with population density over 4,000 people per square mile, but the number of bicycle trips shows no relationship to density. (Niemeier and Rutherford 1995)

The 1990 NPTS found that the greatest number of nonmotorized trips (55 percent of bicycle trips and 34 percent of walking trips) were made for social and recreational purposes, a slight increase from 1983. Family and personal business ranked next (20 percent biking and 32 percent walking) and civic, educational, and religious purposes follow at 14 percent bicycling and 20 percent walking. People were least likely to use nonmotorized transportation for trips related to earning a living (10 percent biking and 12 percent walking). (Niemeier and Rutherford 1995) The Census Bureau found that 4.5 million (4 percent) of the population commuted to work by walking in 1990, a decline from 5.6 percent in 1980. In addition, a half million people bicycled to work in 1990. (USDOT FHWA 1993b)

At current levels of activity, the environmental implications of nonmotorized trips are unclear. The evidence shows that, except for households with income below $20,000, households do not replace motorized with nonmotorized trips. The NPTS also shows that households making nonmotorized trips tend to average fewer daily vehicle-miles traveled. Pedestrians and bicyclists accounted for about 15 percent of traffic fatalities involving motor vehicles in 1995. As discussed in chapter 3, adequate measures of exposure risks for nonmotorized modes do not exist.

[1] A trip in the travel-day section of the Nationwide Personal Transportation Survey is defined as one-way travel from one address to another by any means of transportation. If a person travels to more than one destination, a separate trip is recorded if 1) travel time between two destinations is greater than five minutes, and/or 2) the purpose of travel to one destination is different from the purpose of travel to the other destination. The one exception to this rule is travel to a shopping center or mall, which is considered travel to one destination regardless of the number of stores visited.

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Table 7-4.
Long-Distance Travel by Trip Purpose: 1990
(Travel period)

Trip purpose	Person-miles (millions)	Percent
Total	886,235	100
Earning a living	80,752	9
Family and personal business	129,053	15
Civic, educational and religious	7,227	1
Social and recreational	660,431	75
Other	8,772	1

NOTE: Does not add due to rounding.

SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1993. *1990 NPTS Databook: Nationwide Personal Transportation Survey, Volume 1.* Washington, DC. p. 2-8.

Table 7-5.
Long-Distance Travel by Mode: 1990
(Travel period)

Mode	Person-miles (millions)	Percent
Total	886,235	100
Private vehicles	624,400	70
Public transit	8,353	1
Other[1]	253,482	29

[1] Air travel is 96 percent of long-distance person-miles by "other" modes.

SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1993. *1990 NPTS Databook: Nationwide Personal Transportation Survey, Volume 1.* Washington, DC. p. 2-9.

which are much more common today than in the past, have a harder time minimizing commute distance than single-earner households.

Licensed Drivers and Vehicle Availability

One of the main reasons for an increase in mobility over the past quarter century is the rise in the proportion of the population licensed to drive and the increase in access to vehicles. As noted earlier, people with drivers licenses make more trips and travel greater distances than people without licenses. (USDOT FHWA 1993a, 4-18) In 1995, 177 million people held a drivers license, up from 112 million in 1970, a 58 percent increase, almost twice the growth of the resident population (28 percent). In addition, more of the driving-age population (those over 16) holds a drivers license, up from 78 percent in 1970 to 88 percent in 1995.[9] (USDOT FHWA Various years)

As mentioned earlier, the number of automobiles available in 1993 was 146 million. Another way to calculate vehicle availability is to count the number of vehicles per household. Average vehicle availability per household was 1.66 in 1990, up from 1.61 in 1980.[10] Furthermore, in 1990, 11.5 percent of households were without a vehicle, down from 21.5 percent in 1960. The rate of decrease in the number of vehicleless households has slowed, however, dropping only about 1 percent between 1980 and 1990, although the number remained roughly constant at around 10 million to 11 million between 1960 and 1990. (USDOT FHWA 1993d, 2-2)

Central-city residents are less likely to own a vehicle. In 1990, 12.4 percent of all central-city households (9.7 percent of white and 28.8 percent of black households) owned no vehicles (see table 7-6). A combination of different circumstances explain this, including the inconvenience as well as the expense of maintaining, operating, and parking a vehicle in central cities, plus the accessibility of more destinations via local transit or by walking short distances. Vehicle availability declines with income, but at all levels of income black households are less likely to have a

[9] The NPTS estimates that 74 percent of adults were licensed in 1969 and 89 percent in 1990.

[10] The NPTS estimates 1.8 vehicles per household in 1990, up from 1.6 in 1977. (USDOT FHWA 1993a, 3-37) Vehicles available means those vehicles at home for use by household members, including those owned by the household, company cars, and leased vehicles.

Table 7-6.
Households Owning No Vehicle, by Location and Race: 1990
(In percent)

Location	White	Black
Metropolitan	6.6	25.3
Central city	9.7	28.8
Noncentral city	4.4	14.6
Nonmetropolitan	5.9	23.4

SOURCE: U.S. Department of Transportation, Federal Highway Administration. ND. *Nationwide Transportation Survey 1983 and 1990,* BTS-CD-09 (CD-ROM). Washington, DC: U.S. Department of Transportation, Bureau of Transportation Statistics.

Table 7-7.
Households in the Central City Owning No Vehicle by Income and Race: 1990
(In percent)

Income group	White	Black
All income groups	9.7	28.8
Less than $10,000	30.4	49.5
$10,000–$19,999	11.5	35.4
$20,000–$29,999	5.9	15.5
$30,000–$39,999	4.6	13.7
Over $40,000	2.4	6.1

SOURCE: U.S. Department of Transportation, Federal Highway Administration. ND. *Nationwide Transportation Survey 1983 and 1990*, BTS-CD-09 (CD-ROM). Washington, DC: U.S. Department of Transportation, Bureau of Transportation Statistics.

vehicle than white households. Among the poorest central-city households (earning less than $10,000 per year), 30 percent of white and 50 percent of black households do not have a vehicle (see table 7-7).

Elderly households (those over 65) are much more likely to be without a vehicle than all households. Among white metropolitan households, the 1990 vehicleless rate for elderly households was 17.8 percent, nearly three times higher

Table 7-8.
Elderly Households Owning No Vehicle by Location and Race: 1990
(In percent)

Location	White	Black
Metropolitan	17.8	45.8
Central city	22.2	43.6
Noncentral city	14.3	52.8
Nonmetropolitan	14.8	42.1

SOURCE: U.S. Department of Transportation, Federal Highway Administration. ND. *Nationwide Transportation Survey 1983 and 1990,* BTS-CD-09 (CD-ROM). Washington, DC: U.S. Department of Transportation, Bureau of Transportation Statistics.

than for all white metropolitan households (6.6 percent) (see tables 7-6 and 7-8). For elderly black households in metropolitan areas the vehicleless rate was 46 percent compared with 25 percent for all black metropolitan households. For elderly white households, vehicleless rates are lower in the suburbs than the central city, but the reverse is true for blacks. Vehicleless rates are slightly lower in nonmetropolitan areas than metropolitan areas for both black and white households.

Mobility Outcomes by Socioeconomic and Demographic Group

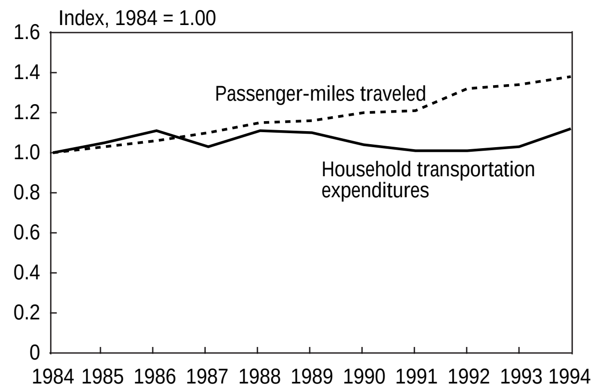
National figures for the average number of miles traveled and the average number of trips are important indicators of personal mobility. Averages, however, can hide enormous variation. In this section, we examine the effect of social, economic, and demographic characteristics, including income, sex, race, and age on personal mobility.

Table 7-9.
Household Transportation Expenditures: 1994

Average income	$36,838
Average annual expenditures	$31,751
Total transportation expenditures	$6,044
Total private vehicle expenditures	5,663
Vehicle purchases	2,725
Gasoline and motor oil	986
Other vehicle expenses	1,953
Total other transportation expenditure	381
Airline fares	249
Intercity bus fares	11
Mass transit fares	58
Taxi fares	14
Intercity train fares	16
Ship fares	31
School bus	1

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics. 1994. Consumer Expenditure Survey.

Figure 7-2.
Mobility and Transportation Expenditures: 1984–94



NOTE: Passenger-miles traveled (pmt) are estimated for miles for which a household expenditure would be incurred. Passenger-miles in heavy trucks and school buses are excluded. Business pmt is included with pmt for personal travel. Given that business travel is unlikely to change dramatically from year to year, the index is unlikely to be affected. The household expenditures figures take the changing number of households into account .

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997*. Washington, DC. December.
U.S. Department of Labor, Bureau of Labor Statistics. 1984–1994. Consumer Expenditure Survey.

Mobility and Income

In 1994, households spent on average just over $6,000 each on transportation. An overwhelming proportion of that money, 94 percent, went to own and maintain private automobiles, about the same percentage spent in 1984. (USDOL BLS 1994) In 1994, only $380 was spent on all other forms of transportation, predominantly airline fares ($250), mass transit ($60), and ship fares ($30) (see table 7-9). Calculating household transportation expenditures in real terms and comparing it with passenger-miles traveled shows that people traveled about 38 percent more in 1994 than in 1984, but spent only about 12 percent more (see figure 7-2).

Spending on transportation increases with age, peaking with households headed by those between 45 and 54 years of age and then declines, particularly sharply for those over 75. In 1994, those between 45 and 54 spent nearly $8,000 and those over 75 spent less than $3,000 on transportation. Most age groups spent about 95 percent of their total transportation expenditures on private vehicles; those over 65 spent less than 90 percent. Spending on transit was almost constant across all age groups at about 1 percent. Airlines fares as a percentage of expenditures increase with age, peaking at 7.9 percent for those over 75. Another large expense for those over 75 (in percentage terms) is ship fares, presumably cruise ships. Older people also spend disproportionately more on taxis (1 percent of transportation expenditures for those over 65 and 2.5 for those over 75) and intercity bus and train fares. (USDOL BLS 1994)

Rural residents spent on average about $900 more on transportation than urban residents in 1994, 24 percent of their expenditures compared with 18 percent for urbanites. Rural residents spent almost their entire transportation budget on private vehicles (97 percent), with most of the rest spent on airlines (2.1 percent). Urban residents spent on average 93 percent on private vehicles, 4.5 percent on airline fares and 1.1 percent on mass transit. (USDOL BLS 1994)

Spending on transportation in absolute dollar amounts increases with income. In 1994, households in the bottom income quintile spent an average of $2,000 on transportation, about 15 percent of their expenditures, while households in the top quintile spent $10,700 on transportation, about 18 percent of their income. The type of transportation bought varies by income. Households in the top quintile spent a higher percentage of their transportation dollars on airfares and a lower percentage on transit than the bottom quintile. (USDOL BLS 1994)

As a result, it is not surprising that mobility increases with income. Indeed, the NPTS shows that richer households, on average, make more and longer trips than poorer ones. In 1990, people in households with annual incomes under $10,000 traveled less than half the distance of people with household incomes of $40,000 and over: 16 miles a day and 2.6 trips compared with 38 miles and 3.6 trips. Part of this difference, particularly in distance traveled, results from the fact that as income rises the proportion of trips using private transportation rises. Correspondingly, the proportion of trips by transit and other means (except airplane), including walking and bicycling, declines (see box 7-4). (USDOT FHWA 1993a, 4-57) Interestingly, people with low income made a greater proportion of their trips by taxi (0.5 percent) than all other income groups (0.1 percent). (USDOT FHWA 1993a, 4-58)

Having a drivers license is also strongly related to income. In households with income over $40,000, 95 percent of adults held drivers licenses in 1990, but only 73 percent in households with income under $10,000. Likewise vehicle availability is less with lower income. Households with income over $40,000 had 2.3 vehicles available, more than twice the 1.0 vehicle available to households with income under $10,000. (USDOT FHWA 1993a, 3-31) Thirty percent of households with income under $10,000 had no vehicle, compared with less than 2 percent of households with income over $40,000. (USDOT FHWA 1993a, 4-54, 4-64) Although data on the age and condition of vehicles in relation to income are not available, it seems reasonable to assume that lower income households with vehicles have less mobility because their vehicles are less capable and reliable.

Every year the Census Bureau calculates the so-called Gini ratio as a measure of income inequality, ranging from 0.0 where every household has the same income to 1.0 where one family has all the income. In 1970, the Gini ratio in the United States was 0.353, but it rose to 0.426 in 1994, a 21 percent increase in inequality. (Weinberg 1996) Reasons posited for less equal incomes are the changing wage structure, declining household size and the growth in women's labor force participation, because high-income women tend to marry high-income men. (Weinberg 1996) It would be interesting to know whether rising inequality shows up in mobility trends.

Data from the NPTS show that the poorest households did not decline in absolute mobility from 1983 to 1990; the average number of person-miles of households under $10,000 remained virtually unchanged (in constant 1990 dollars) (table 7-10). These households were relatively less mobile compared with other groups, however, as households with income greater than $10,000 saw significant increases. Households in the range of $10,000 to $20,000 showed the greatest increase in travel, with 11.5 percent more person-miles per household in 1990 than in 1983. The number of person-miles in households in the highest income bracket of

Table 7-10.
Person-Miles Traveled per Household: 1983–90
(Percentage change, travel day unadjusted)

Annual income (constant $ 1990)	Total	Earning a living	Family and personal business	Civic, educational, and religious	Social and recreational	Other
Less than $10,000	0.3	24.4	33.3	26.4	–27.3	–74.3
$10,000–$19,999	11.5	–2.9	22.6	27.2	15.2	–77.4
$20,000–$29,999	3.6	–15.4	39.8	5.7	–7.5	–0.3
$30,000–$39,999	10.6	–1.9	40.9	40.0	1.0	–65.2
$40,000 and over	8.7	22.6	39.7	–15.1	–8.8	–59.7

SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1993. *1990 NPTS Databook: Nationwide Personal Transportation Survey, Volume 1.* Washington, DC. pp. 4-54 and 4-55.

over $40,000 increased by 8.7 percent during this period. (USDOT FHWA 1993a 4-54, 4-55)

In addition, the poorest households saw a rise in their miles traveled to earn a living (+24 percent) and a dramatic drop in miles for social and recreational purposes (–27 percent). This supports arguments that poor households, often located in central cities, are traveling further to reach employment opportunities in the rapidly growing suburbs and have less resources for discretionary travel for social and recreational purposes. Those in the over $40,000 category saw a similar rise in miles traveled to earn a living (+23 percent), while all other groups saw a decline. Recreational and social travel also declined for households in the $20,000 to $30,000 group and the over $40,000, but by only 8 and 9 percent, respectively. The other household income groups saw an increase in such travel. All groups traveled much more for family and personal business, from between 23 percent for those earning between $10,000 and $20,000 to 41 percent for those earning $30,000 to $40,000. (USDOT FHWA 1993a, 4-54, 4-55)

All income groups increased their use of private modes of transportation, particularly those in the lowest income bracket (see table 7-11). Average annual miles driven per licensed driver in households with less than $10,000 income increased by 45 percent from about 6,200 miles in 1983 to 9,100 in 1990. All other income groups saw an increase between 20 and 30 percent. Those with income between $30,000 and $40,000, for instance, increased from about 11,100 miles per licensed driver in 1983 to 13,800 miles in 1990. (USDOT FHWA 1993a, 3-24)

Mobility and Sex

Women's mobility has increased more rapidly than that of men since 1969. One indicator is the number of miles driven by women. In 1969, the average annual miles driven per female licensed driver was about 5,400, less than half the mileage of men.[11] By 1990, women were driving more, increasing their mileage to 58 percent of men's. Greater mobility for women is also evident in the proportion of women with drivers licenses. In 1969, 61 percent of women and 87

[11] Includes travel day adjusted, travel period, and commercial driving.

Table 7-11.
Average Annual Miles Driven per Licensed Driver by Household Income: 1983 and 1990

Annual income (constant $ 1990)	1983	1990	Percentage change
Less than $10,000	6,245	9,053	45
$10,000–$19,999	8,888	11,061	24
$20,000–$29,999	10,503	13,499	29
$30,000–$39,999	11,148	13,841	24
$40,000 and over	11,946	14,666	23

NOTE: Includes travel day adjusted, travel period, and commercial driving.

SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1993. *1990 NPTS Databook: Nationwide Personal Transportation Survey, Volume 1.* Washington, DC. p. 3-24.

percent of men had a license to drive, a 26 point difference. By 1990, the difference was only 7 points, with 92 percent of men and 85 percent of women holding licenses. (USDOT FHWA 1992, 36)

Although men were still more mobile than women in 1990, women made slightly more trips than men in that year (3.12 versus 3.03). Moreover, between 1983 and 1990 women's trip rate increased 9 percent, while the trip rate of men increased by 4 percent. These figures clearly show that men make longer trips than women, and the distance gap widened between 1983 and 1990. (USDOT FHWA 1993a, 4-12)

Difference in men's and women's mobility can be explained by rates of employment, license holding, and household income, although the disparity is less than in the past. In 1995, women's labor force participation was 58.9 percent, a 43.3 percent increase from 1970. Men's participation was 75.0 percent in 1995, a decline from 79.7 percent in 1970. Women also tend to live in households with lower incomes than men. In 1994, households with the lowest median incomes were those with a female householder and no husband present, 18 percent of all families. (USDOC 1995, 58) At $18,200, the median income of such families was only 66 percent of a family with a male householder and no wife present, and only 35 percent of families with two-wage earners. (USDOC 1996, 469)

There are factors other than license-holding, employment, and household income that account for differences between men's and women's mobility. Many agree that some of the differences in personal mobility can be attributed to women's social roles. Thus, although women have entered the paid workforce in numbers never seen before, women still do more than half of the housework and childcare. (Marini and Shelton 1993) These tasks have two effects on women's travel behavior that are reflected in mileage and trip rates. First, women often make more trips for childrearing and household purposes, such as shopping. Indeed, women with drivers licenses made 1.7 trips a day in 1990 to undertake family and personal business, while men with licenses made only 1.3 such trips a day. Women make fewer trips to earn a living (commuting and other business-related travel), and they also travel shorter distances to work than men, partly because they tend to work closer to home to facilitate childcare and other tasks. (Rosenbloom 1995, 2-6) For a man with a license, the average distance traveled to earn a living was 14 miles in 1990, compared with 9.4 miles for women with licenses. Even men without licenses made longer trips (12.2 miles) than women with licenses. Women without drivers licenses made the shortest trips to earn a living in 1990 (6.1 miles per trip). (USDOT FHWA 1993a, 4-18)

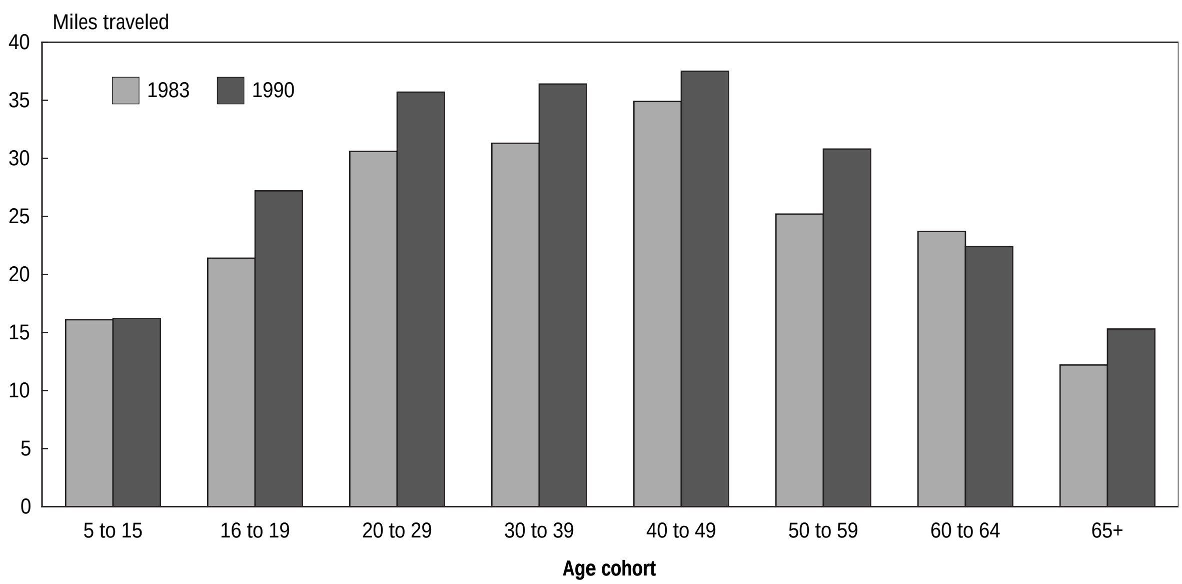
Taking care of children and households tends to make working women highly dependent on their cars, a factor that has important implications for trip reduction and mode shift policies. Women are more likely to use transit than men, but the more children a women has and the younger the children are the more likely she is to drive to work. By contrast, the presence of children in the household had no measurable effect on men's mode choice. Moreover, the general decline in transit use has been faster among women than men. The automobile dependency of women means that trip reduction and mode shift policies, which often use negative incentives to increase the cost of automobile use, strongly impact women's mobility. Such policies are not likely to be successful unless they take into account the mobility needs of women. For instance, it has been suggested that transit pass programs do not adequately compensate women for increased childcare expenses and lost flexibility. (Rosenbloom and Burns 1994)

Mobility and Age

Personal mobility, measured by person-miles, increases with age, peaking with the 40- to 49-year-old age cohort, and then declines, particularly at retirement with the cessation of commuting (see figure 7-3). The number of trips has a somewhat different pattern, peaking with the 30 to 39 age group. Both 16- to 19-year-olds and 20- to 29-year-olds took more trips than 40- to 49-years-olds in 1990, but trip length was shorter, resulting in a lower average amount of person-miles traveled. (USDOT FHWA 1993a, 4-12)

Between 1983 and 1990, the mobility of all age groups increased, except for those between 60 and 64 whose daily person-miles declined slightly from 23.7 to 22.4, largely a result of early retirement. The two groups with the largest increase in daily miles traveled between 1983 and 1990 were the 16- to 19-year-olds, increasing by 28 percent, and the over-65 group, up by 26 percent. The number of trips made by persons in these groups increased, but by lesser amounts, indicating that their trips are getting longer as well as more numerous. One reason for more

Figure 7-3.
Average Daily Miles Traveled by Age: 1983 and 1990
(Travel day unadjusted)



SOURCE: U.S. Department of Transportation, Federal Highway Administration. 1993. *Nationwide Personal Transportation Survey:* 1990 *NPTS Databook, Volume 1.* Washington, DC. p. 4-14.

travel is that the rate of licensed drivers has grown. More young people are being licensed now than in the past, possibly because of the greater availability of automobiles. For those over 65, the increase is due to two factors: 1) more people reaching age 65 already have a license, and 2) the elderly are holding their licenses longer.

People between 16 and 20 years of age have the highest fatality and injury rate in traffic crashes per 100,000 population. (USDOT NHTSA 1996, 85) Between 1969 and 1990, the average annual change in miles traveled per licensed driver in the 16- to 19-year-old age cohort was 3.0 percent, compared with an annual change for all age groups of 2.1 percent. The increase was more dramatic for teenage female drivers at 3.5 percent, compared with teenage males at 2.7 percent. (USDOT FHWA 1993a, 3-18) All teenagers aged 16 to 19 made 79 percent of their trips by private vehicle in 1990, up from 72 percent in 1983. The licensing rate of teenagers also increased over this period, from 62 percent to 69 percent. Despite these increases, the number of drivers between ages 16 and 19, as a percentage of all drivers, fell from 6.6 to 5.9 percent and their percentage of vehicle trips decreased from 6.0 to 5.4 percent. (USDOT FHWA 1993b, 5-5). The baby boom echo (the children of baby boomers), however, will likely reverse this trend in the near future.

One of the important demographic factors that will affect mobility in the coming years is the aging of the population due to longer life expectancy and the graying of the baby boom generation (born between 1946 and 1964). As the median age of the resident population has risen—from 28 in 1970 to 34 in 1995—there has been an increase in average mobility. In the future, the aging baby boomers, all else being equal, will begin to depress personal mobility figures.

Mobility concerns of the elderly can be expected to increase because the elderly population is rising. In 1970, 9.8 percent of the population was over 65; in 1995 it was 12.8 percent. By 2040, the Census Bureau expects 20.7 percent to be over 65 years old. A drop is not expected until 2050, with 20.4 percent over 65.

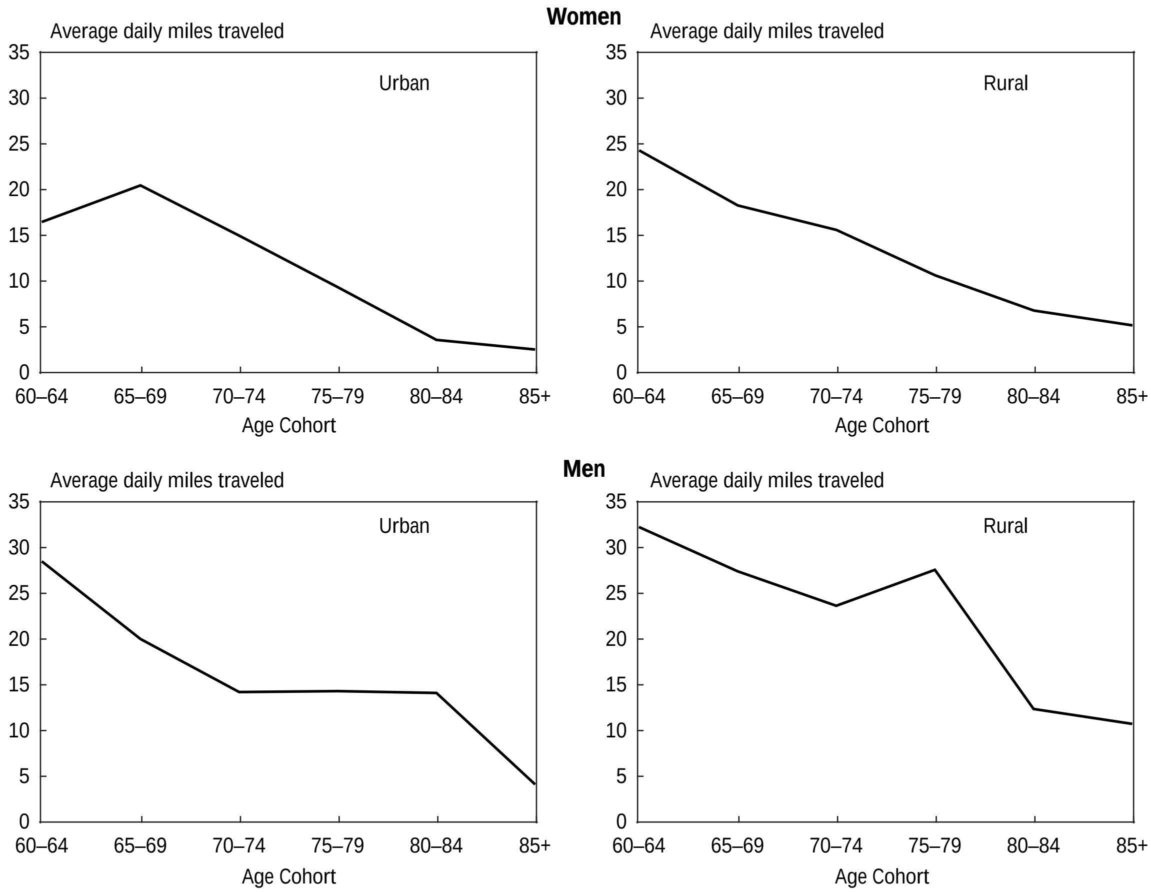
The old of tomorrow may be more likely than their counterparts today to hold drivers licenses, and to live in places that today provide limited options for public transit (the suburbs and the low-density metropolitan areas of the South and West). These factors and the higher incomes of the elderly have increased reliance of the old on automobiles. In 1990, 90.3 percent of the trips by those over 65 were taken by private automobile, up from 81.3 percent in 1977. Their use of public transit declined from 3.1 percent to 1.8 percent of all trips, as did their use of other transportation modes (from 15.6 percent to 7.9 percent). (USDOT FHWA 1993a, 4-30; USDOT FHWA 1986, 6-5) The elderly may drive more, partly because they can (they have a license and an automobile), and partly because they have few alternatives. Nonetheless, there is concern about mobility for the elderly, which declines with age (see figure 7-4).

Race, Ethnicity, and Mobility

Among America's racial and ethnic groups,[12] non-Hispanic whites are the most mobile. In 1990, white men in urban areas averaged 3.4 trips a day and traveled 39 miles, while Hispanic men (of any race) averaged 2.8 trips and traveled 29.5 miles a day. Black men made more trips than Hispanic men at 3.0 a day, but traveled a shorter distance, 24.1 miles daily. Within each category, men traveled more than women, but at 31.1 miles and 3.7 trips a day, white women in

[12] Information about travel by racial and ethnic groups in this section is estimated for people between the ages of 16 and 64.

Figure 7-4.
Travel by the Over-60 Population: 1990
(Travel day unadjusted)

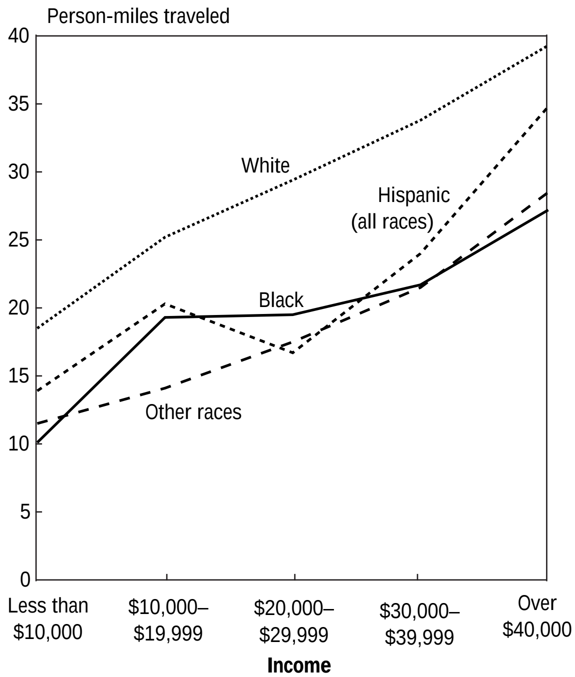


SOURCE: S. Rosenbloom. 1995. Travel by the Elderly. *1990 NPTS Report Series: Demographic Special Reports.* Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

urban areas traveled more than urban men in all other racial and ethnic categories. While women in urban areas traveled fewer miles they tended to make more trips than their male counterparts. Only among urban Hispanics did men make more trips than women. (Rosenbloom 1995, 2-41) Moreover, the differences between men and women in daily person-miles and daily trips were much greater among Hispanics than between men and women in other racial and ethnic groups. (Rosenbloom 1995, 2-6)

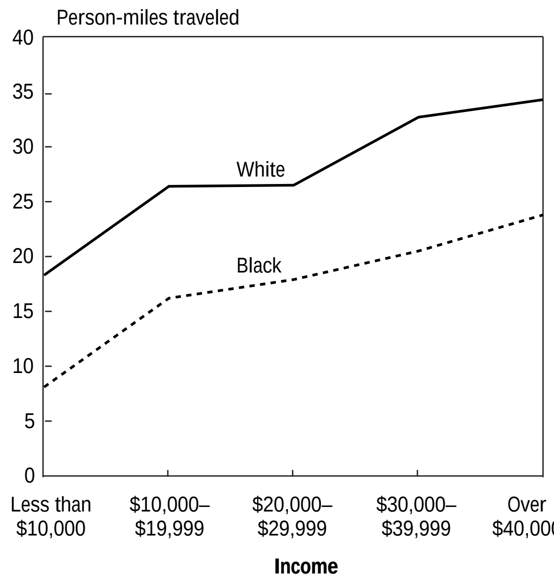
The greater mobility of whites persists even when income and residential location is taken into consideration. Whites appear to travel more than blacks, other races, and Hispanics (of all races), regardless of level of income. It is much more difficult to distinguish travel differences between blacks, other races, and Hispanics (of all races), however (see figure 7-5). The gap between blacks and whites also seems to remain when comparing them in central-city, suburban, and nonmetropolitan areas separately (see figure 7-6).

Figure 7-5.
Average Daily Travel by Race and Income Level: 1990
(Travel day unadjusted)



SOURCE: U.S. Department of Transportation, Federal Highway Administration. ND. *Nationwide Personal Transportation Survey, 1983 and 1990,* BTS-CD-09 (CD-ROM). Washington, DC: U.S. Department of Transportation, Bureau of Transportation Statistics.

Figure 7-6.
Average Daily Travel of Central-City Residents by Race and Income: 1990
(Travel day unadjusted)



SOURCE: U.S. Department of Transportation, Federal Highway Administration. ND. *Nationwide Personal Transportation Survey, 1983 and 1990,* BTS-CD-09 (CD-ROM). Washington, DC: U.S. Department of Transportation, Bureau of Transportation Statistics.

Although the number of vehicles and licensed drivers in the general population has reached very high levels, disparities exist among racial and ethnic groups. One researcher has suggested that vehicle ownership among whites may be saturated, thus the gap between whites and other races and ethnicities may narrow. (Pisarski 1996, xiv) In 1990, 19 percent of Hispanic and 31 percent of black households had no vehicle, and in central cities those proportions rise to 27 percent of Hispanic and 37 percent of black households (compared with 12 percent for all racial and ethnic groups nationwide). In the central cities of very large metropolitan areas, nearly half of the black households had no vehicle. For instance, in New York City, 61 percent of black households were without a vehicle; in Philadelphia, the corresponding figure was 47 percent. (Pisarski 1996, 36–37) In addition, there were disparities among racial and ethnic groups in the percentage of individuals with drivers licenses (see table 7-12).

Vehicle availability and licensing, of course, influence the types of transportation used by different groups. Urban white males and females are more likely to make trips by private vehicle (92 percent of all trips for both sexes) followed by Hispanics and other races. Urban blacks have the lowest percentage, with under 80 percent of trips taken in private vehicles. Black males and females are the most likely to make trips on transit and on foot. Black men in urban areas made 8 percent of their trips on transit and 12 percent by walking. Black women in urban areas made 9 percent using transit and 11 percent on foot. (Rosenbloom 1995, 2-40)

Table 7-12.
Persons Holding Drivers Licenses: 1990
(In percent)

Race/ethnicity	Urban Women	Urban Men	Rural Women	Rural Men
White	91	95	95	96
Black	71	81	78	82
Hispanic (all races)	66	80	82	89
Other	67	81	80	89

SOURCE: S. Rosenbloom. 1995. Travel by Women. *1990 NPTS Report Series: Demographic Special Reports.* Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

The travel behavior of immigrants in the United States in comparison with native-born residents is poorly understood. It is known, however, that immigrants on average have lower incomes than native-born residents. Foreign-born residents of the United States had a lower median income than natives in 1993 (about $12,200 v. $15,900) and recent immigrants (those entering the United States between 1990 and 1994) had much lower incomes on average ($8,400). Moreover, partly as a result of lower income, immigrants are also less likely to own a vehicle, suggesting generally lower mobility. In 1990, 19 percent of households with a foreign-born resident had no vehicle; the corresponding figure for native households was 11 percent. As with income, however, the difference in vehicle ownership between native and immigrant households declines with length of residence in the United States. Immigrant households without a vehicle in 1990 ranged from 29 percent of those who immigrated between 1987 and 1990 to a low of 15 percent with those between 1975 and 1979. It is believed this increase in household vehicle availability is mostly related to increasing income. (Lave and Crepeau 1994)

The differences between the mobility of the foreign-born population in relation to the native-born population are notable, given that the foreign-born population was 23 million in 1994 (8.7 percent), nearly double what it was in 1970 (4.8 percent), the highest level since before World War II. Moreover, their level of mobility is especially important in regions of the country with high proportions of foreign born. Approximately 7.7 million (one-third) are found in California, 2.9 million in New York, and 2.1 million in Florida. Texas, Illinois, and New Jersey also have over 1 million foreign born residents each. (Hansen and Bachu 1995)

Mobility and Location

Mobility varies with geographic location in the metropolitan area. People living in the suburbs traveled the most in 1990 and central-city residents traveled the least. Suburban residents traveled 31.9 person-miles compared with 29.5 miles for rural residents and 24.2 miles for those in the central city. The number of trips per person was almost identical for all three groups. (USDOT FHWA 1993a, 4-38) Those located in suburbs made approximately the same percentage of their trips in private vehicles as did rural residents (nearly 90 percent); central-city residents used private vehicles less (83 percent). By contrast, central-city residents used public transit three times as often as those outside the central city and made twice as many walking trips. (USDOT FHWA 1993a, 4-38) Households in the central city averaged about 11,400 vehicle-miles in 1990 in 1,500 vehicle trips. Suburban households traveled 17,700 miles in 1,900 trips. Households not in an MSA fell in between, traveling 16,000 miles in 1,700 trips. (USDOT FHWA 1993b, 5-19) The number of miles traveled showed little difference in 1990 for metropolitan areas of different sizes.

Greater mobility is related to the growth of employment and number of households in the suburban areas of metropolitan regions.[13] The result has been work commutes of greater distance and more complex traffic patterns.[14] The highest proportion of commuting trips in 1990 were from suburb to suburb, not within the central city nor from a suburb to the central city (see box 7-5). These longer and more complex trip flows encourage the use of private automobiles and discourage the use of public transit and carpools. Suburban development, characterized by lower population densities and wide separation of land uses (e.g., residences, shops, and office parks), has also led to increased trip distances for nonwork trips. (USDOT FHWA 1993a, 4-42)

Factors Affecting Mobility Trends

Many of the factors that have caused mobility increases in the recent past, such as declining household size, increased employment (particularly of women), and increased vehicle availability, are likely to have run their course. There are several other factors that may cause changes in the future, however, such as aging, changing levels of immigration, residential and job dispersal, income growth, changes in the nature of work and workplace, and the mainstreaming of relatively immobile population groups, like the poor.

If income growth continues at a moderate pace over the next few decades, people will have the purchasing power to become more mobile. For example, lower income households without vehicles may be able to afford to purchase an automobile. As incomes increase, more air travel may also be expected. Income growth, however, may not lead to greater vehicle availability among vehicle-owning groups, a market that some say is saturated. Yet, highway mobility could increase if the average amount of driving per driver and per automobile continues to rise.

As baby boomers begin to reach age 65 (starting around 2010), an important question is whether they will travel more or less than those in today's 65-plus age group. Based on today's mobility patterns, the graying of America can be expected to have a dampening effect on mobility growth, but the old of tomorrow may be wealthier, healthier, and more used to traveling. Moreover, if baby boomers age in place, as people

Box 7-5.
Commuting Patterns

Changes in where people work and live within metropolitan areas, particularly the tremendous growth of the suburbs, have led to substantial modifications in commuting patterns. As the population increased and the number of jobs grew, all types of commuting—central city to central city, central city to suburb, suburb to central city, and suburb to suburb—rose from 1960 to 1990. Moreover, every type of commuting grew between 1980 and 1990: 10 percent for central city to central city trips; 12 percent for central city to suburb; 20 percent for suburb to central city; and 58 percent for suburb to suburb. Since 1980, the largest amount of commuter traffic in metropolitan areas has been from suburb to suburb, surpassing the number of commuters traveling within the central city. In 1990, nearly 39 million commuters traveled from suburb to suburb, more than twice the number commuting from the suburbs to the central city (18 million), and over 50 percent more than those traveling from central city to central city (25 million). Suburb-to-suburb commuting almost quadrupled between 1960 and 1990, at the same time as the number of commuters doubled.

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A. Pisarski. 1996.*Commuting in America II: The Second National Report on Commuting Patterns and Trends.* Lansdowne, VA: Eno Transportation Foundation. pp. xviii, 72, 74.

[13] A metropolitan region is a core area with a large population and surrounding areas that have a high degree of economic and social integration with the core.

[14] This may not continue indefinitely. Some researchers suggest that in the long term the decentralization of employment will lead to shorter commuting distances. (Gordon and Wong 1995)

tend to do today, the old will increasingly be located in the suburbs. This could lead to more driving among the young-old (65 to 75), but many people over 75 could become isolated and less mobile if there continue to be few alternatives to driving.

The number of immigrants and where they settle will affect U.S. mobility patterns. Immigrants have lower incomes, on average, than native-born residents, resulting, in part, in less access to private vehicles and lower personal mobility. They do, however, provide a new market for transit providers. How quickly new immigrants achieve mobility levels comparable to those of the native residents, if they ever do, is of great interest to transportation professionals. Because of ongoing changes in immigration law and political and economic factors, it is difficult to predict the future of immigration, particularly the number entering illegally.

The spatial development of the United States and its metropolitan areas will also influence mobility trends, and driving in particular. Will the South and West continue to grow rapidly as they have during the past 25 years? How will metropolitan areas develop spatially? Will metropolitan areas continue to disperse? If so, how will jobs, homes, and other land uses be located in relation to one another? Will these patterns continue to increase people's reliance on the car or not?

Trends related to the growth in the number of people working on a temporary or part-time basis, working in more than one location, or working at nontraditional times may also affect future mobility. Workers with flexible schedules increased from 12.3 percent of those employed in 1985 to 15.1 percent in 1991. Over the same period, the percent of shift workers (those working evening, night, rotating, or other irregular shifts) increased from 15.9 percent to 17.8 percent. (USDOC 1995, 410) These developments impact commuting, where people choose to live in relation to their jobs, and the mode of transportation they use to reach the workplace. Workers with flexible schedules may not have predictable commutes from month to month or even from one day to the next. With frequent changes in the location of their work, they have less reason to select a place to live to minimize their commute, and are less likely than most to carpool or use transit. Moreover, as more people work at times other than the traditional workday hours of 8 a.m. to 6 p.m., the timing of commuting and of "rush hours" could change. (Pisarski 1996)

For workers in these circumstances public transit may be hard pressed to serve the needs of these commuters. In general, transit provides less service during off-peak times, or even no service at all during evenings and weekends. Even when transit service is available, personal safety concerns are exacerbated for those, particularly women, traveling late at night or in the very early morning. For those individuals who work in more than one location, transit may be difficult because of the complexity of schedules and the likelihood of longer commutes.

One final trend is the advance in information technologies (telephones, fax machines, computers, and the Internet) and its effects on transportation demand. These technologies are now making it possible to do errands from home, such as banking and grocery shopping, reducing the need for some types of trips. Such changes, however, may shift transportation demand from the passenger side to the freight side as has already happened with the use of catalog shopping done by mail and telephone, for instance (see chapter 11).

Advances in information technologies may also make it possible for some workers to telecommute, at least part of the time. The current estimate of those who avoid the traditional commute to a central office is 2 million.

(USDOT FHWA 1993c) These people might be working at home or at a telework center (a satellite office in a residential area). The hope is that telecommuting can reduce transportation demand, particularly at peak periods. Given the embryonic state of telecommuting, however, this outcome is far from certain. Some observers suggest telecommuting may not reduce total commuting distance; if people only need to travel to their offices two or three times a week, they may be more willing to commute longer distances. (They may also make more trips on the days they stay at home.) As people locate away from the traditional center, population density decreases, so that one possible result of telecommuting could be longer work- and nonwork-related trips, and more travel overall. (US Congress OTA 1995) Trends in telecommuting will need to be monitored closely to determine their effects on personal mobility.

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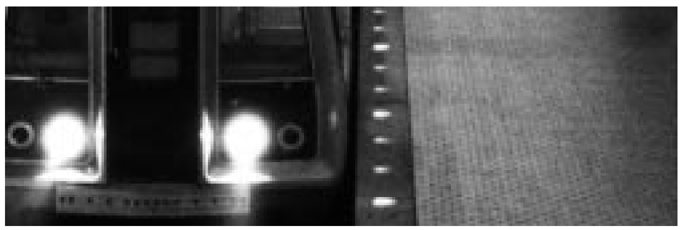
Transportation and Access to Opportunities



Mobility, as discussed in chapter 6, is a measure of movement on the transportation system, such as person-miles per capita. Access, on the other hand, refers to the relative ease by which the locations of activities, such as work, shopping, health care, and recreation, can be reached from another location. Ideally, success of a transportation system would be judged by its role in providing access, not by mobility. Transportation is, after all, not an end in itself but a means for reaching the location of opportunities. In practice, however, we often use revealed mobility (i.e., the number of miles traveled or trips taken over a unit of time such as a day, week, or year) as a proxy for access because it is easier to measure. Not only is measuring accessibility harder, it is very difficult to determine whether higher revealed mobility results in improved access to opportunities. Less travel, and thus lower revealed mobility, might indicate greater access in cases where opportunities are located nearby.

While mobility shows how much people travel, accessibility indicates how easily people can get where they want to go. Accessibility, therefore, is not just a function of better transportation, but results from the interaction of four variables:

1. *Transportation.* Accessibility improves with more links and more frequent, faster, or cheaper service.

2. *Proximity to opportunities.* All else being equal, accessibility improves if opportunities are brought closer together and declines if they are further away.
3. *Personal circumstances.* Access increases with income and with the physical and mental ability to take advantage of opportunities, including transportation.
4. *Quality of opportunities*. Accessibility improves if more or better opportunities become available at the same distance.

As one might imagine, however, these variables are very difficult to measure, particularly in combination (see box 8-1).

This chapter focuses on accessibility and the transportation system (variable 1 above). It also discusses the interaction between transportation and the proximity of opportunities, the so-called transportation/land-use link, by briefly highlighting how the spatial distribution of opportunities has changed over the past 25 years. It examines personal circumstances and

Box 8-1.

Measuring Accessibility

Measuring accessibility is very difficult, as the following hypothetical situation suggests. A large supermarket is built five miles from Bob's house, making it possible for him to travel there by car for groceries twice a week. Before the supermarket opened, Bob would walk to a small neighborhood grocery store half a mile away three times a week, a store that could not compete with the new superstore and is now out of business. Prices at the large supermarket are significantly lower and the selection is better than at the old store. Has Bob's access to opportunities for buying groceries improved?

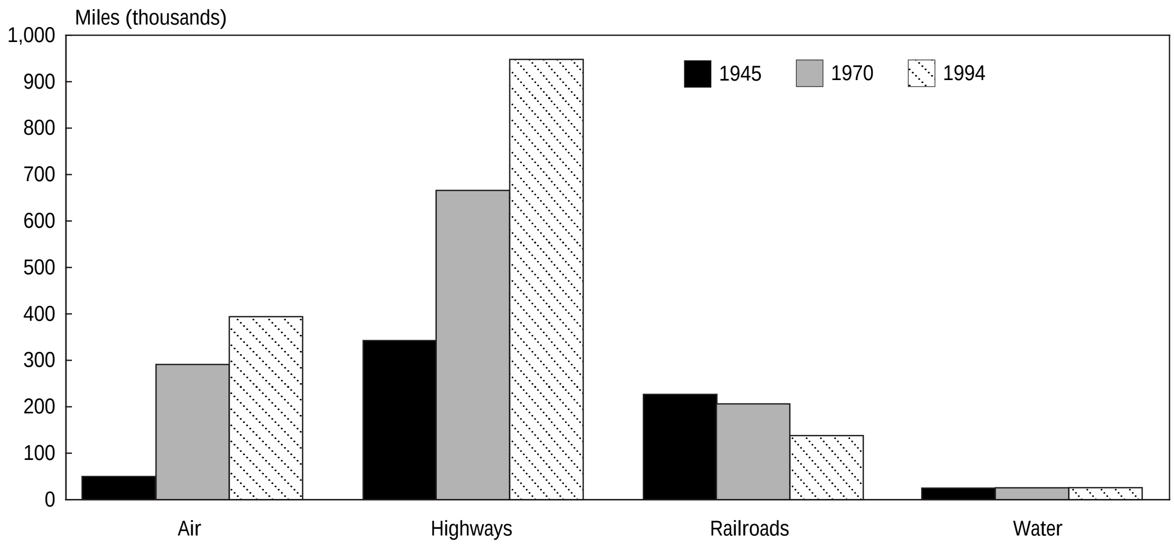
Intuitively the answer is yes, but measuring this access is tricky. If only the average distance to the grocery store, travel speed, and the number of grocery trips made are measured, it might appear that Bob's access has decreased because he has to travel further and takes fewer trips, though the speed of his journey has increased (20 miles weekly v. 3 miles, 2 round trips v. 3 round trips, 30 mph by car v. 4 mph walking). Another interpretation might be that fewer trips can be considered positive, because Bob can carry more groceries in his car and does not need to travel as many times to the store. The out-of-pocket cost of getting to the grocery store has increased in some respects: Bob must pay the auto expenses of travel to the grocery store; it could also be argued that his auto trips generate uncompensated social costs (such as pollution). Bob now spends 40 minutes weekly in travel by automobile to the store compared with 45 minutes weekly when he walked. As a further complication, Bob no longer benefits from the three-times-weekly exercise from his walk to the neighborhood store. Finally, the quality of his opportunity has increased because the supermarket offers lower prices and a better selection of groceries, something difficult to measure without comparing the stock of both stores. Bob's personal circumstances, except perhaps his health, remained unchanged.

To summarize Bob's access to groceries according to the four dimensions of accessibility identified in the text:

- *transportation* is quicker because of a mode switch and time savings, but more costly;
- *proximity to opportunities* declined;
- *personal circumstances* are unchanged, except he gets less exercise; and
- *quality of opportunities* improved.

To make things more complicated the opening of the new store impacts people's access differently: what increases access for one person might mean a decrease for someone else. For Bob's neighbor, Sue, who does not own a car, the accessibility of groceries declined when the neighborhood store closed, even though the new store can be reached by transit. Bus service is available at half-hour intervals on weekdays and Saturday, but not at all on Sunday. It costs Sue $1 each way to ride the bus and it takes approximately 35 minutes (including a 5-minute walk and assuming no waiting time at the bus stop). Sue shops twice a week. Thus, although the quality of her opportunity has improved, her proximity has declined, her transportation cost has increased (to $4), and her time cost has risen from 30 minutes per week to 2 hours and 20 minutes per week. In addition, Sue now only has access to groceries on six days of the week rather than seven.

Figure 8-1.
Intercity Mileage by Major Modes: 1945–94



NOTE: Railroads show miles owned, not operated, and exclude yard tracks, sidings, and parallel railroad lines.
SOURCE: Eno Transportation Foundation. 1996. *Transportation in America,* 1996. Lansdowne, VA.

accessibility from the standpoint of people with disabilities, especially in the context of the Americans with Disabilities Act (ADA) of 1990. This chapter also discusses access to the location of employment sites from the standpoint of low-income, inner-city residents, combining a discussion of personal circumstances, relative location, and transportation links. The quality of opportunities available at different locations is outside the scope of this work, but ultimately must be considered when examining accessibility. Those seeking to make health care more accessible, for instance, must consider not only the location of facilities in relation to transportation, but also the types of health services equipment and staff available.

Transportation Networks and Accessibility

Over the course of the 20th century, the expansion of the nation's transportation networks has made most locations more accessible to travelers. Since the end of World War II, air and highway networks especially have contributed to increased accessibility (see figure 8-1). The geographic extent of waterways changed little over this period, while rail trackage peaked in the 1920s and rail passenger service routes declined. (AAR 1996) Today, most Americans can choose among driving, flying, or riding an intercity bus and/or train to travel between any two states or metropolitan areas, with the main variables being cost and time.

Improved accessibility of locations can also be linked to several nontransportation factors. For example, urbanization has brought people and opportunities closer together. By 1990, approximately three-quarters of the population lived in urban areas. In addition, the country is much wealthier; thus people can afford a higher level of access. Disposable personal income per capita more than doubled between 1960 and 1995 from $8,700 to $18,800 (in chained 1992 dollars). (USDOC 1996, 448)

Highways

In the United States today, highways connect all large and small urban centers and most rural areas. In the mid-1990s, 90 percent of the nation's population resided within five miles of at least one highway in the National Highway System (NHS), a federally designated network of highways that includes Interstates and other key primary and urban arterials and corridors of strategic importance. (USDOT BTS 1996, 30)

The NHS provides direct connections between all of the nation's metropolitan areas (MAs). One measure of the access provided by the NHS is its circuity, defined as the ratio of the shortest route mileage to the great circle distance mileage. The average NHS circuity between all pairs of MAs in the continental United States is approximately 1.176, or only a 17.6 percent increase over a set of "straight-line" highways.[1] This means that, if the straight-line distance between two cities is 1,000 miles, then, on average, the traveler would expect to travel 1,176 miles to get from one city to another. A similar measure of nationwide intercounty circuity is about 1.21, or just 21 percent over straight-line connectivity.[2] Both of these measures reflect a well-developed highway system with generally high levels of interregional connectivity. For most Americans, these highways and the vehicle fleets traveling over them represent a tremendous gain in transportation access during the second half of the 20th century.

[1] The range is only 1.13 to 1.23.
[2] The intercounty circuity includes some important arterials and collector roads as well as the NHS routes (totaling 390,000 miles of highways).

Intercity bus service is especially important to people in rural areas who do not have access to a car—generally, the young, the old, and the poor. (USDOT 1982; Due et al 1989, 84) Intercity bus passenger-miles reached 27 billion miles in 1945, and have since fluctuated with a low of 19 billion miles in 1960 and a high of 29 billion in 1995. As a percentage of intercity passenger-miles, however, bus travel declined from 7.9 percent of all intercity passenger-miles traveled in 1945 to only 1.2 percent in 1995. (Eno 1996)

With increasing competition from the automobile and airplane, costs for providing bus service to places that have only a handful of riders each week have risen. As a result, there has been a dramatic decline in the number of locations served. In 1982, the year the bus industry was deregulated, 11,800 locations were served nationwide, down from 16,800 in 1968. Following deregulation, bus companies eliminated many unprofitable routes and stops, notably in rural areas. By 1991, the number of locations served had fallen to 5,690, less than one-third of those in 1968. (USGAO 1992, 3) Much of the curtailed service was in rural areas.

The intercity component of the bus industry has traditionally had only a few large private carriers, in particular Greyhound and the National Trailways Bus System (since merged), and many small, regional bus providers. Greyhound reduced its routes and buses after its 1991 bankruptcy and reorganization. Today, many communities are served by small, less geographically extensive operations, with around 450 bus companies providing some form of intercity service. Most of these provide charter or tour services, but approximately 50 companies also link to Greyhound's more geographically expansive network. (Issaacs 1995) Residents of rural and small urbanized areas may need to use local bus, van, or taxi service to link up with such services. Various independent private and public programs offer such services. The Federal Transit Act currently requires states to spend at least 15 percent of their Section 18 funding on these and other intercity bus service needs, unless it can be demonstrated by the state that these needs are being adequately met by other means. (Issaacs 1995, 5) In 1992, the U.S. General Accounting Office (GAO) identified 20 states that provided assistance to the bus industry in some form.

Air

After highways, the second most geographically widespread mode is air transportation. Americans are great air travelers. Although not a perfect measure of this, almost 4 in every 10 passengers traveling on the world's scheduled airlines are carried on U.S. airlines. (ICAO 1994) Domestically scheduled aircraft-miles flown grew fivefold from 1960 to 1995. (USDOT BTS 1996, 17) Because of technological innovations, particularly the development of wide-body jets, the number of air passenger-miles grew thirteenfold over this period. (USDOT BTS 1996, 15) The size of the commercial aircraft fleet in 1995 was 5,567 (up from 2,135 in 1960). (USDOT BTS 1996, 209)

General aviation (GA) aircraft also provide access via the many thousands of airfields where scheduled service is not available. Costs relative to scheduled carrier services depend on such factors as the number of people flying and the availability of direct commercial service between the origin and destination. From 1960 to 1994, the number of active GA aircraft is estimated to have risen from 77,000 to 171,000. (USDOT BTS 1996, 33) Almost 60 percent of these aircraft were listed as personal use vehicles in 1994, while 21 percent provided corporate, business, or other work-related services, and 2.3 percent provided air taxi services. GA travel is estimated to have increased nationwide from 2.3 billion to 11.1 billion passenger-miles traveled (1.8 billion to 2.9 billion aircraft-miles) between 1960 and 1994. (USDOT BTS 1996, 15, 17)

Commensurate with the growth in air travel has been the growth in the number of airports, increasing overall accessibility by air. In 1995, there were over 18,000 airports of all sizes and sorts—two and one half times as many as in 1960 (see table 8-1). The growth is due mainly to GA airports, only about half having paved runways and about one-quarter with lighted runways, and heliports. The number of certificated airports (airports serving *scheduled* air carrier aircraft with 30 or more passenger seats), have changed much less. The number of certificated airports declined from 730 in 1980 to 667 in 1995. (USDOT BTS 1996, 6) There are 446 airports with Federal Aviation Administration (FAA) or FAA-contracted towers. (USDOT FAA 1996)

Table 8-1.
The Growth in the Number of U.S. Airports: 1960–94

Year	Total airports[1]	Percentage increase over previous period	Certificated airports[2]
1960	6,881	U	U
1965	9,566	39	U
1970	11,261	18	U
1975	13,251	18	U
1980	15,161	14	730
1985	16,318	8	U
1990	17,490	7	680
1995	18,224	4	667

[1] Includes civil and joint civil-military airports, heliports, STOLports, and seaplane bases in the U.S. and its territories.
[2] Civil and military airports serving air carrier operations with aircraft seating more than 30 passengers.

KEY: U = data are unavailable.

SOURCES: U.S. Department of Transportation, Federal Aviation Administration. 1995. *FAA Administrator's Fact Book*, Washington, DC. April 1995. [cited as of 29 July 1997] Available at www.tc.ZDV/FAA/administrator/airports.html#10.
_____. *FAA Statistical Handbook of Aviation.* [cited as of 7 July 1997] Available at www.bts.gov/oai/faasha.html.

A general decline in ticket prices has increased the accessibility of many places to air passengers. Some of this price reduction can be traced to deregulation of the airlines following the Airline Deregulation Act of 1978. Analysis by the Bureau of Transportation Statistics (BTS) found that prices dropped on average by 31 percent for the top 20 city-pair markets between 1979 and 1995, particularly on routes where small, low-cost airlines began providing service. (USDOT BTS 1996, appendix A; see also USDOT OAIE 1996) Only 3 of the 20 had a price rise in real terms over this period. BTS also estimated that 75 percent of air passengers in 1995 traveled in markets with inflation-adjusted fare reductions and 40 percent traveled in markets in which low-cost carriers competed. (USDOT BTS 1996, 242)

Price reductions have not been limited to heavily traveled routes between major cities. GAO found that the average fare per passenger-mile (in real terms) had generally fallen at airports it examined. Compared with 1979, the average inflation-adjusted fare per passenger-mile in 1994 was about 9 percent lower at small community airports, 11 percent lower at medium-sized community airports, and 8 percent lower at large community airports.[3] Compared with 1979, 1994 airfares were lower at 73 of the 112 airports sampled, higher at 33 airports, and 6 airports showed no statistically significant difference. (USGAO 1996b, 4) The largest fare reductions, as high as 32 percent in real terms, were at western and southwestern community airports, notably where new low-cost airlines had entered the market. In contrast, higher fares, some over 20 percent higher in real terms, occurred in a few small and medium-sized communities sampled in the southeast and Appalachia.

GAO found that the quantity and quality of air service at large community airports was much better in 1994 than in 1979. (USGAO 1996b) At small and medium-sized community airports, the record was mixed. Both the number of aircraft departures and the available seats increased, as did the average number of air service providers, both large and commuter. The number of one-stop destinations reachable from these communities also increased. With greater use of hub-and-spoke systems, however, the number of nonstop (i.e., direct) destinations decreased, on average by 7 percent for the small and by 2 percent for the medium-sized communities sampled. (USGAO 1996b, 38) The percentage of jet aircraft departures from these small and medium-sized communities also decreased, with jets being replaced by more economical turboprop commuter aircraft. The study also found that large community airports have experienced over a 20 percent increase in both the number of departures and the cities reachable by direct service since 1979, mainly because of their role as hubs in airline hub-and-spoke networks.

Many small airports lost jet service after the 1978 airline deregulation, while others lost direct service connections to other airports. The impact, however, on air services and fares at these small airports has varied a good deal by community.

On the eve of deregulation, passenger service was subsidized by the Civil Aeronautics Board at about 150 small airports, boarding from as few as 10 to over 200 passengers a day. In 1978, the

[3] To obtain the fare estimates, GAO used the 10 percent ticket sample contained within BTS's Office of Airline Information "Origin-Destination Survey" data, for a sample of 112 airports taken in May 1995 (49 small, 38 medium, and 25 large metropolitan community airports). GAO defined a small community as having a population within a metropolitan statistical area (MSA) of less than 300,000; medium community airports served MSA populations between 300,001 and 600,000, and large community airports served areas of 1.5 million or more. (USGAO 1996b, 80) GAO did not examine communities with populations between 600,000 and 1.5 million people.

Essential Air Service (EAS) program was established to guarantee continued service from small airports after deregulation. Typically, an EAS airport is guaranteed two round-trip flights per day, six days a week, to a medium or large airport hub. If revenues from air service do not cover costs, the carrier can apply for a subsidy. In 1993, 503 services were designated as EAS-eligible in the United States and Puerto Rico (yet only 128 required a subsidy). (USGAO 1994a, 2) As carriers withdrew in many small and rural communities after deregulation to serve higher density routes, a rise occurred in the number of commuter airlines, which typically operate turboprop aircraft. Commuter carrier enplanements rose from 10 percent to more than 50 percent of rural small community enplanements between 1977 and 1988. (TRB 1991, 120) At large, busy airport hubs such as Chicago's O'Hare International, however, maintaining EAS commuter airline services to smaller airports has been difficult, because the number of available aircraft landing slots is limited. The effects on air travel access were, therefore, seen as mixed in the case of 41 midwestern communities linked to Chicago by EAS eligible service in 1993. (USGAO 1994a)

Small rural airport[4] activity for the period 1977 to 1988 showed overall enplanements down by 15 percent (while they were doubling at the large and medium hub airports), but commuter aircraft often provided more frequent flights than before. Many nonbusiness travelers from more rural areas could, with a little more driving (e.g., up to 100 miles), access the often lower priced flights and more extensive services offered by larger hub airports. (TRB 1991, 130–131)

Judging from census and FAA data, about 60 percent of the nation's population, resided within 30 miles of at least one large, medium, or small hub airport in the early 1990s (see table 8-2). Roughly one-third of the population resided within 30 miles of two or more of these hub airports. Access to airports includes not only transportation by automobile and bus, but, in several of the nation's largest cities, also rail transit with direct-to-the-airport access.[5] (See box 8-2 for a more detailed look at land access to airports.) Within the country's largest, multi-terminal airports many passengers are also moved by intra-airport rapid transit, buses, and within-terminal moving sidewalks.

Rail

As is the case with intercity bus service, gains in intermetropolitan accessibility achieved by highway and air transportation have been partially offset by declines in passenger train connections. Railways have lost riders to the private automobile since the 1920s and to airlines since the 1950s. After World War II, train ridership dropped dramatically from 33 billion passenger-miles traveled (pmt) in 1950 (6.5 percent of intercity pmt) to 9 billion pmt in 1972 (0.7 percent of intercity pmt) (this includes intercity and commuter rail service). By 1995, rail pmt had rebounded to 14 billion. (Eno 1996)

Since 1971, Amtrak (the National Railroad Passenger Corporation) has been the dominant provider of intercity rail passenger transportation within the United States, keeping rail links alive in a number of major passenger corridors, most notably in the Northeast and in southern California, as well as on a number of transnational routes emanating from Chicago. Although intercity rail service had been declining

[4] Airports handling less than 100,000 enplanements annually in 1977.

[5] These are Atlanta International, Chicago Midway and O'Hare International, Cleveland-Hopkins International, Philadelphia International, Lambert-St. Louis International, Michigan Regional (commuter rail), and Washington National. (APTA 1996)

Table 8-2.
Residential Populations Within 30 Miles of Large Hub Airports: 1990

Airport name	Residents
New York La Guardia	11,902,791
Newark International	11,508,061
New York J.F. Kennedy International	11,233,729
Los Angeles International	8,508,493
Chicago O'Hare International	6,439,298
Philadelphia International	4,846,077
Washington National	3,957,409
Dallas-Fort Worth International	3,510,139
Detroit Metropolitan Wayne County	3,431,492
Boston General Edward Lawrence Logan	3,383,560
Washington Dulles International	3,364,257
San Francisco International	3,209,440
Houston Intercontinental	2,994,491
Miami International	2,593,060
Seattle-Tacoma International	2,420,961
Hartsfield Atlanta International	2,348,991
Minneapolis-St. Paul International	2,277,185
Lambert-St. Louis International	2,207,002
Phoenix Sky Harbor International	2,121,689
Pittsburgh International	2,046,121
Denver Stapleton International	1,799,017
San Diego International Lindbergh Field	1,741,647
Cincinnati-Kentucky International	1,573,722
Orlando International	1,128,851
Charlotte-Douglas International	1,106,514
Salt Lake City International	1,036,166
Honolulu International	836,231
Las Vegas McCarran International	723,918

SOURCE: Calculated by Oak Ridge National Laboratory from 1990 U.S. Census Bureau data.

for many years, Amtrak only took over about half the trains still operating in 1971. As a result, intercity pmt dropped from about 6 billion in 1970 to 4 billion in 1975. Since then, intercity pmt has increased, reaching 5.5 billion in 1995. The 460-mile northeast rail corridor between Boston and Washington, DC, is used by about 100 Amtrak trains and 1,100 commuter trains each day. The commuter trains are run by seven regional commuter services that connect large east coast cities. (USGAO 1996a) Commuter rail pmt has increased from 4.6 billion in 1970 to 8.2 billion in 1995.

Travel time on the fastest service between Washington, DC, and New York City is competitive with other modes, at about three hours, especially when terminal access is considered. Although the distance is similar, travel from New York to Boston has remained slower. Travel time between the cities is about 4 hours and 30 minutes. Plans for much faster intercity rail service between these and other cities are currently being discussed, in the form of the Northeast High Speed Rail Improvement Project, and on a broader national scale, as consideration is given to possible markets for magnetic levitation (maglev) technologies or for other types of high-speed trains now operating in some European countries and in Japan. Travel speeds for such high-speed ground transportation (HSGT) technologies vary from 90 miles per hour (mph) to 190 mph, although maglev technologies allow speeds of about 300 mph. Figure 8-2 shows a set of candidate HSGT corridors analyzed recently by the Federal Railroad Administration. These same corridors are also heavily trafficked by air carriers, linking metropolitan areas less than 400 miles apart.

Generally speaking, highways and relatively inexpensive air travel have made up for the decline in passenger train links between cities. Rail travel, however, provides an alternative when other modes are inoperable in the short term. As chapter 1 describes, Amtrak provided one of the few passenger links between cities in the Northeast during heavy snow falls in 1996.

Box 8-2.
Airport Access

Land access to airports is an important issue as air travel and traffic congestion around airports continue to grow. It is estimated, for instance, that congestion at New York's John F. Kennedy airport costs $20 million a year, including lost income to air travelers, drivers of automobiles, limousines, and taxis, and airport employees.

In some places, a lack of ground service for passengers is a problem. In other places, such as Boston's Logan Airport, congestion on surrounding access routes and noncompliance with metropolitan area air pollution standards are problems.

Methods for tackling access problems include provision or enhancement of:

- roads;
- parking;
- curbside facilities and rules enforcement at terminals;
- bus and rail transit;
- intermodal facilities (i.e., the provision of efficient transfers from one travel mode to another, including both passengers and cargo); and
- demand management techniques and intelligent transportation systems technologies.

Another facet of the land access problem is fragmented responsibilities between various government agencies and airports and firms providing travel services. The Las Vegas airport solution was an innovative financial plan to develop highway access by using aviation funds within the airport and National Highway System funds outside of the airport boundaries. Several airports, including those in Charlotte, North Carolina, New Orleans, and Washington (DC) Dulles, have given exclusive rights to van and taxi operations in exchange for guaranteed ride service or certain standards of quality.

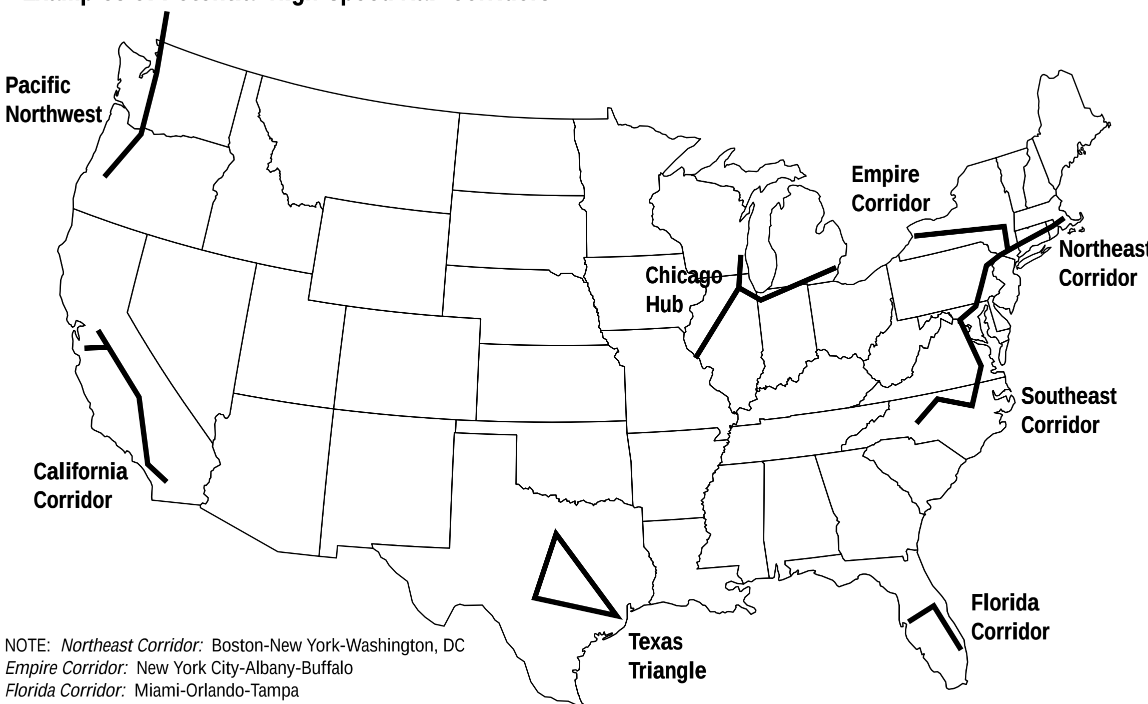
SOURCES
U.S. Department of Transportation, Federal Aviation Administration. 1995. *National Plan of Integrated Airport Systems (APIAS), 1993–1997*. Washington, DC.
U.S. Department of Transportation, Federal Highway Administration and Federal Aviation Administration. 1996. *Airport Ground Access Planning Guide*. Washington, DC.

Accessibility in Metropolitan Areas

About four-fifths of the nation's population resides within metropolitan areas, and more than half live in metropolitan areas with over 1 million people. Housing and commercial activities are widely dispersed across metropolitan areas. Many businesses have benefited from relatively dense highway networks, giving greater access to more suppliers as well as proximity, in terms of travel times and costs, to a larger customer base and labor force. Highways allow residents to live in one suburb while working in another suburb or downtown. In addition, access to more than one employment site is important to multiple-worker households.

The number of workers employed in places outside their county of residence tripled between 1960 and 1990, from 9.4 million to 27.5 million people, an increase from 15 percent to 24 percent. (USDOT FHWA 1994) The average distance between work and home increased by 26 percent between 1983 and 1990, from 8.5 miles to 10.7 miles. By contrast, the average commute time increased by only 10 percent over this period, from 18.2 minutes to 20.0 minutes. As a result, the average commute speed rose from 28.0 mph to 33.3 mph. Thus, the decline in accessibility of worksites has been somewhat mitigated by higher average speeds attainable in the suburbs and further shifts to automobile use from other slower modes. (USDOT FHWA 1993b, 6-21)

Figure 8-2.
Examples of Potential High-Speed Rail Corridors



NOTE: *Northeast Corridor:* Boston-New York-Washington, DC
Empire Corridor: New York City-Albany-Buffalo
Florida Corridor: Miami-Orlando-Tampa
Southeast Corridor: Washington, DC-Richmond-Charlotte, NC
Chicago Hub: Chicago-Detroit-Milwaukee-St. Louis as a network; Chicago-Detroit and Chicago-St. Louis only
Texas Triangle: Dallas/Fort Worth-Houston-San Antonio-Austin
California Corridor: North/South: San Francisco Bay area-Los Angeles-San Diego; South: Los Angeles-San Diego only
Pacific Northwest: Eugene, OR-Portland-Seattle-Vancouver, BC

SOURCE: U.S. Department of Transportation, Federal Railroad Administration. 1996. *High-Speed Ground Transportation for America.* Washington, DC.

Half of the households in urban areas during 1990 were located within one-quarter mile of a transit route, a distance that generally affords quick and convenient access to the service it provides (table 8-3). Many of these households are likely to be located in the more densely developed central areas of large metropolitan regions, where transit service is generally most frequent and provides access to a variety of destinations.

Despite this access, only 2 percent of daily trips in urbanized areas were taken by transit (USDOT FHWA 1993a, 4-58). Even people at the bottom end of the income scale use transit relatively little. Households with income under $10,000 used transit for less than 4 percent of their person-miles of travel in 1990. (USDOT FHWA 1993a 4-60) One reason is that the physical locations of employment have become dispersed over larger areas. Transit is slow compared with the automobile,[6] often requires one or more transfers, and may not provide convenient service to many suburban employment sites, particularly those in outlying locations. Lack of transit access to employment sites has implications for welfare reform, which will require more low-income people without cars (many in the inner city) to find employment (see the discussion below).

[6] In 1990, the average speed of public transportation was 18 mph, whereas private transportation was 35 mph. (USDOT FHWA 1993b, 6-26).

Table 8-3.
Accessibility of Transit Service to Households in U.S. Urban Areas

Distance to nearest transit route	Percentage of households
Subtotal: 1 mile or less	71
Less than ¼ mile	50
¼ to ½ mile	15
½ to 1 mile	6
More than 1 mile[1]	29

[1] Includes households reporting no service available.

SOURCES: Volpe National Transportation Systems Center calculations based on U.S. Department of Transportation, Federal Highways Administration. 1990. 1990 Nationwide Personal Transportation Survey microdata files.

Not all transportation access issues in urban areas are related to work. In central cities, access to grocery stores can be a problem, particularly for less mobile poorer residents. One study found that only about 20 percent of Food Stamp recipients drove their own car to get groceries, whereas 96 percent of non-Food Stamp recipients drove. The number and size of grocery stores, and the prices they charge is another aspect of the access problem. One study found that chain supermarkets located in central city Los Angeles fell from 44 in 1975 to 31 in 1991. (Gottlieb and Fisher 1996) Another study of 21 major metropolitan areas found 19 had 30 percent fewer stores per capita in their lowest income zip codes than the regionwide averages. (Cotterill and Franklin 1995)

Accessibility in Rural Areas

In 1992, approximately one in every five people lived in one of the 2,288 rural (nonmetropolitan) counties of the United States, which contained 83 percent of the nation's land, 18 percent of the jobs, and generated 14 percent of the country's earnings. During the 1970s, population in rural counties increased, a trend reversed in the 1980s. In the 1990s, there has been another reversal with some in-migration. (USDA 1995)

Rural areas are much more accessible today than at the end of World War II, because of highway improvements, increased automobile ownership, and greater availability of air services. As has been discussed, however, accessibility can be a problem for rural residents who do not have an automobile available. Many counties have lost intercity bus and rail connections, as carriers dropped many of their less economical routes. Deregulation of the airlines in 1978 has had a more complex effect on access to air transportation for rural areas (see earlier discussion).

The fundamental difficulty with providing either publicly or privately operated transportation services to rural areas is the low population density within service areas and the consequent high costs per passenger trip. Provision of services is further constrained by limited public revenues with which to improve roads, maintain local airports, or provide transit services. Governments with minimal resources need to be aware of pockets of inaccessibility due to limited travel options. This includes travel within rural areas, between rural areas, and between rural areas and urban centers.

Public Transit

Prior to 1978, nearly all federal transit assistance went to urban areas. Section 18 of the 1978 Surface Transportation Assistance Act directed 2.9 percent of federal transit assistance funds to rural areas and cities of under 50,000 population. The 1991 Intermodal Surface Transportation Efficiency Act increased this rural share to 5.5 percent. In 1992, the program provided an estimated $88 million in funding, or approximately 24 percent of rural transit assistance funds gathered from all sources, with most of the rest coming from state and local government, fares and contributions, and human service organizations. In 1995, total funding for this program was $133 million, falling to $110 million in 1996. (APTA 1996)

These funds must cover a large service area. While only 1 in 13 rural households is without a car, versus 1 in 6 households in the largest cities, many rural households have very limited public transportation services. A 1992 survey of the Section 18 providers (which number over 1,000), sponsored by the Federal Transit Administration (FTA), found that 62 percent of rural residents had some form of Section 18 service, although this included 28 percent of residents with a minimal service level (defined as under 25 trips per carless household per year). Rural carless households averaged only 38 transit trips per year, versus 231 trips in small cities (50,000 to 200,000 population) and 1,223 trips in large cities (over 1 million). (Rucker 1994)

Many of these rural trips were for "essential" purposes: access to employment opportunities (20 percent), to health care (14 percent), and to nutritional and social service programs (17 percent), according to the FTA survey. (Rucker 1994) Countywide or multicounty transit services reported devoting 63 percent of their services to these trip purposes with 60 percent of the riders being either elderly or disabled.

Access Problems

Meeting the Transportation Needs of Persons with Disabilities

Many people have disabilities that make it difficult or impossible for them to operate a motor vehicle or to use public transportation without special equipment or assistance. Such disabilities can include, among others, problems with walking or other motor functions, hearing or sight impairments, and various cognitive and mental difficulties. People who are unable to fully use the transportation system may experience reduced access to opportunities for employment, health care, education, shopping, social and cultural events, and recreation.

In 1990, Congress passed the Americans with Disabilities Act, which protects persons with disabilities from discrimination in, among other things, employment, provision of public services and accommodations, and transportation. The ADA defines a disability as "a physical or mental impairment that substantially limits one or more" of an individual's "major life activities." In 1994, according to the National Health Interview Survey, 26.8 million persons (10.3 percent of the U.S. population) had a chronic condition resulting in some limitation in a major activity, and 12 million of these people (4.6 percent) were unable to carry on a major activity. About 7 million people (23 percent) over 65 had some limitation in their activities; of those with an activity limitation, nearly half were unable to conduct some activity. The elderly poor were especially affected: nearly one-third of the elderly in households with an annual income of less than $10,000 experienced a limitation in some major activity, and nearly 15 percent were unable to conduct some major activity. (Adams and Marano 1995)

These data on the numbers of Americans experiencing chronic limitations on major activities tell little about the number of people who have reduced access to transportation because of physical or mental impairments. BTS, in conjunction with the Centers for Disease Control, sponsored a special survey about the use of transportation by persons with disabilities. Preliminary results from this study, a followup to the 1994 National Health Interview Survey, are expected to become available in late 1997. Box 8-3 presents some of the questions addressed in this survey.

Box 8-3.
Survey of Access to Transportation by Persons with Disabilities

In 1995, the Bureau of Transportation Statistics sponsored several questions on a health statistics survey conducted by the U.S. Department of Health and Human Services. The survey results, expected to be available in late 1997, will allow an estimation of the number of persons with disabilities and their ability to access opportunities.

The survey will help to answer the following questions:

- How many persons with disabilities drive a car?
- Of those, how many need a car with special equipment, and what is that equipment?
- How many persons with disabilities have access to paratransit? If paratransit is used, who operates the service, how often have individuals used the service in the past year, and if they have not used it, why?
- If they have used regular public transit, how often? If they have not used public transit, what was the reason?
- Were they given mobility training to use the system? How difficult is it for them to use public transportation?
- Do respondents have other transportation problems?
- How often in the week preceding the survey did they travel, and by what mode?
- How often did they fly in the last six months, and by what size plane?
- How often did they travel by rail, intercity bus, and cruise ship in the past six months?

Under the ADA, it is a violation of civil rights law to discriminate against persons with disabilities in providing public transportation. Although the ADA applies nationwide, about 600 public transit agencies and 700 key railroad stations have been the focal point for most transportation compliance activities. (Additional ADA requirements apply to intercity bus lines, Amtrak, and other public and private carriers. A separate law, the Air Carriers Access Act of 1986, makes it illegal when providing air transportation to discriminate against a person with physical or mental impairment.[7]) Under the ADA, fixed-route service is to be made available to the disabled; paratransit is to be provided when fixed-route transit does not meet a customer's needs or is inappropriate to the situation. Moreover, paratransit eligibility is no longer based on a person's disability but on whether or not the person has the ability to use the fixed-route system.

This new relationship between fixed-route transit and paratransit has several implications. First, fixed-route service needs to be designed so as to be accessible to persons with disabilities (e.g., aspects such as lifts on buses, and elevators and raised platforms at key train stations). Second, fixed-route and paratransit services will now need to be coordinated and developed together.

With greater accessibility, transit demand by the disabled has increased and will likely increase in the near future. Paratransit ridership was estimated to be 37 million trips in 1995. As the number of accessible fixed-route vehicles has increased, attracting people who might otherwise rely on paratransit for their entire trip has become an important objective of many transit providers.

In order to meet demand and keep costs down, transit agencies must make better use of fixed-route capacity. Paratransit service can be expensive, as suggested by the results of a GAO study. GAO found that, among 12 transit agencies it visited, the cost per paratransit trip varied from $7.11 to $25.68, with an average of $11.63 in 1992. The national average for fixed-route service was estimated for the same time period by the American Public Transit Association (APTA) at $1.75 per trip. (USGAO 1994b, 7) (These figures do not take into account differ-

[7] 49 U.S.C. 41705.

ences in capital costs, however). Barriers that discourage use of fixed-route services include transfer requirements, scheduling, bus drivers with too little training in lift operation, and concern about safety and crime. Transfers between vehicles can be especially difficult for many riders with disabilities. (Baylog et al 1997)

The law and its regulations establish timetables for transit agencies to provide accessible fixed-route transit, paratransit, or equivalent services to persons with mobility, sensory, or cognitive impairments. At the end of 1995, 60 percent of all full-size buses in service were wheelchair accessible, twice the pre-ADA level. By 2001, all fixed-route transit vehicles are expected to be equipped with lifts. The deadline for ADA paratransit compliance was January 26, 1997.

FTA estimates the cost of ADA compliance at $932 million each year between 1995 and 2002 (USDOT FTA 1996)—roughly 4 percent of the combined total transit costs borne by federal, state, and local governments. Capital projects (lifts on buses, elevators and raised platforms at key train stations, and small paratransit buses) are expected to consume about 30 percent of this spending; the remainder would cover operating costs. (Linton 1996) The phase-in of accessible transit is partly supported by FTA funds.

A recent study of transit agencies in the United States and Canada identified 20 approaches for more fully integrating fixed-route and demand response services for persons with disabilities or the elderly. (EG&G Dynatrend and Crain and Associates 1995) Examples include:

- Service routes that, while fixed, allow customers to flag buses and exit buses anywhere along the route. Stops may include entrances to malls, clinics, hospitals, and regular fixed-route services.
- Allowing small deviations in accessible fixed-route service to pick up and drop off passengers.
- Letting people call in advance to request that an accessible bus be placed on a fixed route at a particular time.
- Using paratransit as a feeder service to take people to and from fixed-route transportation services; alternatively, fixed-route services can stop at a paratransit transfer site where people board.
- Subscription services involving accessible fixed-service vehicles.
- Use of low-floor buses that allow use of ramps rather than lifts for wheelchair access; ramps take less time to operate, and thus reduce transfer time, inconvenience to passengers, and maintain operational productivity.
- Use of accessible taxicabs. Often, such taxis are operated by companies that offer nonsubsidized service to the general public, and provide subsidized paratransit services under arrangement with the transit authority.
- Facilitating use of fixed-route services through travel training or, when needed, "buddy systems" in which a volunteer provides ongoing assistance. These techniques may be especially useful in helping persons who have cognitive or developmental disabilities gain the skills and confidence needed to use transit.
- Encouraging more persons with disabilities to use fixed-route services by providing training sessions on lift operations, giving trip planning assistance, and supporting various fare incentives.
- Inventorying bus stops to identify those that are fully accessible, and establishing programs to retrofit existing stops to meet accessibility design standards required for new stops.

Programs such as the U.S. Department of Health and Human Services' Community Transportation Assistance Project provide information to help communities improve accessibility for elderly, disabled, geographically isolated, or license-suspended travelers. For rural and smaller urban communities, the Community Transportation Association of America offers information and assistance, while useful information required by metropolitan area transit providers is also made available by APTA.

Access to Suburban Job Locations from the Inner City

The suburbanization of employment has been a major trend over the past three decades. In Newark, New Jersey, for instance, the percentage of jobs within 10 miles of the city center dropped from 62 percent in 1960 to 40 percent in 1988. (Hughes 1991, 292) In Atlanta, the percentage of jobs in the central city declined from 40 percent in 1980 to 28 percent in 1990. (Ihlanfeldt 1994) Without corresponding residential change, the result can be a "spatial mismatch" between the location of jobs and the location of inner-city residents. It is believed that non-Hispanic whites are the least affected, because they are more easily able to relocate to the suburbs. (US Congress OTA 1995) For others, more so for blacks than Hispanics, accessibility of employment sites is lower. Many of those dependent on transit for the journey to work find suburban jobs inaccessible, because public transit does not serve diffuse suburban locations very well or inexpensively. One research project found that travel time to work for black central-city residents is twice that of suburban whites, because more whites use their own car for such trips. (Holzer et al 1994)

Some argue that this spatial mismatch contributes to higher unemployment rates for central-city residents, particularly blacks. (Hughes 1991) They point out that spells of unemployment also tend to be longer among central-city residents. One study concluded that the duration of unemployment was 25 to 30 percent longer for black youth than white youth, because of the great concentration of blacks in central cities. (Holzer et al 1994) Some analysts contend that the spatial mismatch lowers the wages of workers in central-city jobs, because of the large, low-wage labor pool available there. Finally, spatial mismatch increases the cost of commuting for those employed, lowering the net pay of central-city workers.

Another hypothesis is that high unemployment in low-income, central-city neighborhoods reflects social isolation from the broader community that results in, among other things, less developed informal job networks. (Wilson 1987) These hypotheses stand in contrast to the more common arguments that emphasize the skills and education of individuals and their effects on employment outcomes.

A recent evaluation of these three hypotheses applied to the employment prospects of urban youth in several metropolitan areas in New Jersey concluded that the low job skills of low-income central-city residents contributed the most to unemployment rates in the studied areas. Both social isolation and spatial mismatch were found to contribute much less to unemployment rates. (O'Regan and Quigley 1996)

Research on the causes of unemployment in central-city neighborhoods will draw greater attention with the enactment of the new federal welfare law, the Personal Responsibility and Work Opportunity Reconciliation Act of 1996. Under this law, welfare recipients generally will be able to receive benefits for only two years in one stretch without working, and for only five years during their lifetime. Finding work thus has become imperative for current welfare recipients. Success in a job search involves availability of employment opportunities, job skills, and also being able to reach jobs.

Recent studies of the potential effect of welfare reform on local labor markets in the Cleveland area estimated that 20,000 welfare recipients may be new entrants into the job market over the next few years. (Leete and Bania 1995 and ND; Coulton et al 1996) Analyzing where opportunities are likely to become available in relation to where welfare recipients live suggests that major transportation access problems may arise as people seek to move from welfare to work. A large proportion of new job seekers in Cleveland live in inner-city neighborhoods. The vast majority of job opportunities, by contrast, are located in the suburbs. Many new job sites cannot be reached easily by public transit, and for all practical commuting purposes, some cannot be reached at all without a car. An estimate of the number of jobs accessible from five neighborhoods in Cleveland that had high welfare caseloads revealed that at the average commute time by public transit of 37 minutes, only about 1 in 10 jobs were accessible. Allowing 80 minutes by public transit made only 40 to 45 percent of the jobs accessible. Within an average commute time of 20 minutes by car about one-third of jobs openings were accessible from the five neighborhoods. Doubling the car commute brings about 70 to 75 percent of jobs within reach. (Coulton et al 1996) A different study of one low-income neighborhood found that one-third of the available jobs are not served by public transit at all. (Leete and Bania 1995)

Similar results were found in an analysis of welfare-to-work issues in Boston by the Volpe National Transportation Systems Center for the Bureau of Transportation Statistics. The research found that although 99 percent of welfare recipients have access to transit (within half a mile of transit), only 43 percent of employers likely to have entry-level jobs could be reached by transit. (Lacombe 1997)

While transportation is only one aspect of the issue—the Cleveland studies, for example, found that 47 percent of the welfare population had less than the 11 years of education considered needed for most entry-level jobs—improving transportation access to suburban jobs in locations currently not served by public transit could help people in their efforts to get off welfare. Some programs already exist, including Wisconsin's Jobride program, Detroit's Suburban Mobility Authority for Regional Transportation, and the Suburban Job-Link program in Chicago. For example, one service offered by the not-for-profit Suburban Job-Link program is the "Job Oasis," which helps the unemployed prepare themselves for job interviews and educates them about the needs of the employers they will meet. It also provides free pre-employment transportation to the Oasis job training facility.

Health Care in Rural Areas

A transportation issue in access to health care is the travel time required to obtain care, both emergency and routine. Where are doctors, hospitals, and health care facilities located relative to the populations they serve? Has the accessibility of health care improved or deteriorated?

Rural areas and small towns face problems of transportation access to medical care that are atypical in large metropolitan areas. People must often travel greater distances to obtain care, and smaller cities often have less transit service than large metropolitan areas. As noted earlier, essential trips, like those for medical care, are a major component of transit service in rural areas.

Short-term general hospitals (those equipped to treat short-term illness and surgery, rather than chronic ailments or disabilities) are more numerous relative to population in rural counties than in urban areas. The number of beds in these general hospitals, per 10,000 people in the county, is only slightly higher in rural counties than in urban areas. To reach one of these hospitals rural residents typically travel further than urban residents: urban counties have six times as many hospitals and eight times as many hospital beds per 1,000 square miles than do rural counties, implying two and one-half to three times as much straight-line distance to these facilities in rural counties as in urban. (USDHSS 1996)

Access to physicians is lower on average in rural counties than in urban counties, both in terms of number of people served and the size of service areas. There are two and one-half times the number of physicians relative to the patient population in urban areas than in rural ones. In terms of geographical access, there are seven times more doctors per 1,000 square miles in urban areas as in rural. Pediatricians are much scarcer per 1,000 children aged 14 and younger in rural areas than in urban areas—the patient (child) to pediatrician ratio is nearly four times higher in rural counties than in urban. (USDHSS 1996)

One study of the rural elderly found that transportation was not a significant problem in accessing health care facilities for nonemergency purposes. Indeed, less than 2 percent of the elderly said that transportation problems had stopped or delayed them from receiving treatment in the previous year. (Damiano et al 1995, 40)

Emergency medical service (EMS) responses to rural vehicle crashes, at least in the case of fatal accidents, are less rapid than in urban areas. In 1995, 88 percent of all responses to a fatal urban crash were within 10 minutes of notification, while the corresponding figure was 55 percent for fatal rural crashes. Urban congestion does not offset the greater distances to cover in rural areas. Moreover, the time to take the victim to a hospital from the scene of a rural crash was substantially greater than in urban areas. Nearly twice the number of victims were delivered to a hospital within 20 minutes of EMS arrival in urban crashes as in rural ones. About 46 percent of victims in urban areas reached the hospital within half an hour after a crash, whereas this was true for only 14 percent of victims in rural crashes. (see table 8-4).

Table 8-4.

Response Times of Emergency Medical Services (EMS) in Fatal Vehicle Crashes: 1995

(Percent of cases within specified times, in minutes)

	EMS notification until arrival at scene[1]		EMS arrival at scene until arrival at hospital[2]			Time of crash to EMS arrival at hospital[3]		
	Less than 10	Less than 20	Less than 20	Less than 30	Less than 40	Less than 30	Less than 40	Less than 50
Urban	88	99	42	73	88	46	71	86
Rural	55	90	22	47	67	14	32	53

[1] Percent of cases where times unknown: urban = 51; rural = 38
[2] Percent of cases where times unknown: urban = 73; rural = 69
[3] Percent of cases where times unknown: urban = 73; rural = 70

SOURCES: U.S. Department of Transportation, National Highway Traffic Safety Administration. 1996. *Traffic Safety Facts 1995.* Washington, DC.

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Mobility: The Freight Perspective

More than 6 million business establishments in the United States rely on the nation's interconnected network of transportation services as they engage in local and interstate commerce and international trade. Because of the widespread availability of transportation and advances in information technology, U.S. businesses are able to transport raw materials, finished goods, services, and people effectively, often across great distances.

On a typical day in 1993, about 33 million tons of commodities, valued at about $17 billion, moved an average distance of nearly 300 miles on the U.S. transportation network.[1] (USDOT BTS 1996b) Even these large figures understate the total daily goods movement in the U.S. economy. For example, the figures do not include the transportation of agricultural products from farms to off-farm storage or processing facilities, the movement of most imported products within the United States, or the movement of solid waste collected by local governments from households and businesses.

The freight transportation industry in the United States is evolving to serve a changing and growing economy. Freight transportation is essential for industrial production and supports a vibrant service sector. It connects farms, manufacturers, mar-

[1] The daily estimate was calculated by the Bureau of Transportation Statistics from final datasets in the 1993 Commodity Flow Survey (CFS), plus additional data on waterborne and pipeline shipments not fully covered in the CFS.

kets, and households in rural, urban, and metropolitan areas. The movement of freight permits economies of scale in production by extending the area from which producers and consumers can draw inputs and goods economically.

Freight transportation has become part of a complex logistical system that links the production and consumption processes of an economy that is becoming more globalized. Today, numerous establishments in the United States and around the world may be involved as a product is manufactured, assembled, and delivered to the consumer. To ensure that needed services are provided and delivery dates met, transportation providers often coordinate information about shipments, and can inform customers of progress during the course of a shipment. Firms may use several transportation modes to meet customer requirements that are as diverse as shipping several tons of chilled beef from Iowa to Tokyo by truck, rail, and sea in two weeks, or ensuring the next-day delivery of a birthday gift.

This chapter describes domestic goods movement for major industrial sectors in the United States in a more comprehensive way than was possible before the release in 1996 of data from the Commodity Flow Survey (CFS).[2] The CFS, conducted by the Bureau of Transportation Statistics (BTS) and the Census Bureau in 1993, is the most important single source of data about the domestic movement of goods, although some gaps still exist. Where available, other data are also presented to provide a more complete picture of commodity movement. The chapter presents new estimates of the movements of commodities by truck to, from, within, and through each state. These estimates show the magnitude of interstate commerce on the nation's highways, particularly the traffic that travels through states.

[2] Some CFS data discussed here differ from preliminary data presented in *Transportation Statistics Annual Report 1996*.

The chapter also discusses shipments by mode and state. For example, trucking continues to increase its market share. Air freight is growing rapidly. The use of intermodal freight and containers for international trade is growing. Enormous amounts of farm products travel north to south on the Mississippi River to Gulf Coast ports for export. Large manufacturing states such as California, Texas, Illinois, New York, and Michigan are destinations for interstate shipments from several states.

Several domestic and global trends are examined that are likely to continue to shape freight transportation. These trends include growing domestic commerce, increasing international trade, new business strategies, and consumer pressure for more rapid delivery of goods and services. Also discussed in this chapter are concerns about bottlenecks impeding the movement of freight, especially intermodal freight. According to the U.S. Department of Transportation, some oceangoing vessels may have as little as a four-hour window to meet and load a double-stacked railroad train heading eastbound across the continental United States. (USDOT MARAD 1996, chapter 6)

Although today's knowledge of individual modes of freight transportation is increasing, important information gaps remain. For example, with freight volumes rising and little or no expansion of transportation networks, data on the timeliness of deliveries and changes in the quality of service would be helpful. Hence, the chapter concludes with a discussion of data needs.

Commodity Movement in the United States

Most freight movement is associated with the production, manufacture, and distribution of commodities. In addition, large quantities of materials are transported in activities as diverse as the relocation of households and businesses, the delivery of mail and parcels, and the collection and disposal of solid waste. Table 9-1 shows estimates of the transportation of various commodity groups, measured by value and ton-miles.[3]

Given this breadth of activity, no single source of information fully covers the movement of all goods in the economy. The broadest picture of domestic commodity movement is the 1993 CFS (see box 9-1). The CFS sampled shipments by all modes of transportation from U.S. manufacturing, mining, wholesale trade, and selected retail trade and service establishments in 1993. It covered a far broader spectrum of the economy than the largest previous survey of freight movement, conducted in 1977. (USDOC Census 1981)

In 1993, domestic establishments in the sectors covered by CFS shipped materials and finished goods weighing 12.2 billion tons, generating 3.6 trillion ton-miles of transportation output. The goods shipped were valued at more than $6.1 trillion. (These figures were calculated by BTS using CFS data and additional data on waterborne and pipeline shipments not fully covered in the CFS.[4]) The values and tons counted by the CFS are much larger than the value-added and final weight of materials passing through the production and consumption chain.[5] This is because the CFS totals are comparable to the sum of individual transactions linking several separate movements. In the case of replacement catalytic converters for automobiles, for example, stainless steel converter housings produced by a specialty metal facility might be shipped to a subassembly plant where the catalyst is inserted; the resulting units might then be shipped to a warehouse for subsequent distribution to muffler shops. If each of these establishments happened to be surveyed by the CFS, the value and tons of three shipments would have been counted.

Table 9-2 presents the value, weight, value per ton, and ton-miles of major commodities shipped by establishments sampled by the CFS. The commodities are specified by two-digit Standard Transportation Commodity Classification codes. Food and kindred products accounted for the highest dollar amount of shipments identified in 1993, followed by transportation equipment. The major commodities by weight were petroleum and coal products, nonmetallic minerals, and coal. Food and kindred products ranked fourth.

The major commodities vary greatly when ranked by the value per ton of different shipments. In 1993, ordnance, ammunition, and related accessories ranked highest, averaging nearly $26,000 per ton. The second and third highest categories by value were instruments, photographic, and optical goods, and leather products, averaging over $20,000 per ton. Nonmetallic mineral shipments ranked the lowest, at $12 per ton, followed by coal at $21 per ton. On average, commodities worth over $5,000 per ton accounted for 41 percent of the value of total shipments but only 2 percent of the tons and 5 percent of the ton-miles. Commodity categories that averaged less than $1,000 per ton accounted for less than half of the value, yet accounted for most of the tons and ton-miles, 96 percent and 91 percent, respectively (see table 9-3).

The CFS is by far the most complete freight data source available that covers all modes. It did not, however, survey all goods movement or shipments, and so the discussion of major com-

[3] Ton-miles are calculated by summing the product of the weight of shipment by the distance shipped. A ton-mile is the equivalent of moving one ton of goods one mile.

[4] The additions to waterborne and pipeline shipments are listed in table 9-5.

[5] The value of CFS shipments should not be compared with the ostensibly similar figure for GDP in 1993 ($6.6 trillion). GDP is the net output of goods and services produced in a given year and measures the value-added of production by labor and capital in that year. The value of goods measured in the CFS includes the market value of goods used in production and as final demand, which means that goods may be counted more than once in the production cycle.

Table 9-1.
Major Categories of Freight Shipments in the United States

Groups	Major components	Value or ton-miles	Comments
Raw materials			
Energy products (1994)	Crude oil[1]	582 billion ton-miles	Over 99 percent moved by pipeline and water.
	Refined petroleum products[1]	465 billion ton-miles	About 91 percent moved by pipeline and water.
	Natural gas[1]	20 trillion cubic feet by pipeline	A small portion moved by truck.
	Coal[2] (1993)	$23 billion, 488 billion ton-miles	By value: about 52 percent moved by rail.
Lumber, forest, and pulp or paper products (1993)[2]	Lumber or wood products	$127 billion, 121 billion ton-miles	By value: 86 percent moved by truck; 7 percent by rail.
	Pulp or paper products	$195 billion, 101 billion ton-miles	By value: 82 percent moved by private or for-hire truck; 10 percent by rail.
	Other forest products (e.g., bark)	$1.7 billion, 3.6 billion ton-miles	By value: 44 percent moved by for-hire truck.
Mining products (1993)[2]	Metal ores (e.g., iron, copper, lead)	$20 billion, 37 billion ton-miles	By value: 64 percent moved by for-hire truck; 14 percent by rail.
	Nonmetallic minerals (e.g., quarry stone, crushed stone, sand)	$21 billion, 155 billion ton-miles	By value: 76 percent moved by private and for-hire truck; 16 percent by rail.
Farm and food products (1993)[2]			
Farm products	Grains, vegetables, fruit, livestock, and poultry	$142 billion, 276 billion ton-miles	By value: 68 percent moved by private and for-hire truck; 15 percent by rail; 7 percent by water.
Food products	Processed meat or poultry, canned or preserved fruit, vegetables, dairy products, and beverages	$857 billion, 271 billion ton-miles	By value: 94 percent moved by private and for-hire truck.
Fish products	Fresh fish and other marine products, fish hatcheries and farms products	$11 billion, 1.7 billion ton-miles	By value: 79 percent moved by truck; about 3 percent by truck and air combination.

Table 9-1.
Major Categories of Freight Shipments in the United States ***(continued)***

Groups	Major components	Value or ton-miles	Comments
Manufactured, industrial, and consumer products (1993)[2]			
Equipment, machinery, and instruments	Transportation equipment, electrical machinery, computers, and instruments	$1.7 trillion, 93 billion ton-miles	By value: 63 percent moved by truck; 17 percent by parcel, postal, and courier services.
Industrial products	Chemicals, metals, rubber products, clay, concrete, glass, and stone products	$1.3 trillion, 474 billion ton-miles	By value: 77 percent moved by truck; 6 percent by rail.
Consumer products	Apparel, furniture, leather products, tobacco, and textile mill products	$574 billion, 34 billion ton-miles	By value: 75 percent moved by truck; 11 percent by parcel, postal, and courier services.
Miscellaneous	Miscellaneous products of manufacturing, ordnance, and unknown	$322 billion, 19 billion ton-miles	By value: 73 percent moved by truck; 18 percent by parcel, postal, and courier services.
Household and business moving (1994)[3]			
Household goods	Personal effects and general household goods	About 49 percent of moving industry shipments, 75 percent of its revenues	This sector's share of shipments has declined since 1987.
Office moves	Furniture, equipment, and property of offices, stores, hospitals, museums, etc.	About 0.8 percent of moving industry shipments, 1.1 percent of its revenues	This sector has remained steady since 1987.
Electronic and trade exhibits	Goods including objects of art, displays, and exhibits	About 50 percent of moving industry shipments, 24 percent of its revenues	Since 1987, this sector has grown the fastest in shipments.
Municipal solid waste (MSW) and other waste materials			
	Municipal solid waste (1994)[4]	209 million tons; value and ton-miles information are not available	Trucks account for most movement. Rail shipments, while a small part of the total, are growing rapidly.
	Waste and scrap (1993)[2]	$18 billion, 28 billion ton-miles	By value: 79 percent moved by truck; 17 percent by rail.
	Waste hazardous materials/substances (1993)[2]	$558 million, 314 million ton-miles	

NOTE: The data presented in this table exclude most imports, shipments crossing the United States en route between foreign origins and destinations, and shipments by service and retail industries, and governments.

SOURCES:
[1] U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.
[2] U.S. Department of Commerce, Bureau of the Census. 1996. Commodity Flow Survey data.
[3] American Movers Conference. 1995. *Moving Industry Financial Annual.* Alexandria, VA.
[4] U.S. Environmental Protection Agency. 1996. *Characterization of Municipal Solid Waste in the United States: 1995 Update.* Washington, DC. March.

Box 9-1.
The 1993 Commodity Flow Survey

The Commodity Flow Survey (CFS) was undertaken by the Bureau of Transportation Statistics (BTS) and the Bureau of the Census, with the support of the Federal Highway Administration. It provides information on the value, weight, mode, and distance that commodities were shipped by industries in manufacturing, mining, wholesale trade, and selected retail and service industries during 1993.[1] The most comprehensive prior survey, the 1977 Commodity Transportation Survey, limited shipment measurements to manufactured commodities shipped beyond local areas of production.

The 1993 survey has major advantages over other sources of transportation data. For example, it:

- covers local freight movement, not just intercity shipments;
- identifies parcel, postal, and courier as a separate mode of transportation;
- includes freight movement between coastal ports, which has been ignored in other estimates; and
- estimates for the first time freight carried by intermodal combinations of carriers.

The 1993 CFS also gathered additional new information about shipments, determining whether commodities were shipped in containers, were hazardous materials, and were exports.

For the CFS, the Bureau of the Census collected data from approximately 200,000 business establishments, selected by geographic location and industry, including all 50 states plus the District of Columbia. Each business surveyed reported on a sample of individual shipments made during a two-week period in each quarter of 1993. This produced a total sample of about 12 million shipments. From this sample of establishments and shipments, commodity flows were estimated for a universe of approximately 800,000 businesses.

Despite the extensive nature of the CFS, some freight flows were not sampled. The 1993 CFS covered export shipments, but obtained information about imports only in cases where a U.S. establishment took over a shipment after it reached a U.S. port of entry. Also, the survey excluded establishments classified in the Standard Industrial Classification as farms, forestry, fisheries, governments, construction, transportation, households, foreign establishments, and most retail and service businesses (except warehouses and catalog or mail-order houses). These sectors were excluded from the survey in order to achieve a cost-effective and manageable sample size. The CFS also did not cover shipments of crude oil. Most crude oil is moved by pipeline and water transportation, and Oak Ridge National Laboratory has estimated commodity flows for these two modes. (Where specified in this chapter, BTS has drawn on the Oak Ridge estimates to supplement the CFS findings. Otherwise, the CFS data alone are used.) Finally, the CFS obtained information about the major commodity shipped by the sampled establishment, but not about any secondary commodities included in the shipment, thus underestimating some commodity movements.

[1] The selected retail and service industries were motion picture and videotape distributors, catalog mail-order houses, and auxiliaries such as warehouses.

modity movements that follows draws on data from other sources as well to provide as complete a picture as possible.

Petroleum, Natural Gas, and Coal

Although it is often possible to locate factories near customers, oil, gas, and coal deposits are fixed in location, and hence cannot be developed without adequate transportation infrastructure. Whether processed onsite or shipped as raw material, these resources tend to be heavy, voluminous, or bulky, and may be hazardous to transport.

The nation's economy depends on efficient transportation of petroleum products, natural gas, and coal to meet its energy needs, and as inputs for many chemicals, plastics, and other products. In 1995, the United States imported 8.84 million barrels of crude oil and petroleum products every day while exporting 0.95 million barrels, for a net import of 44.5 percent of its petroleum supply of 17.7 million barrels per day.[6] (USDOE 1996, 138) The Gulf Coast receives

[6] The issue of national dependence on imported petroleum is discussed in chapter 4.

Table 9-2.

Shipments Identified in the Commodity Flow Survey: 1993

STCC code	Commodity description	Value (million dollars)	Tons (thousands)	Value per ton (dollars)	Ton-miles (millions)
	Petroleum and coal	**382,920**	**3,015,778**	**127**	**774,872**
29	Petroleum or coal products	359,471	1,885,833	191	287,081
11	Coal	23,449	1,129,945	21	487,791
	Timber and forest products	**323,364**	**911,104**	**355**	**225,025**
26	Pulp, paper, or allied products	195,002	217,233	898	100,721
24	Lumber or wood products, excluding furniture	126,662	663,351	191	120,669
08	Forest products	1,700	30,520	56	3,635
	Mining	**40,973**	**1,935,943**	**21**	**192,312**
10	Metallic ores	20,278	149,562	136	36,895
14	Nonmetallic minerals	20,695	1,786,381	12	155,417
	Farm and food products	**1,010,388**	**1,499,389**	**674**	**548,990**
20	Food or kindred products	856,884	859,764	997	270,984
01	Farm products	142,442	636,630	224	276,260
09	Fresh fish or other marine products	11,062	2,995	3,693	1,746
	Equipment, machinery, and instruments	**1,704,766**	**160,553**	**10,618**	**93,191**
37	Transportation equipment	652,474	87,617	7,447	49,098
35	Machinery, excluding electrical	442,770	34,180	12,954	19,112
36	Electrical machinery, equipment, or supplies	411,030	30,156	13,630	19,591
38	Instruments, photographic goods, optical goods, watches, or clocks	198,492	8,600	23,080	5,390
	Industrial products	**1,265,465**	**1,748,539**	**724**	**474,171**
28	Chemicals or allied products	532,907	545,405	977	236,856
34	Fabricated metal products	237,316	84,895	2,795	30,489
33	Primary metal products	228,610	266,409	858	97,266
30	Rubber or miscellaneous plastics products	175,267	52,349	3,348	25,528
32	Clay, concrete, glass, or stone products	91,365	799,481	114	84,032
	Consumer goods	**574,148**	**62,079**	**9,249**	**34,210**
23	Apparel or other finished textile products	291,203	15,128	19,249	9,967
22	Textile mill products	102,189	24,757	4,128	11,341
25	Furniture or fixtures	69,471	16,568	4,193	9,789
21	Tobacco products, excluding insecticides	60,640	3,225	18,803	931
31	Leather or leather products	50,645	2,401	21,093	2,182
	Waste materials[1]	**18,816**	**131,707**	**143**	**27,905**
40	Waste or scrap materials	18,258	130,894	139	27,591
48	Waste hazardous materials or waste hazardous substances	558	813	686	314
	Miscellaneous and unknown	**322,359**	**50,730**	**6,354**	**19,411**
39	Miscellaneous products of manufacturing	200,803	20,731	9,686	10,992
41	Miscellaneous freight shipments	81,297	20,830	3,903	5,038
19	Ordnance or accessories	17,174	663	25,903	629
42	Containers, carriers or devices, shipping, returned empty	1,144	702	1,630	230
	Commodity unknown	21,941	7,804	2,812	2,522

[1] Excludes data on municipal solid wastes. KEY: STCC = Standard Transportation Commodity Classification.

NOTE: The commodity groups cited above sum to the following rounded totals; for value, $5.8 trillion; for tons, 9.7 billion; and for ton-miles, 2.4 trillion. These totals differ from the larger totals specified in the text and in table 9-5, because they do not include additions to account for waterborne and pipeline shipments not fully covered in the Commodity Flow Survey.

SOURCE: U.S. Department of Commerce, Bureau of the Census. 1996. *1993 Commodity Flow Survey, United States,* TC92-CF-52. Washington, DC.

Table 9-3.
U.S. Commodity Shipments by Value per Ton: 1993
(In percent)

Categories	Value	Tons	Ton-miles
Less than $1,000	46.4	95.7	91.4
$1,000 to $5,000	12.4	2.2	3.6
More than $5,000	41.2	2.1	4.9

NOTE: The total used to calculate the percentages in this table excludes estimates of waterborne and pipeline shipments made by Oak Ridge National Laboratory, whereas table 9-5 includes these estimates.

SOURCE: U.S. Department of Commerce, Bureau of the Census. 1996. *1993 Commodity Flow Survey: United States*, TC92-CF-52. Washington, DC.

most of the imported crude oil and petroleum products; the New Jersey/mid-Atlantic area is also a major destination point for these imports. Pipelines play a key role in the domestic movement of petroleum, petroleum products, and natural gas—accounting for most natural gas movement, and over 55 percent of crude oil and refined petroleum product movement. Alaskan crude oil moves through pipelines from the oil fields to Valdez and then by tanker to West Coast and Gulf Coast refineries (via the Panama Canal).

Although the CFS undercounted pipeline movement of petroleum and petroleum products, BTS adjusted the pipeline estimates upward using data provided by Oak Ridge National Laboratory (ORNL). In 1993, about 1.3 billion tons of crude oil and crude oil products worth $180 billion were transported by pipelines. Pipelines, plus tankers or other water carriers, accounted for almost all of the 582 billion ton-miles of crude petroleum transported in 1994, and over 90 percent of the 465 billion ton-miles of refined petroleum products transported (see table 9-1). Trucks and railroads accounted for the remaining 9 percent of refined product movement. (USDOT BTS 1996a, 1-18, 1-19)

Since the 1970s, the yearly domestic movement of natural gas by pipeline has been steady at about 20 trillion cubic feet. (USDOE 1995) During the last decade, natural gas imports from Canada have risen appreciably, spurred in part by the 1992 completion of the Iroquois Project. Smaller amounts of natural gas are imported from Algeria and Mexico. Imports now account for 12 percent of consumption. A small amount of liquefied natural gas is exported, using specialized tankers, with Japan the largest purchaser. (USDOE 1996, 186)

The United States consumed about 941 million tons of coal in 1995—the largest amount ever, and twice as much as three decades ago. Electric utilities accounted for 88 percent of coal use; the other major use is to make coke for steel production. About 88.5 million tons were exported in 1995, well below export peaks in 1981 (113 million tons) and 1991 (109 million tons). (USDOE 1996, 208)

The pattern of coal transportation is changing. Three decades ago, 95 percent of domestically produced coal was mined east of the Mississippi River. Since then, more coal has been produced in the western states, with western coal equaling 47 percent of total output in 1995. This growth is partly due to the demand, created by new air pollution standards, for the low-sulfur coal mined in Montana and Wyoming, particularly in the Powder River Basin. (USDOE 1996, 207)

In 1993, 52 percent of the value of the nation's coal moved by rail, 16 percent by for-hire truck, and 7 percent moved by inland water transportation. Disclosure restrictions limit information about the remaining 25 percent of the modal shares. (USDOC Census 1996a)

Agricultural and Food Products

Grain and other agricultural products are shipped primarily by truck, rail, and water, although some high-value perishable goods move by air. There can be great year-to-year variation in the quantity and kind of grain shipments, reflecting changes in weather, farm policies, and world demand for U.S. food. In 1992, for example, 389 million tons (353 million metric tons) of grain were harvested on U.S. farms, while in 1993 the harvest level was 285 million tons (259 million metric tons). (USDA NASS 1996, table 1) Some of this grain would have been kept on farms for use as livestock feed or stored for later delivery. Depending on market prices, part of one season's production may be transported off-farm in a later year. There are no complete, accurate estimates of the volume of farm products trucked from farms to off-farm facilities, where products are gathered for storage, shipment, or processing.

The CFS estimated agricultural goods shipments subsequent to their arrival at the first off-farm processing, storage, or transportation facility. Such agricultural product shipments (listed as farm products in table 9-2) amounted to 637 million tons in 1993, and produced 276 billion ton-miles. (The volume of shipments should not be compared with the volume of grain harvested. Grain comprises only part of farm production. Also, the tonnage of a commodity may be counted more than once as it moves from one establishment to another.)

A U.S. Department of Agriculture analysis found that rail, barge, and truck shipments of grain increased between 1978 and 1989, although year-to-year movements varied considerably. Railroads accounted for most of the grain movement—fluctuating between 42 percent and 49 percent of the total during the 12-year data period—followed by trucks and then barges. (USDA AMS 1992, 5–9)

Modal shares vary greatly among commodities. Wheat growers in the Plains States, for example, use rail carriage primarily—reflecting the lack of proximity of their cropland to most waterways. Corn grown for export is often trucked to barges from cropland accessible to the Mississippi River or other waterways. Trucks are often used to transport corn locally, including corn used as animal feed. (USDA AMS 1992, 10–11)

Food and kindred products (which include processed meat and poultry, preserved fruit and vegetables, dairy and bakery products, beverages, and other food products) accounted for nearly 15 percent of the total value of shipments in 1993. In 38 states, this food commodity category ranked first, second, or third by value of shipments. In this category, two groups of shipments together accounted for nearly 40 percent of the value of shipped food and kindred products: 1) canned or preserved fruits, vegetables, and seafood (valued at $171 billion), and 2) fresh or frozen meat or poultry (valued at about $167 billion). (USDOC Census 1996a)

Exports are a major component of agricultural shipments. The volume of bulk grain exports is enormous: nearly 110 million tons (99 million metric tons) of grain in 1994 (28 percent of the harvest), compared with grain imports of only 6.8 million tons (6.2 million metric tons).

Export shipments of higher value agricultural products have increased significantly since the 1970s. For example, horticultural products, including fresh fruit and vegetables needing relatively quick delivery, are among the fastest growing components of exported commodities, accounting for $10 billion in exports in fiscal year 1996. This represents a tripling in value since fiscal year 1986. (USDA FAS 1997)

Wood Products

Since 1970, an increased volume of wood products produced, imported, exported, and consumed in the United States has generated increased transportation demand. In 1993, according to the CFS, the cumulative shipments of lumber and other manufactured wood products totaled 663 million tons, and generated 121 billion ton-miles. Pulp and paper products shipments accounted for an additional 101 billion ton-miles (see table 9-2). Trucks moved about 86 percent of lumber and wood products by value, and rail moved 7 percent. Trucks moved 82 percent of pulp and paper products by value, and rail moved 10 percent.

The above figures do not capture some of the movement of pulpwood and sawlogs from harvest sites to mills, where they are turned into lumber, paper, and other wood products.[7] Trucks account for nearly all of that movement.

Two major trends have affected logging-related transportation needs over the last 25 years—growth in overall timber demand and regional changes in timber production. While timber demand is cyclical, reflecting trends for other products such as housing, overall demand for forest products has grown throughout most of this century. The nation's timber harvest was 327 million tons in 1995, about 50 percent more than the 1970 level. Nearly all the growth occurred in the Southeast, the Northeast, and the north central states, which together now account for more than three-quarters of the total harvest, compared with about 60 percent in 1970. Timber harvest in the Pacific Coast region has declined, while the Rocky Mountain region has experienced some growth. (USDA Forest Service 1996)

The United States imports a large portion of its lumber and some of its timber from Canada, which accounts for three-quarters of lumber imports and for nearly all log imports into the United States. Preliminary figures for 1993 show Japan as the recipient of about 65 percent of exported U.S. logs and about 36 percent of exported U.S. lumber products. (USDOC Census 1996b, table 1132)

Manufactured Equipment, Industrial Products, and Consumer Goods

The transportation demands of more than 380,000 manufacturing establishments in the United States (USDOC Census 1996b, table 839) reflect great diversity in products, geographic location, and customer needs. The ability of manufacturers to transport materials, parts, and merchandise efficiently and reliably from one part of the country to another has allowed dispersed industrial production, fostering regional economic development. A firm may manufacture a product in several places around the country and still market it nationally and internationally.

In 1993, over $1.7 trillion worth of equipment, machinery, and instruments, $1.3 trillion in industrial products, and $574 billion of nonfood consumer goods were shipped in the United States (see table 9-2). The value per ton among these large categories of manufactured commodities differs greatly. In 1993, equipment, machinery, and instruments shipments averaged about $11,000 per ton; consumer products averaged $9,200 per ton; and industrial products averaged about $725 per ton.

Trucks and intermodal combinations carry a large proportion of manufactured goods. Trucks

[7] The listing of forest products in table 9-2 includes gums, barks, Christmas trees, ferns, turnips, and other nonwood forest products, and does not include most timber and pulpwood shipments, which are classified under lumber or wood products. The movement of wood by independent truckers who perform no cutting is classified as nonmanufacturing.

moved 63 percent of equipment and machinery, 77 percent of industrial products, and 75 percent of consumer goods in 1993. More specifically, 95 percent of the shipments within the United States of computing and office machines (valued at $153 billion) were carried by truck; parcel, postal, and courier services; or truck and air intermodal combinations. (USDOC Census 1996a)

Motor vehicles and equipment[8] accounted for over 8 percent of the cumulative shipments measured in the CFS, valued at about $480 billion. Trucks moved about 66 percent of these shipments, truck and rail intermodal moved 13 percent, and rail moved 6 percent. (USDOC Census 1996a)

Many other categories of manufactured goods shipments move primarily by truck and intermodal carriers. In 1993, for example, clothing[9] valued at over $226 billion was shipped by businesses, often to retail outlets in shopping malls. About 80 percent moved by truck and about 15 percent moved by parcel, postal, and courier services. (USDOC Census 1996a)

Other Movement of Materials and Goods

In addition to goods traditionally viewed as commodities, large quantities of other materials are transported within the United States. These include letters, documents, and small parcels; items transported by business and household movers; and municipal solid waste. (Although not addressed here, government agencies, including the military, and construction firms also move large amounts of materials over the domestic transportation network.)

[8] This is STCC three-digit level 371.

[9] This is a subset of STCC 23, apparel or other finished textile products.

► Packages, Parcels, and Mail

Movement of letters, documents, and small packages and parcels containing products for service providers, other businesses, and households is a major freight activity, which is usually intermodal in nature. In 1993, U.S. businesses relied on parcel, postal, or courier services to transport goods valued at over $560 billion, producing 13 billion ton-miles in the process. Businesses used these services to move 24 percent of electrical machinery, equipment, or supplies, as well as over 20 percent of the total value of industrial machinery, equipment, and computers. (USDOC Census 1996a)

Some service sectors rely heavily on parcel, postal, and courier services. For example, the CFS found that over 75 percent of ophthalmic or opticians goods (valued at $4.7 billion) moved in this manner. About 3 percent of these high-value goods (valued at $171 million) moved by intermodal truck and air combination. (USDOC Census 1996a, 78) Shipments by this mode sampled in the CFS were typically small packages and express letters carried by the U.S. Postal Service or courier companies.

► Municipal Solid Waste and Other Waste Materials

In 1994, Americans generated 209 million tons of municipal solid waste (MSW).[10] Of this, 61 percent was sent to landfills, 15 percent went to incineration facilities, and 24 percent was shipped to recycling and composting facilities. Once picked up from a source, such as a household or store, MSW may be transported just a

[10] Municipal solid waste includes discarded durable goods, nondurable goods, containers and packaging, food wastes and yard trimmings, and miscellaneous inorganic wastes. MSW comes from residential, commercial, institutional, and industrial sources. Industrial MSW is limited to packaging and office wastes, however, and does not include wastes generated by industrial processes.

few miles or as much as 2,000 miles before reaching its final destination. (USEPA 1996)

Local decisionmakers choose how and where MSW is transported. Garbage trucks may transport refuse to a final disposal site or to a transfer station. In communities with curbside recycling, a portion of MSW is picked up and transported by truck directly to local recycling facilities. After some processing, separated materials (e.g., plastics, newspaper, and aluminum) are baled and hauled to processing facilities by trailer truck and rail. In many rural areas, residents and businesses transport their trash themselves to a nearby landfill. The MSW that goes to transfer stations is compacted and then transported to a landfill or incinerator via trailer trucks, rail, or barge. Complete national data are not available on the shares held by different modes, but trucks seem to carry most MSW; barges transport the least. Railroads handle a small, but growing, share. In 1993, railroads shipped about 3.5 million tons of MSW, a 40 percent increase over 1992. (Freeman 1996)

Landfill regulations in the 1986 amendments to the Resource Conservation and Recovery Act encouraged closing older, local landfills and development of large, regional landfills. While the goal of regionalization may be environmental protection or the capture of economies of scale in landfill operation, the change has tended to increase the hauling distances for MSW, thereby enhancing transportation's role.

An estimated 9 percent of MSW is shipped interstate. These shipments are increasing, driven by regionalization of landfills and consolidation in the waste handling industry. Most interstate shipments are between adjacent states, but in some cases much longer distances are involved. New York, for example, shipped MSW to 10 states in 1995. California shipped wastes 2,000 miles to Ohio in 1992. Some states dispose of MSW transported from Canada and Mexico. In 1992, Mexico shipped wastes to New Mexico, British Columbia to the state of Washington, and Ontario to several eastern states. (Repa 1993)

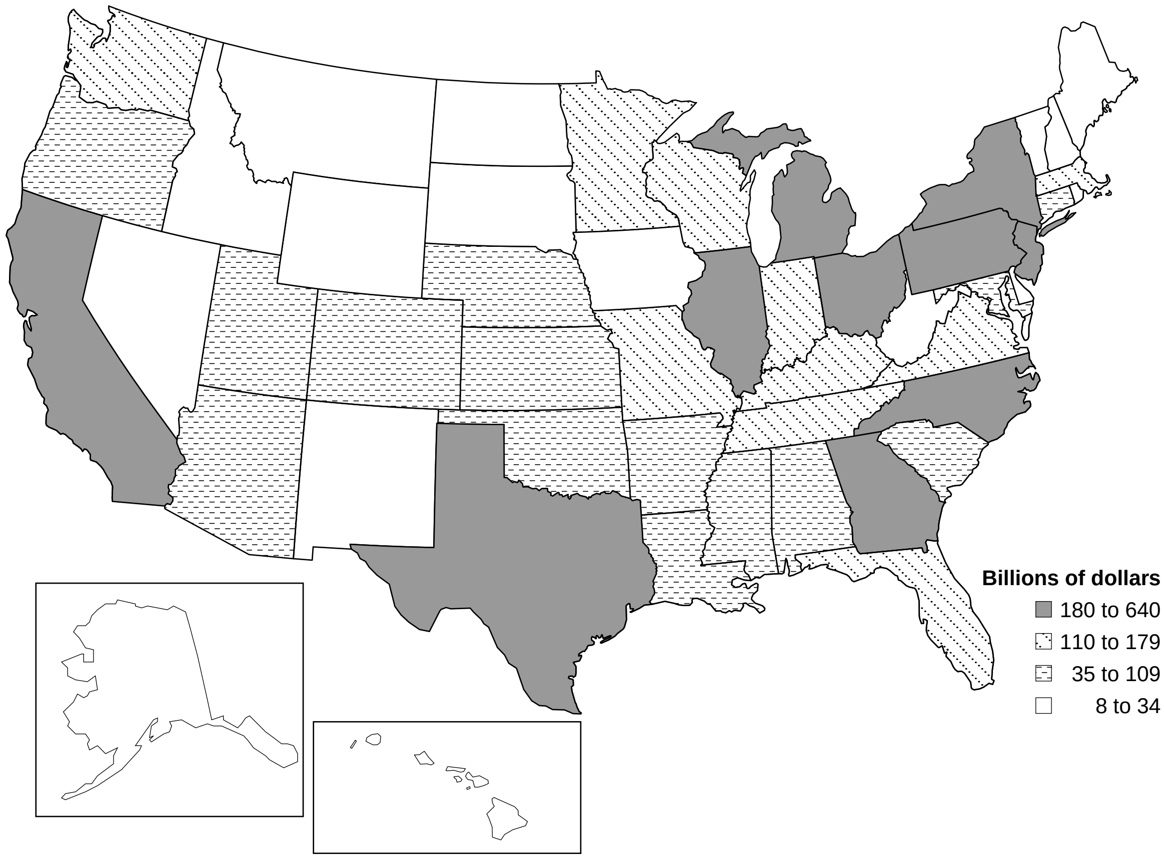
Industrial scrap (consisting mostly of iron, steel, or other metal scrap commodities) and industrial waste are usually not part of the MSW waste stream, and have their own collection and distribution network. There are markets for industrial scrap, and for some kinds of industrial wastes. CFS data show that about 131 million tons of scrap materials and industrial waste were moved in 1993. By value, about 79 percent moved by truck and 17 percent moved by rail. (USDOC Census 1996a, 22)

► Household and Business Moving

The moving industry serves three markets: households, trade shows, and offices. In 1994, the Bureau of the Census reported that about 43 million U.S. residents moved to a different location. Based on an average household size of 2.67 persons, this is equivalent to over 16 million household moves. About 59 percent, or 9.5 million households, moved within the same county; the remaining moves were divided about equally between intrastate and interstate moves. (USDOC Census 1995, table 66; and 1996b, table 33)

Since 1987, there have been major shifts in the distribution of shipments and revenues between the household and trade show components of the industry. In 1994, the movement of household goods (personal effects) accounted for about 49 percent of the industry's total shipments, down from about 61 percent in 1987. Despite the large decline in share of total shipments, the percentage of revenue generated by household shipments declined only slightly, from 78 percent in 1987 to 75 percent in 1994. By contrast, the movement of trade exhibits, displays, and related electronic goods accounted for 50 percent of the industry's total shipments in 1994, up from 38 percent in 1987. Revenues increased only slightly from 20

Figure 9-1.
Value of Commodity Shipments by State of Origin: 1993



SOURCE: U.S. Department of Commerce, Bureau of the Census. 1996. Commodity Flow Survey data.

percent to 24 percent in 1994. Office moves account for only a small share of the market: 0.8 percent of shipments and 1.1 percent of revenues in 1994, relatively unchanged since 1987.

Intrastate and Interstate Freight Movement

▶ Origination of Shipments

Many factors affect the magnitude of shipments originating in a state, including the size of the state's population and economy, its resource base, and its land area. Not surprisingly, over one-third of the shipments by value originate in states with large manufacturing bases, such as California, New York, Michigan, Texas, and Illinois (see figure 9-1). These states were also the destination for a large portion of shipments.

Nationally, about 62 percent of shipments by value and 35 percent by weight were sent out-of-state in 1993 (see table 9-4). In terms of value, there were only seven states where within-state shipments accounted for more than 50 percent of shipments: Alaska, California, Florida, Hawaii, Montana, Texas, and Washington. These states tend to be large in area or, in the case of Hawaii and Alaska, geographically distant from the rest of the United States. Only six states—Delaware, Kentucky, Montana, Nebraska, West Virginia, and Wyoming—shipped more by weight out-of-state than within-state.

Figure 9-2 illustrates the importance of high-value shipments relative to high-weight shipments originating in each state. For example, a fairly high proportion of shipments originating in California are high-value, while high-weight shipments (e.g., coal and petroleum) are particularly important for Wyoming, Louisiana, and West Virginia. To understand the numbers in figure 9-2, consider the case of Wyoming. Shipments originating in Wyoming account for 0.1 percent of the value of all shipments covered by the CFS and 3.0 percent of the weight. The difference equals -2.9 percent. Thus, the numbers in figure 9-2 tell us the amount by which a state's share of the value of total national shipments is higher or lower than its share of the weight of these shipments.

► Destination of Shipments

The movement of manufactured products between states has a pattern of concentrated destinations: California, Texas, New York, and the historic industrial belt stretching from Illinois to Pennsylvania. Figure 9-3 shows the state of origin and the state of destination of the largest 50 interstate flows by value of shipment for manufactured goods. For example, California is the destination of six of the top 50 major interstate flows by value.

The concentration of shipments to and from California, Texas, New York, and Illinois arises in part from their large populations, manufacturing bases, and importance in assembling parts manufactured in other states. Another explanation for the concentration is that California, Texas, and New York have major ports; thus, shipments destined for those states include manufactured goods for export. Figure 9-3 also shows that there are major flows to and from Georgia and New Jersey.

Highlights of Truck Shipments by State

The wealth of information to be gleaned from the CFS is well illustrated by figures 9-4 and 9-5, which show interstate truck shipments by states. The pie charts show total shipments by truck that, in each case, moved within the state, passed through the state, or had either an origin or a destination within the state. The size of each pie chart indicates the size of all the truck shipments associated with the state, measured by value in the case of figure 9-4 or by ton-miles for figure 9-5.

Nationally, shipments crossing state boundaries accounted for 73 percent of the ton-miles and 55 percent of the value of commodity movements by truck. In 25 states, shipments passing through the state accounted for more than half of the value of commodity movements by truck. In 19 states, through shipments accounted for more than half of the state's ton-miles by truck. The largest shares of shipments within states tend to be in states that are geographically large with widely separated major cities, such as California and Texas, or in the corners of the country, such as Florida and Washington. The relatively large share of intrastate traffic in Michigan is overstated because imports from Canada are not included in the estimates. The large concentration of truck activity in the corridor from Illinois to Pennsylvania shows the continuing importance of this manufacturing belt.

Similar maps showing freight moved by other transport modes can be prepared from the statistics of the 1993 CFS, and the forthcoming 1997 CFS, to indicate origin and destination of shipments and local and through traffic.

Table 9-4.
Interstate Shipments as a Percentage of a State's Total Shipments: 1993

State of origin	Percent of value	Percent of weight	State of origin	Percent of value	Percent of weight
U.S. total	62.3	35.3	Montana	47.0	57.8
Alabama	66.2	28.8	Nebraska	70.9	51.0
Alaska	19.2	17.4	Nevada	74.1	19.0
Arizona	57.3	23.0	New Hampshire	77.8	NM
Arkansas	73.7	41.0	New Jersey	68.7	40.6
California	38.8	8.8	New Mexico	51.7	40.3
Colorado	57.6	23.8	New York	58.8	23.8
Connecticut	79.2	23.0	North Carolina	61.9	30.4
Delaware	85.2	72.2	North Dakota	62.5	43.9
Florida	36.8	18.2	Ohio	62.5	30.0
Georgia	66.8	28.3	Oklahoma	65.5	45.1
Hawaii	7.4	10.8	Oregon	58.5	19.8
Idaho	68.2	35.5	Pennsylvania	64.7	38.1
Illinois	66.0	42.6	Rhode Island	79.1	45.8
Indiana	71.6	43.9	South Carolina	69.5	36.5
Iowa	64.9	39.6	South Dakota	60.0	44.9
Kansas	74.7	46.2	Tennessee	74.4	39.2
Kentucky	75.6	51.0	Texas	40.0	16.3
Louisiana	50.7	33.6	Utah	63.8	19.2
Maine	65.5	27.2	Vermont	65.8	31.9
Maryland	69.0	43.4	Virginia	63.5	28.4
Massachusetts	66.5	28.3	Washington	44.2	16.2
Michigan	52.1	26.1	West Virginia	74.6	63.7
Minnesota	60.0	41.3	Wisconsin	64.9	30.5
Mississippi	71.3	43.9	Wyoming	70.8	84.3
Missouri	73.5	36.6			

KEY: NM = not meaningful.

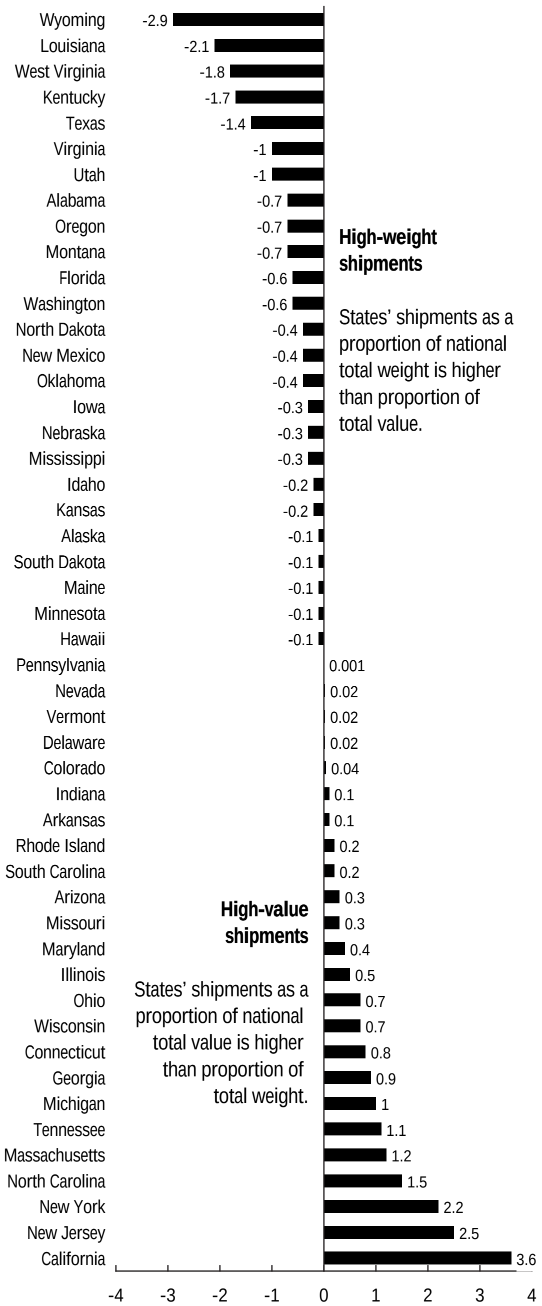
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *1993 Commodity Flow Survey: United States Highlights,* Washington, DC.

Shipment Characteristics

Freight shipments can be classified by distance: local (less than 100 miles), short-haul (beyond 100 miles, but within a 250-mile radius of its origin), and long-haul (beyond a 250-mile radius). The CFS confirms the importance of local transportation to businesses throughout the nation. In 1993, nearly 40 percent of the value and 67 percent of the weight of all shipments moved between places under 100 miles apart. More than 55 percent of the value and 79 percent of the weight—7.6 billion tons—traveled less than 250 miles. About 45 percent of the value and 21 percent of the weight were shipped beyond 250 miles.

Figure 9-6 shows that high-value shipments on average were moved greater distances than low-value shipments (e.g., goods shipped over 1,500 miles in 1993 had an average value of $3,000 per ton, compared with an average of $500 per ton for goods shipped less than 100 miles). Of course, low-valued goods are often ubiquitous (such as sand and gravel), and move

Figure 9-2.
Difference in States' Share of the Value and Weight of Total U.S. Shipments Measured in the CFS: 1993



NOTE: Excludes New Hampshire because data for the state do not meet publication standards. The figure presents states' relative shares of the value and weight of the total national shipment. A positive number shows that the state's shipments represent a larger share of the value than weight of total national shipments. A negative number shows that the state's shipments account for a larger proportion of the weight than the value of the national debt.

SOURCE: U.S. Department of Commerce, Bureau of the Census. 1996. 1993 Commodity Flow Survey data.

only short distances, but another reason for this pattern is that people and businesses are willing to pay the extra cost of shipping high-value commodities long distances by air in exchange for speedy on-time delivery.

High-value shipments are characterized by low weight (see figure 9-7). Almost one-third of the value of shipments of electrical machinery, equipment, or supplies and over 24 percent of shipments of industrial machinery, equipment, and computers weighed less than 100 pounds. Over 80 percent of shipments by parcel, postal, or courier services were under 100 pounds.

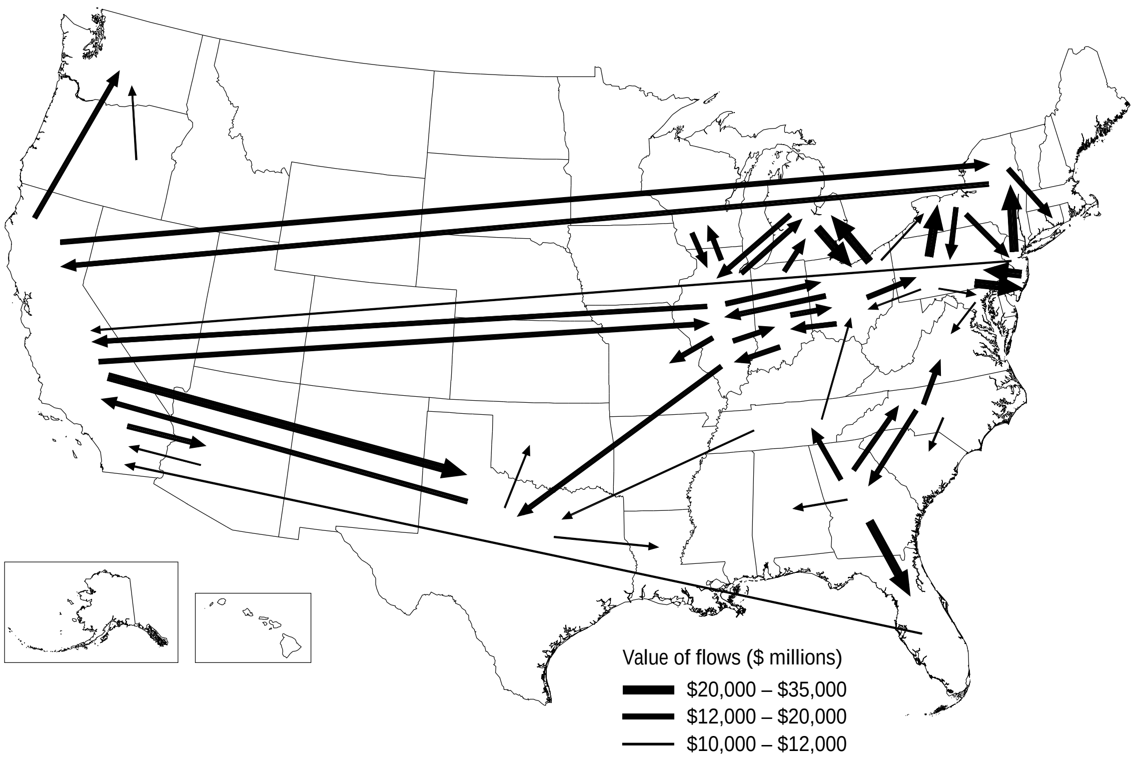
A sizable proportion of high-weight long-distance freight moves by rail, which can carry both bulk commodities and time-sensitive items (e.g., containers, automobiles, and vehicle parts) at a low unit cost.

Freight Movement by Mode

Various factors influence the choice of mode, including type of commodity, transportation costs, modal service characteristics, and accessibility of shipper and receiver to the mode. Bulk commodities typically are transported slowly at a low unit cost. High-value time-sensitive commodities often move by truck, air-truck, and rail-truck intermodal combinations.

From 1970 to 1995, ton-miles of domestic freight movement for all modes increased by 65 percent. Air carriers' ton-miles grew the most rapidly, more than quintupling over the period. (USDOT BTS 1996a, 20) Intercity truck ton-miles also grew rapidly, more than doubling. Trucking (including for-hire and own-use) was the most frequently used mode, measured both by shipment value (71.9 percent) and by weight (52.5 percent) for freight moved in 1993 (see table 9-5). (USDOT BTS 1996b) Trucks dominated even more for shipment distances of less than 500 miles.

Figure 9-3.
Origins and Destinations of the Top 50 Interstate Commodity Flows by Value: 1993



SOURCE: U.S. Department of Commerce, Bureau of the Census. 1996. Commodity Flow Survey data.

Railroads produce slightly more ton-miles than any other mode. In 1993, according to the CFS/ORNL estimate, 13 percent of all domestic tonnage and about 26 percent of the ton-miles within the United States used rail carriage. (USDOT BTS 1996b) Railroads moved more freight, over longer distances, and with fewer resources in 1995 than in 1970. While freight train-miles increased only 7 percent between 1970 and 1995, the average length of haul rose 64 percent to 843 miles. (AAR 1996, 33, 36) Net ton-miles per train-hour,[11] one measure of efficiency, rose 71 percent to 63,000 ton-miles in 1995. (AAR 1996, 38)

[11] This is a measure of the number of tons hauled and the miles traveled during an average hour of a freight train's operation.

Over 17 percent of all tons moved within the United States (some 24 percent of ton-miles) involved some form of waterborne transport in 1993. (USDOT BTS 1996b) Waterborne freight is transported along the coasts, on the Great Lakes, and on inland waterways.

Figure 9-8 shows value per ton of shipments by mode of transportation, including intermodal combinations. Not surprisingly, the highest value shipments per ton moved by air (including truck and air), followed by parcel, postal, or courier services (which typically move goods weighing less than 100 pounds and often use air transport as well). The relatively low value of shipments by truck (averaging only $690 per ton) reflects the wide range of commodities moved—from coal, sand, and gravel, to high-value electrical equip-

Figure 9-4.
Value of Truck Shipments by State: 1993

NOTE: The size of each circle represents shipments by truck from manufacturing, mining, farming, and wholesale establishments. It does not reflect imports, shipments crossing the United States en route between foreign origins and destinations, and shipments by service industries, governments, and households. Shipments from, to, and within each state are compiled from the 1993 Commodity Flow Survey, supplemented by data compiled by Oak Ridge National Laboratory to include farm-based shipments in the 1992 Census of Agriculture. Oak Ridge estimated throughshipments by assigning flows to the most likely routes on the National Highway Planning Network.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics. May 1997.

ment and parts. The lowest value shipments per ton moved by water.

Intermodal Freight Shipments

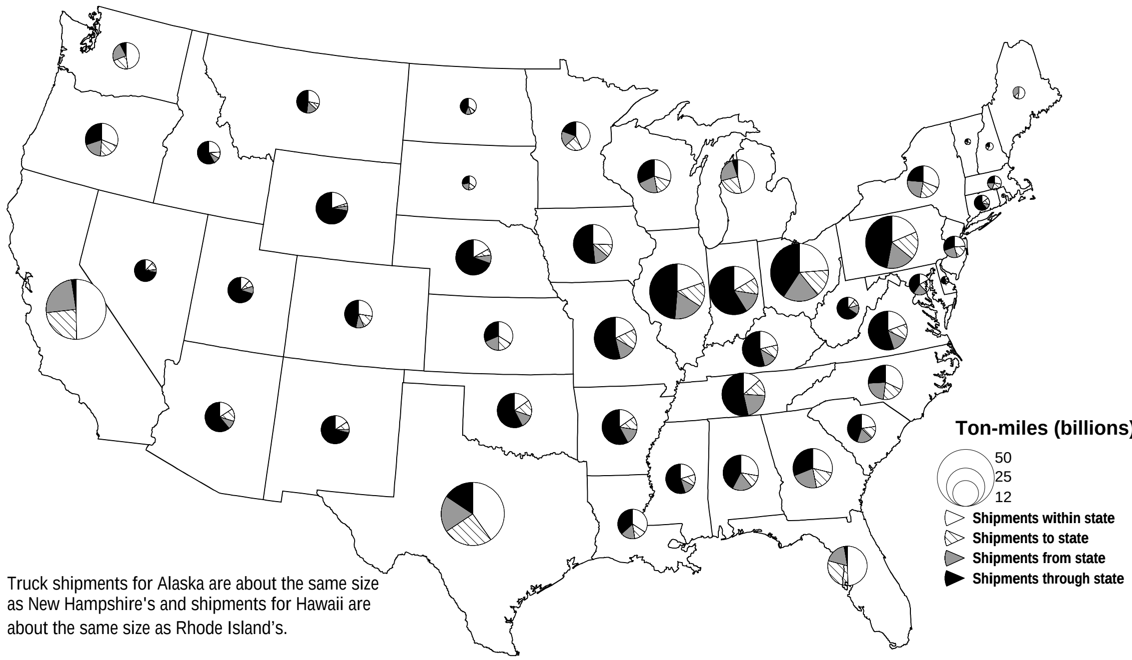
In 1993, intermodal shipments exceeded 200 million tons of goods valued at about $660 billion. These figures are for shipments moved by two or more modes, as well as by parcel, postal, and courier services, but not including truck-air intermodal.[12] These shipments accounted for about 11 percent of all CFS/ORNL shipments by value, but just under 2 percent by weight. The classic intermodal combination of truck and rail accounted for $83 billion (nearly 13 percent of the $660 billion), and about 41 million tons of intermodal shipments. In addition to the $660 billion, about 3 million tons, valued at about $134 billion, is estimated to have moved by truck and air combination.[13]

Intermodal shipments are higher in value per pound on average than typical single-mode shipments. The average value of goods shipped by air (including truck and air) was $22.15 per pound,

[12] In table 9-5, shipments by intermodal truck and air were aggregated with shipments moved by air only.

[13] Excludes shipments reported in the CFS as transported by air only.

Figure 9-5.
Ton-Miles of Truck Shipments by State: 1993



NOTE: The size of each circle represents shipments by truck from manufacturing, mining, farming, and wholesale establishments. It does not reflect imports, shipments crossing the United States en route between foreign origins and destinations, and shipments by service industries, governments, and households. Shipments from, to, and within each state are compiled from the 1993 Commodity Flow Survey, supplemented by data compiled by Oak Ridge National Laboratory to include farm-based shipments in the 1992 Census of Agriculture. Oak Ridge estimated through shipments by assigning flows to the most likely routes on theNational Highway Planning Network.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics. May 1997.

followed by parcel, postal, and courier services ($14.91 per pound) and by truck and rail combination ($1.02 per pound). Goods shipped only by truck averaged only 34¢ per pound. Goods shipped by rail, water, and pipeline averaged less than 10¢ per pound.[14]

Generally speaking, states producing goods with a high value per unit of weight moved a greater part of their shipments by intermodal transportation, while states producing goods with low value per unit of weight relied more on rail, water, and pipeline.

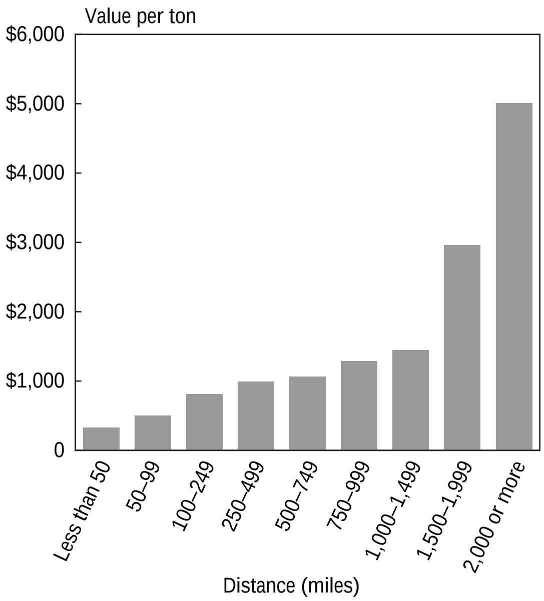
[14] Calculated by BTS from 1993 Commodity Flow Survey data, plus additional data on pipeline and water provided by Oak Ridge National Laboratory.

Freight Shipments to and from the United States

This section briefly describes trends in international freight shipments to and from U.S. seaports and airports, as well as transborder land shipments by truck and railroad between the United States and Canada or Mexico.[15] (Chapter 10 discusses freight trends in other countries.)

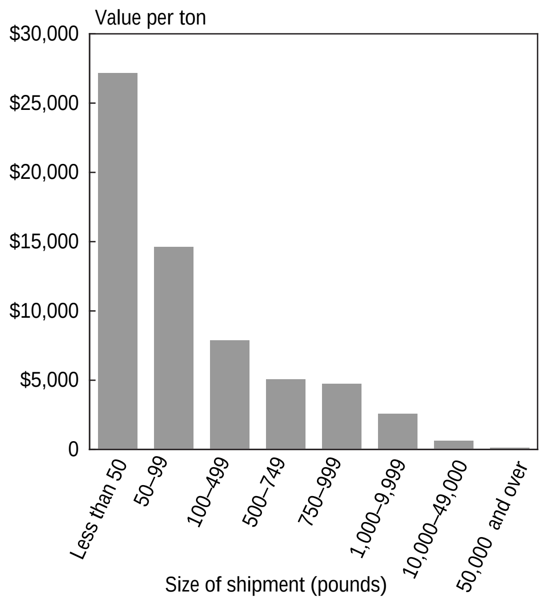
[15] Trucks and railroads provide a vital intermodal link for trade with countries outside North America by moving freight to airports and seaports, but information about the scope of this movement is incomplete. Also, there is little information available about the domestic movement of goods that are transshipped through the United States from abroad to a destination in another country.

Figure 9-6.
Value per Ton of Shipments by Distance Within the United States: 1993



SOURCE: U.S. Department of Commerce, Bureau of the Census. 1996. *1993 Commodity Flow Survey: United States,* TC92-CF-52. Washington, DC.

Figure 9-7.
Value per Ton of Shipments by Shipment Size: 1993



SOURCE: U.S. Department of Commerce, Bureau of the Census. 1996. *1993 Commodity Flow Survey: United States,* TC92-CF-52. Washington, DC.

► Waterborne Freight

Between 1970 and 1995, U.S. international waterborne freight nearly doubled, while domestic freight only grew by 15 percent (see table 9-6). The total tonnage of all U.S. waterborne freight, including internal domestic commerce as well as international trade to and from U.S. ports, increased by 46 percent to 2.2 billion tons.

International waterborne traffic involves exports and imports through coastal and Great Lakes ports. The tonnage of imports and exports increased through coastal ports, but declined for Great Lakes ports from 1970 to 1995. (U.S. Army Corps of Engineers 1997, 1-4)

In 1994, U.S. oceanborne imports and exports amounted to $517 billion (current dollars), an enormous increase from $49 billion in 1970. (USDOC Census 1996b, table 1058) Although both imports and exports grew, export's share of the total value of waterborne trade fell from 50 percent in 1970 to 34 percent in 1994, indicating the negative U.S. trade balance. Figure 9-9 shows the regional distribution of the total value of oceanborne foreign imports and exports in 1993, compared with 1970 and 1980. In 1970, East Coast ports had over 50 percent of the total value of trade, with the West Coast taking the third place at 20 percent. By 1993, the West Coast was the leading region with 45 percent while the East had fallen to second place with 38 percent. (USDOC Census 1990 and 1996b)

► Air Freight

Air freight moves via all-cargo air carriers as well as by air carriers that transport primarily passengers. Between 1980 and 1995, freight revenue ton-miles by passenger carriers grew much faster in the international market (173 percent) than in

Table 9-5.
U.S. Freight Shipments by Transportation Mode: 1993

	Value (billions)	Tons (millions)	Ton-miles (millions)	Value (percent)	Tons (percent)	Ton-miles (percent)
Total, CFS plus ORNL estimates	$6,124	12,157	3,627,919	100.0	100.0	100.0
Truck (for-hire and private)	4,403	6,386	869,536	71.9	52.5	24.0
Water	251	2,128	886,085	4.1	17.5	24.4
Rail	247	1,544	942,561	4.0	12.7	26.0
Pipeline	180	1,343	592,900	2.9	11.0	16.3
Air (including truck and air)	139	3	4,009	2.3	0.03	0.1
Intermodal[1] total	660	208	235,856	10.8	1.7	6.5
Parcel, postal, and courier services	563	19	13,151	9.2	0.2	0.4
Truck and rail	83	41	37,675	1.4	0.3	1.0
Other intermodal combinations[2]	13	149	185,030	0.2	1.2	5.1
Unknown	243	544	96,972	4.0	4.5	2.7

[1] Intermodal is a combination of parcel, postal and courier services; truck and rail; and other intermodal combinations including truck and water and rail and water. It excludes truck and air, which is added to air transportation.
[2] Includes truck and water, rail and water, and other combinations.

KEY: CFS = Commodity Flow Survey; ORNL = Oak Ridge National Laboratory.

NOTE: The figures for water shipments in this table include the following rounded ORNL estimates: $187 billion, 1.6 million tons, and 614 billion ton-miles. The figures for pipeline shipments include these ORNL estimates: $90 billion, 859 million tons, and 593 billion ton-miles.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics calculations based on 1993 Commodity Flow Survey data, plus additional data provided by Oak Ridge National Laboratory.

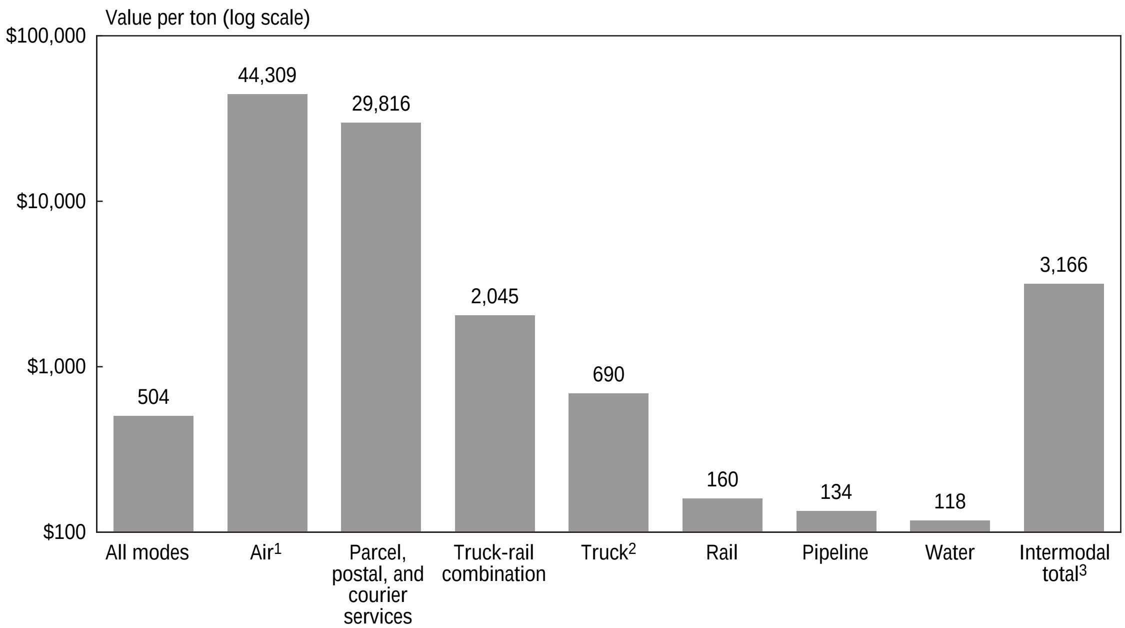
the domestic market (88 percent).[16] Revenue ton-miles produced by the all-cargo air carriers grew even faster. In 1995, the seven major all-cargo air carriers[17] flew 9.3 billion revenue ton-miles, up 405 percent from 1980.

In 1993, nearly 13 percent of CFS shipments of office, computing, and accounting machines moved by air (including truck and air combination). In addition, about 27 percent of these shipments moved by parcel, postal, and courier services—with some proportion of this moved by air.

[16] The trend data start in 1980 instead of 1970 to cover the post-deregulation period. Economic deregulation of the commercial air carrier industry in the United States began in 1977.
[17] All-cargo air carriers in 1995 were Challenge Air Cargo, DHL Airways, Emery Worldwide, Federal Express, Northern Air Cargo, Polar Air Cargo, and United Parcel Service.

Imports and exports shipped by air grew rapidly—from 11 percent of the value of all international trade in 1970 to 25 percent in 1994. (USDOC Census 1990 and 1996b) Table 9-7 lists the nation's major air freight gateway cities and the tonnage passing through them in 1994. U.S. flag carriers moved 41 percent of the freight tonnage. Among the nation's top 15 domestic gateways, the share of freight carried by U.S. flag carriers ranged from nearly 100 percent in Memphis, Tennessee, to 7 percent in Fairbanks, Alaska. Between January and May 1995, the period with the most recent information, the major country markets for U.S. products ranked by tons of air freight shipped were: Japan, the United Kingdom, Germany, Colombia, and South Korea. (USDOT OIA 1996)

Figure 9-8.
Value per Ton of Shipments by Transportation Mode: 1993



[1] Includes truck and air combination.
[2] Includes for-hire, private, and a combination of for-hire and private.
[3] Intermodal is a combination of parcel, postal, and courier services; truck and rail; and other intermodal combinations including truck and water and rail and water. It excludes truck and air, which is added to air transportation.

NOTE: The data are plotted on a logarithmic scale. Data that span a wide range are often plotted on a log scale to display variations at the low end as clearly as variations at the high end. This figure, for example, would show no detail below $1,000 per ton if it had been plotted on the familiar linear scale. Data for water and pipeline include estimates of shipments not captured by the CFS and calculated by the Oak Ridge National Laboratory (ORNL).

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics calculations based on 1993 Commodity Flow Survey data, plus additional data provided by Oak Ridge National Laboratory.

► NAFTA and Transborder Freight

The growth in international trade since the inception of the North American Free Trade Agreement (NAFTA)[18] highlights the importance of north-south land freight movements among the United States, Canada, and Mexico. Information from the BTS Transborder Surface Freight Dataset, collected by the Census Bureau, shows that, in 1995, nearly $274 billion worth of goods moved by land between the United States and Canada, up 10.5 percent from 1994, the first year the trade agreement was in effect. By value, 68 percent of this trade moved by truck, 20 percent by rail, and 4 percent by pipeline; the rest moved by other surface modes. Over $97 billion worth of goods moved by land between the United States and Mexico in 1995, up 7.8 percent from 1994. By value, 81 percent of this trade moved by truck, and 14 percent by rail. (USDOT BTS 1996c)

In 1995, there were 11,000 truck crossings from Mexico to the United States on an average weekday. This represents a 27 percent increase from 1992, and is expected to grow. In 1995, of the trucks crossing from Mexico to the United States, about 66 percent entered through Texas,

[18] NAFTA went into effect on January 1, 1994.

Table 9-6.
Waterborne Freight: 1970–95
(In millions of tons)

Type of shipment	1970	1995	Change (percent)
Total (domestic and international)	1,532	2,240	46
International	581	1,147	97
Imports			
Coastal	313	654	109
Great Lakes	26	19	–27
Exports			
Coastal	206	442	115
Great Lakes	36	33	–8
Domestic	951	1,093	15

SOURCE: U.S. Army Corps of Engineers. 1996. *Waterborne Commerce of the United States, 1995.* New Orleans, LA. Part 5, tables 1-1 and 1-2.

about 24 percent through California, and about 10 percent through Arizona. (USGAO 1996a)

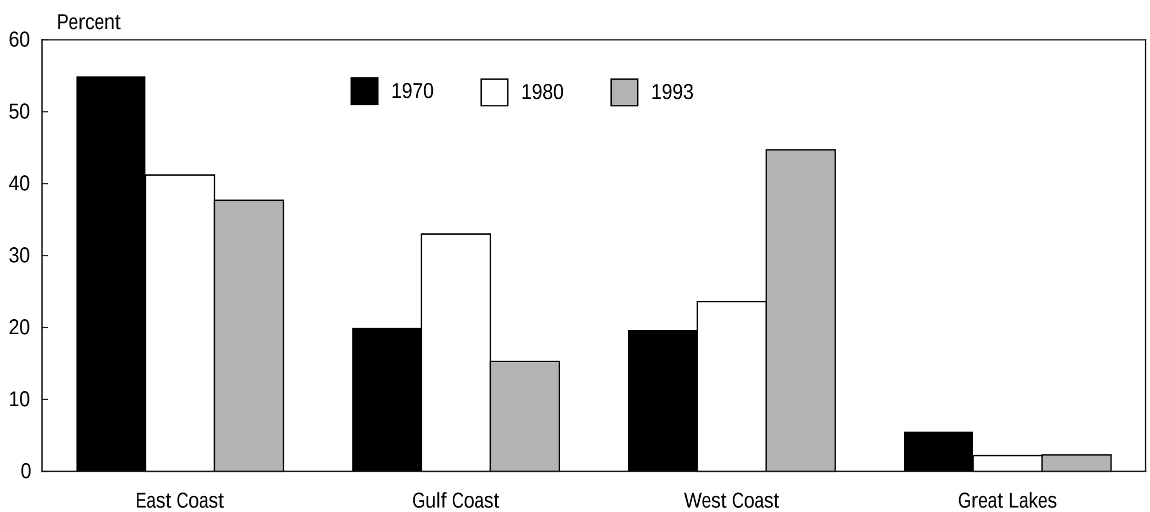
Factors Affecting Freight Movement

Growth in the U.S. population and the economy are key factors in the increase in freight movement. (see figure 9-10). Between 1970 and 1995, the U.S. resident population increased by nearly 59 million people (a 29 percent increase), and gross domestic product (GDP) nearly doubled in chained dollars. (See chapters 1 and 2 for more details.)

Today's businesses often require higher priced, higher quality transportation to assure quicker product deliveries, on time, with little product loss or damage. These requirements are one reason for the growth of trucking.

As business practices have changed, so too have the modal competitors, with, for example, rail carriers turning to intermodal arrangements or seeking technological improvements that cut costs. Business uses of more expensive transportation modes fit a pattern of a dynamic, glob-

Figure 9-9.
Regional Share of Total Annual Value of Oceanborne International Trade: 1970, 1980, and 1993



SOURCE: U.S. Department of Commerce, Bureau of the Census. 1990 and 1996. *Statistical Abstract of the United States.* Washington, DC.

Table 9-7.
Top 15 U.S. International Air Freight Gateways: 1994

Gateway city	All carriers (thousand tons)	U.S. flag carrier (percent)	Other flag carrier (percent)
Total, all gateways	5,661	41	59
Miami, FL	1,225	49	51
Anchorage, AK	966	53	47
New York, NY	890	28	72
Los Angeles, CA	473	16	84
Chicago, IL	391	27	73
San Francisco, CA	257	24	76
Newark, NJ	179	58	42
Atlanta, GA	136	45	55
Honolulu, Oahu, HI	127	27	73
Fairbanks, AK	105	7	93
Boston, MA	103	31	69
Houston, TX	98	37	63
Washington, DC	84	43	57
Memphis, TN	77	100	0
Dallas/Ft. Worth, TX	65	57	43

NOTE: Includes scheduled and nonscheduled operations.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, T-100 program data.

alized economy moving toward lower overall cost of production and product distribution.

In part because of improved and pervasive transportation infrastructure, businesses have more choice in siting new facilities than a few decades ago. Manufacturing companies may have branch plants, distribution centers, and supplier networks in far-flung locations, with raw materials, parts, and employees often in transit between facilities. Efficient and reliable transportation permits interaction between these locations and extends the area over which industries can market their goods and services, thus increasing options for consumers.

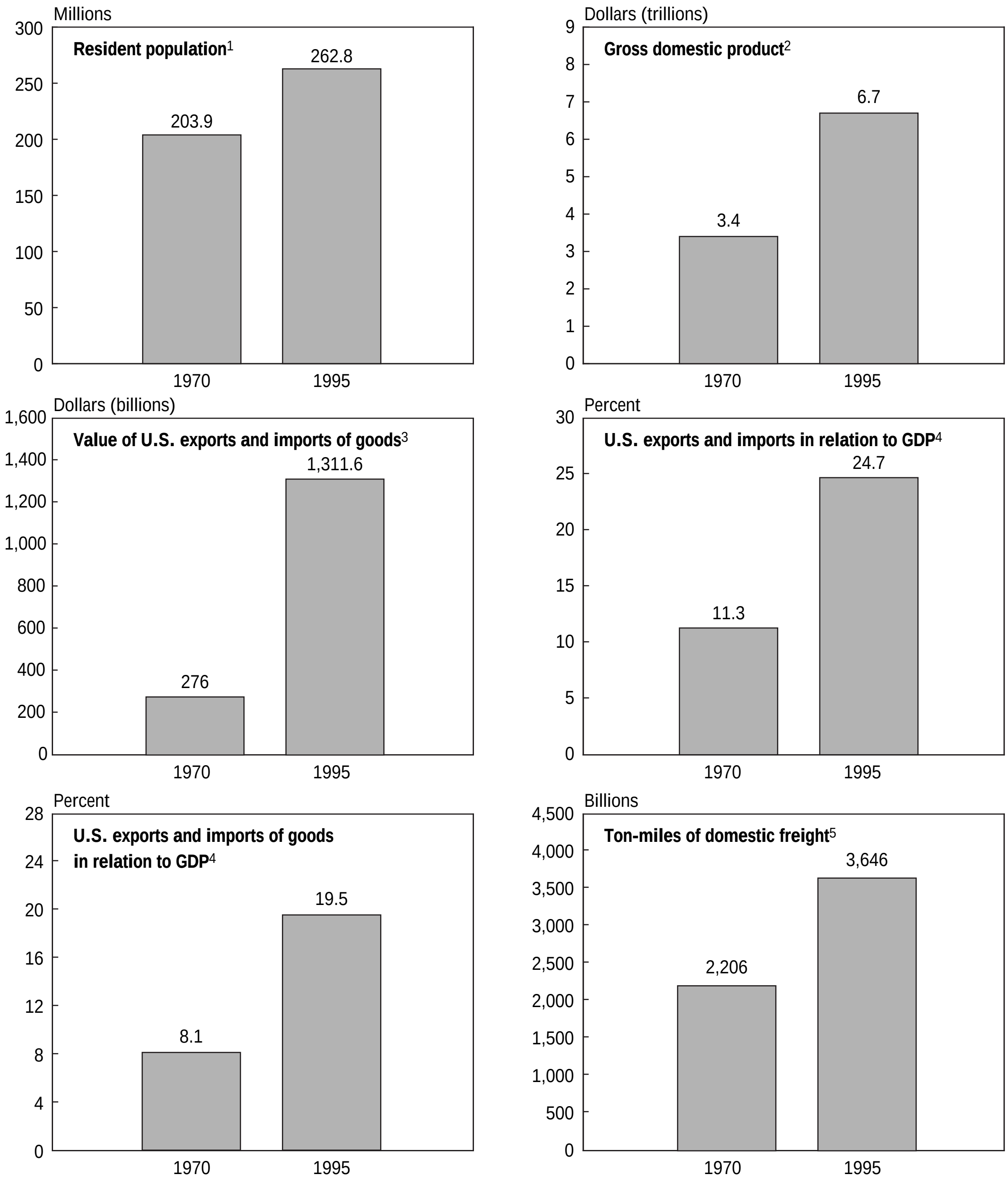
International trade, as figure 9-10 illustrates, has become an increasingly important component of the U.S. economy. The ratio of the sum of U.S. exports and imports to U.S. GDP[19] over time shows this trend clearly. (GDP measures the value-added by all goods and services in the economy, while the sum of exports and imports measures the size of the international trade component of an economy.)

In 1995, the ratio between total exports and imports of goods and services and U.S. GDP was 24.7 percent, compared with 11.3 percent in 1970. Trade in goods, which is closely related to freight movement, also more than doubled its ratio to GDP—from 8.1 percent in 1970 to 19.5 percent in 1995. (USDOC BEA 1996) The volume of international trade has also increased.

As diverse sectors of the U.S. economy—from agriculture to high-technology manufactured goods to consumer products—have responded to the growth in international trade, transportation has both helped to shape and been shaped by changing demands. For example, major U.S. ports have grown in importance, reflecting use of large container vessels to ship goods between the Pacific Rim and Europe and the United States. In some cases, transportation innovations were a key factor in expanding trade. In the agricultural sector, improved refrigerated containers and better coordination to minimize delays have enabled many of the world's large cities to have year-round supplies of fresh fruits and vegetables once obtained only locally, and chilled meat and dairy products are now traded globally. (Henderson et al 1996, 133) Without such innovations, the volume of trade in perishable commodities would be more limited.

[19] The ratio of the sum of U.S. exports and imports to GDP should not be confused with the share of international trade as a component of GDP. The latter measures the net value of exports minus imports as a component of GDP.

Figure 9-10.
Trends in U.S. Population, GDP, International Trade, and Domestic Ton-Miles of Freight: 1970 and 1995



NOTE: Figures for gross domestics product (GDP) and for the value of exports and imports are expressed in chained 1992 dollars.
SOURCES: [1] U.S. Department of Commerce, Bureau of the Census. 1997. *Statistical Abstract of the United States, 1996.* Washington, DC.
[2] U.S. Department of Commerce, Bureau of Economic Analysis data. 1996.
[3] U.S. Department of Commerce, Bureau of Economic Analysis data. 1996. Expressed as the sum of exports and imports in positive numbers.
[4] U.S. Department of Commerce, Bureau of Economic Analysis data.1996. Expressed as the ratio of the sum of the value of U.S. exports and imports to GDP.
[5] U.S. Department of Transportation, Bureau of Transportation Statistics.1996. *National Transportation Statistics, 1997.* Washington, DC. December.

Global competition and technological advances are changing the way in which many goods are manufactured and distributed within the United States and elsewhere in the world. Manufacturers often obtain raw materials and inputs, conduct operations, and rely on suppliers all around the world. Transportation innovations, coupled with the information technologies discussed in chapter 11, have enabled close coordination between producers, transporters, and distributors of goods and materials at every stage of production.

Many companies use information technology to compare their stock levels with existing and anticipated orders quickly, and then to analyze resupply options. They can rely on readily available transportation services (including in some cases their own truck fleets) to deliver goods as they are needed, called just-in-time (JIT) delivery systems (see box 9-2).

Changes in the transportation industry itself affect how businesses transport goods. Growth in containerization and associated developments by railroads and ports have contributed to growth in intermodal transportation. Recent railroad company realignments due to consolidations and mergers are expected to improve efficiency and profits, and reduce the costs for long-haul traffic.

In recent years, shippers and carriers have been able to use technology to track freight vehicles and cargo from trip origin to final destination—steps that often enable their business customers to reduce costs and fill orders more reliably. Technological innovations such as bar coding to allow shipments to be verified and

Box 9-2.
Just-in-Time Delivery Systems

For much of this century, standard inventory practice involved stockpiling large quantities of materials and parts to ensure that industrial production was not stopped by delays or breakdowns in supply. Likewise, wholesalers and retailers maintained large inventories to avoid products being out of stock.

Since about 1980, many U.S. businesses have shifted to a management and production style known as just-in-time (JIT). JIT involves deliveries of materials and parts as they are needed in the manufacturing process, and delivery of final products to distributors as they are demanded by customers. This almost always means more frequent and smaller product shipments than in the past. American businesses that use JIT include Levi Strauss, General Motors (GM), and the Campbell Soup Company. Levi Strauss linked suppliers to manufacturing and distribution centers, and adopted a system of automatically replenishing inventory at the company's sales outlets. Through JIT, GM's service parts division reduced inventories and costs of its own operations and its dealers. (Trunick 1996) At the Campbell Soup Company, JIT is used for inbound delivery of raw materials, mostly perishable agricultural products.

Retailers also are capitalizing on rapid and reliable transportation to speed delivery and offer more choices to customers. Overnight, two-day, and three-day delivery to consumers of products as diverse as computers and clothing have become the hallmark of many catalog sales companies—firms that might otherwise have difficulty competing with stores that offer customers immediate receipt of merchandise.

JIT practices put a premium on transportation system reliability and speed, and can lead to the selection of new sites for terminals, distribution centers, and manufacturing and assembly plants. JIT also places a premium on quick and reliable communication among business partners. As a result, JIT processes have taken full advantage of, and spurred demand for, improved computer and communications technologies. Although transportation costs may increase due to JIT, there is a greater decrease in total production costs.

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P.A. Trunick. 1996. Build for Speed. *Transportation and Distribution.* February. pp. 67–68.

Box 9-3.
ITS Applications in Trucking

Intelligent transportation systems (discussed in detail in chapter 11) offer opportunities to improve the efficiency and safety of truck fleet operations, benefiting the motor carrier industry, state motor carrier regulatory agencies, and the public.

In addition to business applications common to most industries, information technologies (IT) can be used for electronic exchange and processing of information about the vehicle, the driver, the motor carrier, and—in some cases—the cargo. This could lead to electronic clearance of many trucks at state and international border crossings and other enforcement locations, thus avoiding the costs and delay of a stop. Transponder-equipped trucks would automatically transmit information about credentials, safety status, and weight to the regulatory body. This information could be cross-checked (again using IT) against safety records or other databanks to which the authority had direct access. If the check identified a potential problem, the vehicle would be stopped for inspection, allowing the other trucks to pass by. For stopped vehicles, some facets of the inspection process could be automated to expedite the process.

Electronic exchange of information requires close coordination, technical compatibility, and data-sharing among numerous public and private entities—a circumstance that has limited deployment to date. The potential benefits, however, are such that implementation is moving ahead.

Automation of the many administrative processes and related paperwork that burden carriers and state agencies could produce savings for both parties. (State regulatory functions include safety, collection of taxes and fees, and registration and certification of vehicles and drivers.) Examples include electronic application for credentials, and automated reporting of mileage and fuel use. An onboard or carrier database on shipments of hazardous materials would provide emergency response teams with timely and accurate knowledge of cargo contents in emergency situations.

tracked, electronic data interchange for online transmission of business messages, and satellite linkups to in-vehicle navigation equipment help carriers identify least-cost routes or avoid traffic bottlenecks (see box 9-3).

Access Issues in Freight Movement

Despite technological advances, connections between the transportation modes are typically the weakest links in the nation's transportation system. (NCIT 1994) Bottlenecks at the nation's transfer terminals can result in costly delays. Transfers of freight moving between east and West Coast states have long been a problem. Historically, the national rail network has been divided between eastern and western railroad companies, with none of the railroads providing coast-to-coast service on a single set of tracks. Even with mergers that have led, since the 1970s, to the dominance of a few large railroad companies, eastern railroads must link up with western railroads at such gateway cities as New Orleans, Memphis, St. Louis, Kansas City, and, most of all, Chicago.

Growth in world trade has been accompanied by significant changes in ocean fleets, thus creating seaport access problems. Large ports must be able to accommodate very large container ships, called post-Panamax vessels because they are too large to traverse the Panama Canal (see box 9-4). Ports need more facilities, particularly larger and faster cranes, to handle such large vessels and to load and unload them efficiently; simultaneously, the ports need to handle many container vessels in order to justify investment in container-handling equipment. Growth in the size and number of container ships also increases landside traffic and stresses the ability of connecting modes to handle this traffic.

Relatively few U.S. harbors have channel depths adequate for the largest commodity vessels when they are fully loaded. Traffic congestion at these large ports can be serious, with delays in processing often impacting the cost-effective delivery of goods. As a result, both seaside and landside access to these port areas have become important transportation concerns. (USGAO 1996b) Conflicts have also arisen

Box 9-4.
Container Ships and Port Access

The container ships of today bear only a passing resemblance to the first container ships of the mid-1950s, which were converted tankers. The containers aboard these early ships simply permitted more effective use of ship cargo capacity, and onloading and offloading of goods. Before long, however, containers were used to transport shipments from origin to destination without intermediate repacking. During the 1960s and 1970s, motor carriers and railroad operators set up container facilities of their own, as they recognized the efficiencies available through containerized transport. The growing demand for intermodal container transportation also spurred demand for larger, specialized container ships. Today, modern intermodal movement of freight by ship and rail requires ports with streamlined terminal operations, sophisticated equipment for loading and unloading double-stack trains, and close coordination with land delivery systems, including the use of cargo and equipment tracking systems.

The diversity of port capacities, transport networks, and transported goods has spawned a wide variety of specialized container vessels, including those with their own cranes and those with roll-on/roll-off capabilities.[1] In some cases, new container ships adapt to the constraints of a port's existing capabilities; in others, ports adapt to the needs of these enormous ocean vessels.

The biggest container ships, which are far too large to pass through the Panama Canal, are called "post-Panamax" vessels. These ships are longer than a football playing field, carry between 4,000 and 5,000 20-foot-equivalent container units (TEUs), and can cruise at speeds of 25 knots. "Post-Panamax Plus" vessels may reach lengths of 1,100 feet and have capacities of up to 6,000 TEUs. (Muller 1995)

The size of post-Panamax vessels and the growth in their numbers pose challenges for port managers. To load and unload these vessels efficiently, huge cranes, costing as much as $8 million each, are needed to reach more than 150 feet across the beams of the largest vessels. Channels must have 45 foot depths to accommodate these vessels—leading to environmental conflicts over dredge operations (see chapter 4). Space, often at a premium in the dense urban setting of many major ports, must be available to store and sort containers for transshipment, and transport infrastructure must be adequate to clear a vessel's entire load in as few as eight hours.

One requirement for continued growth in containerization is enough intermodal capability to handle increased landside traffic resulting from international trade. For example, in 1994, container traffic for the port of New York and New Jersey, the nation's third largest container port, was just over 1.4 million TEUs. Assuming the typical truck-trailer combination carries two TEUs, this annual through-put translates into over 700,000 one-way truck trips per year (over 1,900 truck trips a day).

[1] A vessel designed to allow cargo to be driven on and off the vessel.

REFERENCE

G. Muller. 1995. *Intermodal Freight Transportation*, 3rd edition. Lansdowne, VA: Eno Transportation Foundation.

between environmental objectives and the need to dredge harbors and dispose of resulting materials (see chapter 4).

In the United States, container growth (8.1 million intermodal trailers and containers moved by rail in 1995, up from 3 million in 1980 (AAR 1996, 26)) has meant relatively less traffic at smaller ports and the emergence of a few, dominant, container ports. (Kuby and Reid 1992; U.S. Congress OTA 1995, chapter 6) Increased containerization also has affected the balance between East Coast and West Coast ports, with West Coast ports handling an increasing proportion of the fast-growing Pacific Rim trade. Today, four of the top five U.S. container ports are located along the Pacific Coast, led by Los Angeles and its close neighbor at Long Beach, with over 3.7 million 20-foot equivalent units (TEUs) combined container traffic in 1994. On the East Coast, the port of New York and New

Jersey is the leader, with over 1.4 million TEUs in 1994. Total U.S. container traffic was about 12.2 million TEUs in 1994. (USDOT 1995, 242)

To handle the growing demand for landbridge transport by rail and truck, considerable private and public investment is going into dockside and landside improvements. The San Pedro Bay Ports are prime examples. The proposed solution to landside access, the Alameda Corridor Project, is an estimated $1.8 billion improvement program to consolidate 90 miles of rail track, owned by three rail companies, into one 20-mile rail corridor linking the San Pedro Bay Ports to railyards near downtown Los Angeles and to the national railroad system. The project also will widen and improve the highway paralleling the rail corridor. The goal is to eliminate delays at local highway-rail grade crossings, to take trucks off these roads, and to save costs through more timely access to shippers and receivers nationwide. (ACTA 1997)

▶ Transborder Freight Movements

There is an east-west orientation evident in the nation's major highways and railways, linking Pacific Coast cities to the nation's interior and to Atlantic and Gulf Coast cities. In the western United States, highway and rail routes that run north to south tend to be relatively circuitous. There is little inland commercial waterway traffic west of the Mississippi River Basin, other than on the Columbia-Snake River System in the Pacific Northwest, and that traffic is east-west oriented.

A key freight access and infrastructure question in the coming years is how this pattern of supply will affect, and be affected by, new transportation demands arising from recently liberalized trade policies, notably the 1993 North American Free Trade Agreement with Canada and Mexico, and the 1994 agreement resulting in the creation of the World Trade Organization.[20] Concern exists about whether north-south transportation costs could hinder the growth of trade among the United States, Canada, and Mexico. Existing highway, rail, and water links afford states in the northeast and midwest comparatively good access to eastern Canadian cities, which, in turn, have relatively good access to the U.S. Gulf Coast ports. Trade with Canada is concentrated in the industrialized northeast and midwest, and the states of California, Texas, and Washington. Trade with Mexico is even more concentrated geographically, notably with Texas and adjacent southwestern states.

Data Needs

Inadequate data on the value, tonnage, and ton-miles of freight across all modes for all sectors of the economy have long made it difficult to present a complete picture of the magnitude and extent of freight movements in the nation. While the 1993 CFS has greatly increased our knowledge of freight flows, it does not cover all sectors of the economy and the data published are at a high level of geographic aggregation. Understanding of domestic freight movements could be improved through:

- *Information on how much freight is moved in all sectors of the economy,* including agricultural shipments from farms, shipments by government, retail, and service sectors, and household goods movement by all modes of transportation (available data lack uniformity in definitions, tabulation methods, and reporting standards).
- *Improved methods for obtaining data about freight movement at the metropolitan level.* Local data may provide insight into trans-

[20] The World Trade Organization, the successor to the General Agreement on Tariffs and Trade, was established on January 1, 1995.

portation demands, relationships between freight movements and business patterns, and traffic corridor analysis (which requires data from overlapping geographic regions). To improve local freight data, a uniform survey instrument and methods could be developed for use by metropolitan and local agencies. This data, collected locally, would need to be consistent with data from the CFS.

- *More detailed information on freight mode split to improve understanding of the use of intermodal transportation.* In the case of shipments moved by parcel, postal, and courier services, it is not possible to determine how much freight was transported by an intermodal combination and how much was moved by a single mode. Information on the sequential use of transportation modes is needed for better transportation planning. Disaggregated data may help to identify infrastructure investment requirements, available transportation alternatives, and freight market choices.

Data on the domestic movement of international freight to and from the United States are inadequate. For example, the domestic origin of exports may be recorded as the headquarters city of an establishment, not the place where the shipment actually originates. Information on the true origin of shipments is important for better understanding the implications of trade policies and patterns. Also, for overland transborder exports, it is not always clear which intermodal combination of transportation was used to move the freight.

Better information is needed about the final destination of imports. Also, information is scanty about the domestic movement of goods that are transshipped through the United States from abroad to a final destination in another country. Information about through freight traffic is lacking because much of this freight is bonded and handled by foreign shippers not included in the CFS.

There is also a need for better information on changes in shipment frequency and travel time from origin to destination. Such information would help illuminate changes in the freight industry, such as shipping and geographical patterns, modal shares, equipment requirements, the reliability of freight deliveries, and the use of electronic devices for information interchange and tracking freight. To better understand the competitiveness of U.S. freight transportation in the global economy, answers to these questions are needed: how much does it cost to move domestic and international freight (especially freight moving under contract arrangements); how much do businesses spend on moving freight, and is this changing over time; how long does it take to move domestic freight from origin to destination; and how reliable are freight deliveries? Such information could help decisionmakers evaluate investment and other policy choices, and could be useful in evaluating the outcomes of such choices.

The nation's freight transportation system continues to respond to dynamic changes in the national and global economy. Changes in the mix of manufactured products, improvements in information and communications systems, and shifts in centers of global production and trade patterns will continue to affect the pattern of freight movement in the United States. Continued monitoring of freight movements will be needed in the years ahead.

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Global Trends: Passenger Mobility and Freight Activity

Global economic growth and the integration of trade, finance, and manufacturing continue to widen and intensify. Expanding passenger mobility and freight activity both facilitate and are a result of this growth and integration. This chapter explores global changes in passenger mobility and freight activity and their implications and impacts. It reviews trends in countries belonging to the Organization for Economic Cooperation and Development (OECD),[1] the former East Bloc (FEB),[2] and in other non-OECD countries.[3] The chapter shows that almost all countries—developed and developing—are facing similar transportation challenges resulting from increasing mobility and freight activity, as well as a shift in modes. It also shows that all countries are struggling to find and apply appropriate solutions. The final section discusses the implications of changing mobility in passenger and freight transportation worldwide.

[1] In 1997, OECD member countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Hungary, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Poland and Hungary are included here with the former East Bloc countries and South Korea with non-OECD countries, because the data and information used in this chapter predates their entry into the OECD.
[2] FEB refers to countries of central and eastern Europe, Russia, and other republics of the former Soviet Union.
[3] This chapter often refers to non-OECD countries as "developing countries," even though the state of economic development among this group varies widely.

As discussed in chapters 6, 7, and 9, various statistical indicators are necessary to assess trends in mobility and freight activity. In passenger transportation, mobility can be defined as the potential for movement. Chapter 7 focused on personal mobility in the United States, and chapter 9 on freight activity. Mobility was measured in physical terms, such as vehicle- or passenger-miles traveled (pmt) and ton-miles. In this chapter, international standard metric units are used, such as the annual number of vehicle-kilometers traveled (vkt) or passenger-kilometers traveled (pkt). This chapter combines data for travel, including vkt and pkt, with inventory data on the number of motor vehicles as surrogates for personal mobility. Freight activity can be measured by commercial vkt, metric tons, metric ton-kilometers (mtk), or average trip distance. This chapter uses the number of mtk as the best available surrogate for freight activity. Lastly, the chapter presents mobility and activity indicators on a per capita, per household, or per vehicle basis whenever possible to permit better international comparison.

Because the quality and quantity of passenger and freight data vary greatly across countries, the discussion is illustrative rather than definitive (see box 10-1). In addition, as the data used here are national in scope, they may mask important differences at the local and regional levels in many countries.

Box 10-1.

Data Difficulties and Limitations

Inconsistent and inadequate data hamper the comparison of transportation systems and policies across countries. The data in this chapter should be thought of as allowing only approximations, not precise country and regional comparisons. Still, as the reader of this chapter will find, even allowing for data problems, trends are clear and some conclusions are evident. The two main categories of data problems are availability and methodology.

Industrialized countries, including the United States, Japan, and Western Europe, have data that are relatively comprehensive and readily available. Developing country data are often less accessible and much less extensive. A few organizations develop and publish detailed and somewhat comparable sets of trend statistics. These are often limited, however, to a specific set of countries or to a specific mode. Without such cross-country statistical sources, national data must be used, where available. This can be a complex undertaking, because transportation-related datasets may be provided by more than one government agency.

The availability of passenger and freight data varies by data category. In general, passenger data are more robust and usually include several indicators such as passenger- or vehicle-kilometers traveled, or numbers of vehicles, although more data are available for road transportation than for other modes. In contrast, data on freight transportation are often limited to indicators of metric ton-kilometers and modal share. Measures of origin and destination, average distance shipped per mode, and intermodal shipments are often not available.

In addition to the lack of data, definitions and collection methodologies differ among countries. For example, countries generally collect travel data through national surveys and may define the term "trip" differently, which affects response rates. Collection methodologies in some countries may lead to an underreporting of modes such as bicycling and walking. In addition, some countries, such as Canada, collect statistics on personal mobility in a way that is not directly comparable to U.S. statistics.

Global Trends and Factors

While the pace and extent of change vary, common trends are underway worldwide. For both passenger and freight transportation, motor vehicles are gaining increasing modal shares, often at the expense of other modes. At the same time, many countries are also experiencing rapid growth in passenger and freight air transportation, although it accounts for a relatively small modal share. In general, these changes are occurring faster in countries with rapidly developing economies than they are in already industrialized countries. Table 10-1 provides a snapshot of transportation infrastructure in several countries.

Passenger Mobility

Passenger mobility, whether measured by pkt or vkt or the number of motor vehicles, has increased worldwide in the last 20 years. Growth in the use of passenger cars[4] and similar vehicles dominates all the statistics on increased mobility. In addition, air transportation is responsible for a small but rapidly growing part of domestic passenger travel worldwide. Domestic passenger air travel increased an average of 2.5 percent annually (measured in pkt) between 1985 and 1994 worldwide, although this growth was even more rapid in some countries and regions. (OECD 1997) Indeed, in many countries, air travel has been the fastest growing mode of passenger transportation in recent decades. (IEA 1996a, 47)

Motor vehicles, particularly private passenger cars, are now dominant in most OECD countries and are gaining modal share elsewhere. In 1994, automobiles and similar passenger vehicles accounted for 86 percent of the pkt in the United States and 52 percent in Japan, while they accounted for 80 percent of pkt in Western Europe in 1993 (see figure 10-1). In China, passenger road transportation (buses and cars) edged out rail in 1992 to take 46 percent of all passenger-kilometers traveled. (World Bank 1994a) Data are not available for private cars in India, but road transportation accounts for an estimated 85 percent of passenger travel in 1992. (World Bank 1995b)

Between 1970 and 1990, growth in both the number of cars and in highway travel was higher in Europe and Japan than in the United States, as shown by figure 10-2. The United States, however, continues to have more automobiles and more automobiles per capita than any other country. In 1991, the most recent year for which comparative data are available, the United States also led in overall mobility, with 24,331 pkt (15,119 pmt) per person. (As reported in chapter 1, the per capita U.S. figure for 1995 was 26,554 pkt (16,500 pmt) by motor vehicles and 27,681 pkt (17,200 pmt) by all forms of transportation.) Most Europeans traveled half as much; people in developing countries traveled considerably less (see table 10-2).

Non-OECD countries added cars at almost twice the rate as did OECD countries from 1970 to 1990, and accounted for 19 percent of the world's passenger cars in the early 1990s. (OECD 1995) Still, passenger rail and nonmotorized transport (such as bicycles and walking) remain important contributors to mobility. In general, people in developing countries travel less than those in developed countries because of immature transportation systems; less disposable income; limited access to cars, buses, and trains; and more congested urban areas.

Freight Activity

As with passenger travel, freight activity is increasing worldwide, with domestic metric ton-

[4] The term passenger car is used in this chapter to refer to several categories of vehicles. For the United States, this category includes automobiles, taxis, and light trucks. Japan's passenger car category is broken down into cars for private and commercial use. Since 1987, Japan has separately counted trucks for private use, but aggregates the data under its motor vehicle category, which includes buses, passenger cars, and trucks for private use. The European Conference of Ministers of Transport (ECMT) compiles "road passenger transport" data in three categories: cars and taxis; two-wheeled motor vehicles; and coaches, buses, and trolley buses. ECMT's car and taxi data are comparable to OECD passenger car data. OECD's passenger car data refer to passenger cars seating not more than nine persons (including driver), rental cars, taxis, jeeps, and estate cars/station wagons and similar light, dual-purpose vehicles. Other countries are often less specific and may break down surface passenger data into only a general road category.

Table 10-1.
Transportation Infrastructure in Selected Countries: An Overview
(Data for 1995 or most recent year available)

OECD countries	
United States[1]	*Railroads.* 213,000 km main line (Class I and Amtrak) routes *Highways.* 6,296,000 km; 3,819,000 km paved *Inland waterways.* 41,000 km, excluding the Great Lakes and St. Lawrence Seaway *Pipelines.* 183,000 km for crude oil; 139,000 km for petroleum products; 2,029,000 km for natural gas *Airports.* 18,224
Canada	*Railroads.* 78,148 km (1994) *Highways.* 849,404 km; 253,692 km paved (1991) *Inland waterways.* 3,000 km, including the St. Lawrence Seaway *Pipelines.* 23,564 km for crude and refined oil; 74,980 km for natural gas *Airports.* 1,386
France	*Railroads.* 34,074 km (1994) *Highways.* 1,511,200 km; 811,200 km paved (1992) *Inland waterways.* 14,932 km; 6,969 km heavily traveled *Pipelines.* 3,059 km for crude oil; 4,487 km for petroleum products; 24,746 km for natural gas *Airports:* 476
Germany	*Railroads.* 43,457 km (1994) *Highways.* 636,282 km; 501,282 km paved (1991) *Inland waterways.* 5,222 km (1988) *Pipelines.* 3,644 km for crude oil; 3,946 km for petroleum products; 97,564 km for natural gas (1988) *Airports.* 660
Italy	*Railroads.* 19,503 km *Highways.* 305,388 km; 277,388 km paved (1992) *Inland waterways.* 2,400 km *Pipelines.* 1,703 km for crude oil; 2,148 km for petroleum products 19,400 km for natural gas *Airports.* 138
Japan	*Railroads.* 27,327 km (1987) *Highways.* 1,111,974 km; 754,102 km paved (1991) *Inland waterways.* 1,770 km *Pipelines.* 84 km for crude oil; 322 km for petroleum products 1,800 km for natural gas *Airports.* 175
Mexico	*Railroads.* 24,500 km *Highways.* 242,300 km; 84,800 km paved *Inland waterways.* 2,900 km *Pipelines.* 28,200 km for crude oil; 10,150 km for petroleum products; 13,254 km for natural gas; 1,400 km for petrochemical *Airports.* 2,055
United Kingdom	*Railroads.* 16,888 km *Highways.* 360,047 km, including Northern Ireland; 360,047 km paved, including Northern Ireland *Inland waterways.* 2,291 *Pipelines.* 933 km for crude oil; 2,993 km for petroleum products; 12,800 km for natural gas *Airports.* 505

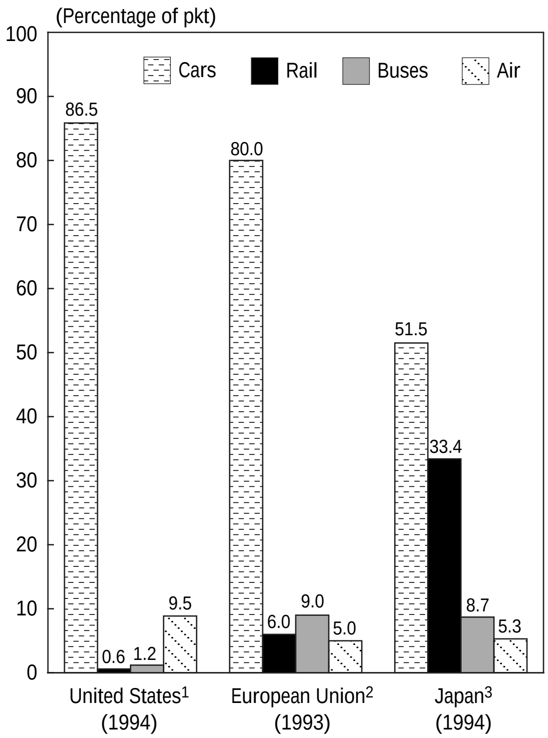
Table 10-1.
Transportation Infrastructure in Selected Countries: An Overview ***(continued)***
(Data for 1995 or most recent year available)

Former East Bloc countries	
Czech Republic	*Railroads.* 9,434 km (1988) *Highways.* 55,890 km (1988); paved not available *Inland waterways.* Not available *Pipelines.* 5,400 km for natural gas *Airports.* 116
Hungary	*Railroads.* 7,785 km (1994) *Highways.* 158,711 km; 69,992 km paved (1992) *Inland waterways.* 1,622 km (1988) *Pipelines.* 1,204 km for crude oil; 4,387 km for natural gas (1991) *Airports.* 78
Poland	*Railroads.* 25,528 km (1994) *Highways.* 367,000 km, excluding farm, factory, and forest roads; 235,247 paved, of which 257 km are limited access expressways (1992) *Inland waterways.* 3,997 km (1991) *Pipelines.* 1,986 km for crude oil; 360 km for petroleum products; 4,600 km for natural gas (1992) *Airports.* 134
Russian Federation	*Railroads.* 154,000 km (1994) *Highways.* 934,000 km (445,000 km serve specific industries or farms and are not available for common carrier use); 725,000 km paved or graveled (1994) *Inland waterways.* 101,000 km (1994) *Pipelines.* 48,000 km for crude oil; 15,000 km for petroleum products; 140,000 km for natural gas (1993) *Airports.* 2,517
Non-OECD countries	
Brazil	*Railroads.* 30,612 km (1992) *Highways.* 1,617, 148 km; 161,503 km paved (1991) *Inland waterways.* 50,000 km navigable *Pipelines.* 2,000 km for crude oil; 3,804 km for petroleum products 1,095 km for natural gas *Airports.* 3,467
China	*Railroads.* 65,780 km *Highways.* 1,029,000 km; 170,000 km paved (1990) *Inland waterways.* 138,600 km; 109,800 navigable *Pipelines.* 9,700 km for crude oil; 1,100 km for petroleum products; 6,200 km for natural gas (1990) *Airports.* 204
India	*Railroads.* 62,211 km (1994) *Highways.* 1,970,000 km; 960,000 km paved (1989) *Inland waterways.* 16,180 km *Pipelines.* 3,497 km for crude oil; 1,703 km for petroleum products; 902 km for natural gas (1989) *Airports.* 352

[1] See chapter 1 for a fuller description of the U.S. transportation system.

SOURCES:
For the United States: U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.
For other countries: U.S. Central Intelligence Agency. 1996. *The World Fact Book 1995.* Washington, DC.

Figure 10-1.
Modal Shares



[1] United States. Car total includes data for passenger cars, taxis, and light trucks. Rail total includes light rail, heavy rail, and commuter and intercity rail. Bus total includes data for transit motor buses and intercity buses. Air total includes data for certificated air carriers, domestic carriers, and general aviation.

[2] European Union. Car total includes data for private cars. Rail total includes data for intercity and commuter rail, and light rail (where available). Bus total includes local buses and intercity coaches. Air total includes domestic carriers.

[3] Japan. Car total includes data for private and commercial passenger cars. Rail total includes Japan railways and private rail. Bus total includes buses for private and commercial use. Air total includes general aviation and domestic carriers.

KEY: pkt = passenger-kilometers traveled.

SOURCES:
For United States: U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.
For Europe: European Commission. 1995. *The Trans-European Transport Network. Transforming a Patchwork into a Network.* Brussels, Belgium.
For Japan: Japan Ministry of Transport. 1996. *National Transportation Statistics Handbook 1995.* Tokyo. 15 February.

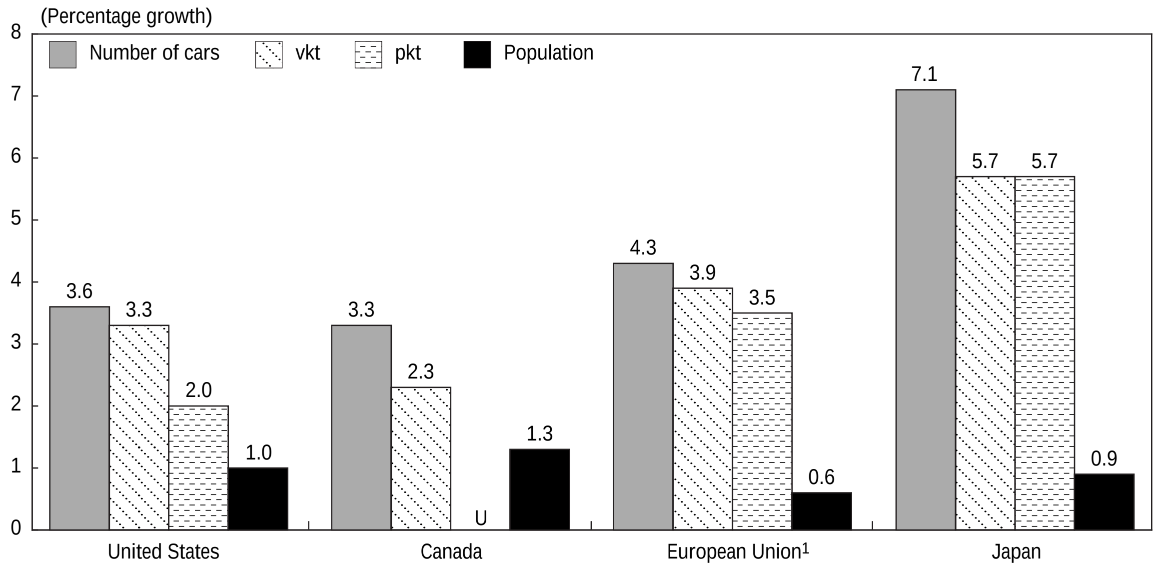
kilometers increasing in most countries over the past 25 years.[5] Road transportation has become more dominant, and the percentage claimed by air freight has grown rapidly in many countries (although air remains a small and specialized part of freight activity).

Average annual growth rates in domestic freight activity vary a good deal among countries. OECD members increased their domestic freight activity at an annual rate of between 1 percent (e.g., France, the United Kingdom, and the Netherlands) and 4 percent (e.g., Italy, Japan, and Spain) between 1970 and 1994. In the United States, freight activity increased 2 percent annually during this same period (and, as reported in chapter 1, this 2 percent growth rate continued through 1995). Freight activity grew much more rapidly in some developing countries. China saw a 7.5 percent annual increase between 1970 and 1992. From 1970 to 1994, however, freight activity in the FEB grew much more slowly and inconsistently, and, in some cases, declined.

Most of the world's domestic freight activity, on either an absolute or a per capita basis, is concentrated in OECD countries, especially the United States. In 1994, U.S. domestic freight activity was estimated at 5.13 trillion mtk.[6] (USDOT BTS 1996a) In comparison, domestic freight activity in Western Europe was 1,430 billion mtk (979 billion ton-miles), and in Japan equaled 557 billion (382 billion ton-miles).[7] It should be noted that the relatively larger area and lower population density of the United

[5] This chapter focuses on domestic freight activity within countries and regions worldwide. It does not report the growth in freight traffic between countries (i.e., international trade). International freight transportation for the United States is discussed in chapter 9.
[6] The estimate includes mtk for oil pipeline, Class I rail, intercity truck, Great Lakes and inland waterways, and domestic coastwise shipping. Non-Class I rail, local trucking, and domestic air carrier services are not included.
[7] The Japanese data are for 1991.

Figure 10-2.
Average Annual Growth Rate of Passenger Cars and Their Use, in Relation to Population: 1970–90



[1] Member states of the European Union are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

KEY: vkt = vehicle-kilometers traveled; pkt = passenger-kilometers traveled; U = data are unavailable.

NOTE: Several types of motor vehicles may be included in the car category for different countries. See footnote 4 in the text for further discussion.

SOURCES:
For United States:
U.S. Department of Transportation, Federal Highway Administration. Various years. *Highway Statistics.* Washington, DC.
U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.
Organization for Economic Cooperation and Development. 1995. *Environmental Data 1995.* Paris, France: OECD Publication Services.
For other countries:
Organization for Economic Cooperation and Development. 1992. *Environmental Data 1992.* Paris, France: OECD Publication Services.
_______. 1995. *Environmental Data 1995.* Paris, France: OECD Publication Services.
Japan Ministry of Transport. 1996. *National Transportation Statistics Handbook 1995.* Tokyo, Japan. 15 February.
European Commission. 1995. *The Trans-European Transportation Network: Transforming a Patchwork into a Network.* Brussels, Belgium.

States tends to generate more metric ton-kilometers because of the greater distances that need to be overcome in moving goods between production and consumption centers. On a per capita or "freight intensity" basis, the United States similarly led other countries with 19,683 mtk (13,482 ton-miles) per capita in 1994 compared with 10,112 mtk (6,926 ton-miles) for Canada and 1,752 mtk (1,200 ton-miles) for China (see table 10-3).

The nature of freight activity is also changing worldwide. Between 1970 and 1994, the use of road transportation grew faster than that of other modes in many countries, thus increasing trucking's modal share, often at the expense of rail. A variety of factors, including geography and business production changes, influence the rate of growth and the extent of the shift among modal shares. The shift toward road transportation has been most pronounced in non-OECD countries, although several OECD countries, particularly those in Western Europe, have very high proportions of road freight transportation.

Demand for faster and more efficient delivery of higher value, lower weight, high-technology goods has influenced the rapid growth of air freight in many countries in recent decades. Express delivery companies such as Federal

Table 10-2.
Domestic Passenger-Kilometers Traveled per Capita, Selected Countries: 1991

	Passenger-kilometers traveled	
Country	**Total passenger travel (billions)**	**Per capita**
OECD countries		
United States[1]	6,134.7	24,331
Mexico[2]	301.1	3,428
Western Europe[3]	4,250.0	11,535
Japan[4]	1,331.0	10,741
Former East Bloc countries		
Russian Federation[5]	1,000.0	7,194
Hungary[6]	76.1	7,354
Non-OECD countries		
China[7]	617.8	537
Brazil[8]	667.0	4,374

[1] U.S. total includes light and heavy rail, and commuter and intercity rail; trolley, motor, and intercity bus; automobile, taxi, motorcycle, light truck; and air travel by certificated domestic air carriers and general aviation.
[2] Mexican total includes travel by road, rail, water, and domestic air.
[3] Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. Western European total includes travel by bus and coach, rail, private auto, and domestic air.
[4] Japan total includes rail, bus (commercial and private use), passenger car (commercial and private use), private-use truck, and water.
[5] Russian total includes rail, bus, private auto, taxi, and domestic air.
[6] Hungarian total includes national rail, auto and taxi, and coach, bus, and trolleybus.
[7] China total includes rail, road, water, and civil aviation.
[8] Brazil total includes private and public road transport, rail, and domestic air.

SOURCES:
United States: U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington DC. December.
Mexico: Secretaria de Communicaciones y Transportes/Instituto Mexicana del Transporte. 1995. *Manual Estadistico del Sector Transporte 1993.* Mexico City, Mexico.
Western Europe: European Commission. 1995. *The Trans-European Transport Network: Transforming a Patchwork Into a Network.* Brussels, Belgium.
Hungary: European Conference of Ministers of Transport. 1994. *41st Annual Report: Activities of the Conference.* Paris, France: Organization for Economic Cooperation and Development.
Japan: Japan Transport Economics Research Center. 1995. *Transportation Outlook in Japan, 1994.* Tokyo, Japan.
Russian Federation: World Bank. 1993. *Transport Strategies for the Russian Federation.* Washington, DC.
China: Ministry of Communications. 1992. *Statistical Yearbook of China 1992.* Beijing, China.
Brazil: Ministerio Dos Transportes, Empresa Brasileira de Planejamento de Transportes. 1995. *Anuario Estatistico dos Transportes: 1995.*

Table 10-3.
Domestic Freight Intensities, Selected Countries: 1994

Country	**Metric ton-kilometers per capita[1]**	**GDP per capita (1994 U.S. dollars)[2]**
OECD countries		
United States	19,683	$25,505
Canada	10,112	18,562
Mexico (1993)	2,204	4,266
Japan (1991)	4,491	36,740
Western Europe		
Germany (1993)	4,271	25,133
France	3,454	22,953
Italy	3,892	17,916
United Kingdom	2,821	17,427
Former East Bloc countries		
Czech Republic	4,799	3,499
Hungary	2,588	4,072
Poland	3,294	2,415
Non-OECD countries		
China (1992)	1,752	439

[1] Excludes domestic air freight. Total includes data for rail, road, inland waterways, and coastal shipping where applicable and when available.
[2] Gross domestic product components are calculated at purchaser values for the United States, Canada, France, Italy, Japan, Mexico, the Czech Republic, Hungary, and China.

SOURCES: United States: U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.
Canada: Transport Canada. 1996. *T-Facts,* 1996-09-26. Ottawa.
Mexico: Secretaria de Communicaciones Transportes/Instituto Mexicano del Transporte. 1995. *Manual Estadistico del Sector Transporte 1993.* Mexico City.
Japan: Japan Transport Economics Research Center. 1995. *Transportation Outlook in Japan, 1994.* Tokyo.
Western Europe: European Conference of Ministers of Transport. 1995. *Activities of the Conference: Resolutions of Ministers of Transport and Reports Approved in 1995.* Paris, France: OECD Publications Service.
___. 1995. *European Transport Trends and Infrastructural Needs.* Paris, France: OECD Publications Service.
___. *Transport: New Problems, New Solutions.* Paris, France: OECD Publications Service.
Former East Bloc countries: European Conference of Ministers of Transport. 1995. *Activities of the Conference: Resolutions of Ministers of Transport and Reports Approved in 1995.* Paris, France: OECD Publications Service.
___. 1996. *Transport: New Problems, New Solutions.* Paris, France: OECD Publications Service.
China: Ministry of Communications. 1992. *Statistical Yearbook of China 1992.* Beijing.
GDP: World Bank. 1995. *World Bank Atlas 1996.* Washington, DC.

Express and DHL emerged to meet this demand. According to the International Civil Aviation Organization, domestic and international air freight rose an average of 7.5 percent per year worldwide between 1985 and 1994. (OECD 1997) Other sources indicate similar trends. European Union (EU) data show an annual increase of 4 percent in air freight between 1970 and 1991. (Banister and Berechman 1993, 19) During this same period, domestic air freight expanded an average of 6.9 percent per year in the United States. (USDOT BTS 1996a) In Japan, domestic air freight grew an average of 12.1 percent annually although its modal share is still very small. (JTERC 1995)

Influencing Factors

Shifts over time in passenger and freight activity can be traced to changes in social functions, the economy, population, government policies, and to advances in technology. These factors, which vary in importance by country and region, interact in complex ways. Table 10-4 presents socioeconomic factors for several countries.

Passenger Mobility

Many of the factors affecting personal mobility trends in the United States that are discussed in chapter 7 also apply in other countries. For example, in many OECD countries there has been a shifting of population and workplaces from urban centers to more dispersed, suburban locations. Suburbanites are more likely to use cars and roads for access to jobs and other activities. Suburbs also have lower population densities than urban centers, making mass transportation less economical, while the population and job shifts out of the city also mean that traditional transit patronage falls. In many developing countries, however, people are migrating from the countryside to larger urban areas and capital cities for jobs and other opportunities. In all cases, the urban poor face problems of transportation accessibility and cost, while transit operators are hard pressed to provide services without increased resources.

Labor force participation has increased in almost all countries, largely because of a rise in the number of working women. Women entering the workforce tend to increase rates of automobile ownership and use.

Population growth increases the demand for transportation. The age distribution of a population also influences demand, because young people and old people tend to travel less than those in the 20- to 50-year-old age group. Age distribution can affect mode preferences. For example, young adults may be more accepting of bus and train transportation (or have fewer alternatives) than middle-aged people who want the convenience of and are able to pay for private automobile travel. Population density also can affect modal preferences and the availability of transportation.

Rising personal income, which has occurred in most countries, is associated with increasing automobile ownership and passenger travel by other modes. Other factors, however, temper the effect of rising wealth. Singapore and Hong Kong, despite their high per capita incomes, have relatively low automobile ownership rates. One reason is geography: both are small city-states where travel distances are short. (USDOT BTS 1996b)

Government policies can promote or discourage certain modes. Examples of government policies include funding for road and airport construction, public transit subsidies, the provision of bicycle lanes and parking facilities, fuel and automobile taxes, highway tolls, auto-free zones, and special transit lanes. Deregulation and privatization of transportation supply are underway in many countries. Parts of the British railway system have been privatized, as has been

Table 10-4.
Socioeconomic Indicators, Selected Countries

Country	Area (thousands of square meters)	Population (thousands, 1994)	Population growth rate (1985–94)	Inhabitants per square kilometer (1994)	Urban population as percentage of total population 1970	1994	Gross domestic product[1] (GDP–U.S. dollars in millions, 1994)	Real average annual GDP growth rate 1970–94[2]
OECD countries								
United States	9,373	260,651	1.0	27.8	74%	76%	$6,648,013	2.8%
Canada	9,976	29,251	1.3	2.9	76	77	542,954	3.6
France	549	57,960	0.5	105.6	71	73	1,330,381	2.5
Germany	357	81,407	0.5	228.1	80	86	2,045,991	U
Italy	301	57,190	0.1	189.9	64	67	1,024,634	2.7
Japan	378	124,960	0.4	330.8	71	78	4,590,971	3.7
Mexico	1,973	88,402	2.2	44.8	59	75	377,115	3.4
United Kingdom	245	58,375	0.3	238.5	89	89	1,017,306	2.3
Former East Bloc (FEB) countries								
Czech Republic	79	10,295	0.0	130.3	U	65	36,024	U
Hungary	93	10,161	–0.4	109.3	49	64	41,374	2.2
Poland	313	38,341	0.3	122.5	52	64	92,580	U
Russian Federation	17,705	148,366	0.5	8.4	U	73	376,555	U
Non-OECD countries								
Brazil	8,512	159,100	1.8	18.7	66	77	554,587	4.8
China	9,561	1,190,918	1.4	124.6	18	29	522,172	8.7
India	3,288	913,600	2.0	277.9	20	27	293,606	4.5

[1] GDP components are calculated at purchaser values for the United States, Australia, Canada, France, Italy, Japan, Mexico, the Czech Republic, Hungary, and China.
[2] Base year is 1970.

KEY: U = data were unavailable.

SOURCES:
World Bank. 1994. *World Development Report 1994: Infrastructure for Development.* New York, NY: Oxford University Press.
____. 1995. *World Development Report 1995: Workers in an Integrated World.* New York, NY: Oxford University Press.
____. 1996. *World Atlas 1996.* Washington, DC: International Bank for Reconstruction and Development.
____. 1996. *World Development Report 1996: From Plan to Market.* New York, NY: Oxford University Press.
Organization for Economic Cooperation and Development. 1996. *OECD in Figures: Statistics on the Member Countries.* Paris, France: OECD Publications Service.

Aeroflot, the Russian airline. While many transit systems are heavily subsidized, Singapore's is profitable. Other government policies, such as economic restructuring in the FEB, also affect passenger travel and freight activity.

Geographic conditions influence transportation structure. For example, the population of Japan is heavily concentrated in one linear corridor (Tokyo to Osaka), which helps to explain the continuing popularity of rail services in Japan, despite large increases in automobile ownership. The linear corridor effect similarly contributes to the viability of train service in the Northeast Corridor of the United States, between Washington, DC, New York City, and Boston.

Freight Activity

A nation's economic health affects the level and composition of its freight transportation. Rapid economic development in countries such as China and India has contributed to rising levels of freight activity. In contrast, the stagnant economies of many FEB countries meant slow growth rates or declines in freight activity in the late 1980s and early 1990s.

Sectoral economic changes also influence freight activity. In most OECD countries, manufacturing and services, rather than agriculture or mining, are the dominant economic sectors. Consequently, manufactured goods, often of lower weight and higher value than traditional primary commodities, account for an increasing proportion of goods transported, stimulating a shift from rail to road and air transportation. Expanding non-OECD countries are undergoing economic changes, often at a more rapid pace than OECD countries. Development strategies in countries such as India, China, and the FEB countries have focused on shifting from the processing of raw materials to the production of semiprocessed or complete, higher value, and lighter density goods. Changes in transportation demand and services can be expected to follow.

Business production changes in recent decades have impacted freight transportation, especially in OECD countries. These changes include just-in-time delivery and product customization. As discussed in chapter 9, shippers increasingly insist on transportation speed, efficiency, and flexibility in meeting their needs. In this new environment, logistics management is a critical component of freight transportation. Usually, road transportation offers the most flexibility in responding to these changes.

New technology influences freight activities. Intelligent transportation systems and electronic data interchange provide better information on routing, traffic conditions, and potential trouble spots.

Government policies and regulations have both direct and indirect impacts on the provision of and demand for freight networks and services. State-owned or regulated freight transport was common in many OECD and FEB countries. In the past 10 to 15 years, countries as diverse as the United Kingdom, Mexico, and Poland have privatized state-owned or controlled entities and deregulated many transportation sectors. Often, road transportation was one of the first sectors to be deregulated.

Regional trade agreements like the North American Free Trade Agreement (NAFTA)[8] and common markets such as the European Union[9] influence the level and nature of freight activity within countries. Such agreements can be expected to increase international trade between member countries through reductions in tariffs and other trade restrictions, including restrictions on transportation. As international commerce grows, the level of domestic freight activity within member countries may also rise.

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[8] NAFTA, which became effective on January 1, 1994, established a free trade area between the United States, Canada, and Mexico.

[9] In 1997, the 15 member countries of the European Union are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

Trends by Region: Passenger Mobility

OECD Countries

This section reviews passenger mobility in OECD countries—Western Europe, Japan, Canada, and Mexico, but not the United States, which is covered in chapters 6 and 7.

► Western Europe

Surface passenger mobility increased an average of 3 percent annually in Western Europe[10] between 1970 and 1990—from about 2,100 billion pkt (1,300 billion pmt) to approximately 3,900 billion pkt (2,400 billion pmt). Modal shares shifted toward automobiles and airplanes away from railroads and buses. There are still marked differences, however, in car ownership rates among Western European countries (see table 10-5). During the 1980s, air travel grew faster (at 6 percent annually) than travel by passenger car (3.3 percent). (Banister and Berechman 1993)

For urban travel, the distance traveled increased by more than 50 percent, but the amount of time spent traveling (about one hour per day) and the average number of short journeys (three per day) remained constant. (ECMT 1996a)

[10] Three ways to characterize "Europe" for transport purposes are as OECD Europe, the European Union, and the European Conference of Ministers of Transport (ECMT). In general, the discussions here refer to OECD or ECMT Europe. See footnote 1 for a list of OECD countries. Members of the ECMT include: *Austria, Belgium*, Bosnia-Herzegovina, Bulgaria, Croatia, the Czech Republic, *Denmark*, Estonia, *Finland, France, Germany, Greece,* Hungary, *Ireland, Italy,* Latvia, Lithuania, *Luxembourg,* Moldova, *the Netherlands, Norway,* Poland, *Portugal,* Romania, the Slovak Republic, Slovenia, *Spain, Sweden, Switzerland,* Turkey, and the *United Kingdom*. The countries in italics are referred to here as "Western Europe."

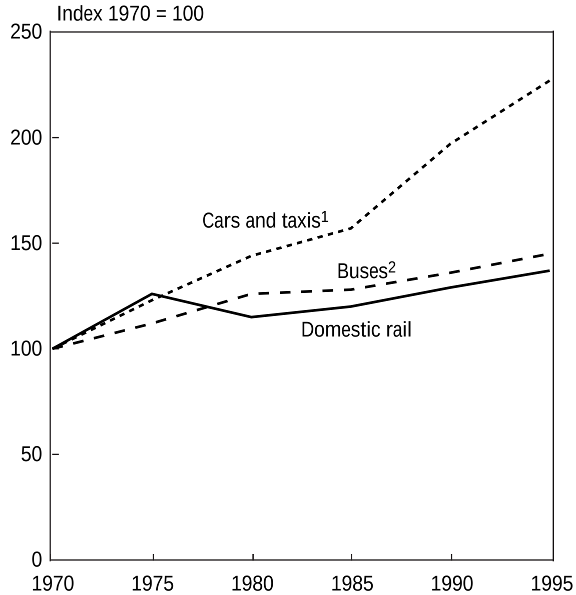
Table 10-5.
Passenger Cars per Capita and Density, Selected Countries: 1994

Country	Cars[1] per 1,000 inhabitants	Cars per square kilometer
OECD countries		
United States		
Cars, taxis, and light trucks	727	20
Cars and taxis	514	14
Canada	487	1
Mexico	92	4
France	430	45
Germany	492	112
Denmark	312	38
Italy	513	99
Turkey	46	10
United Kingdom	410	97
Australia	470	1
Japan	341	113
FEB countries		
Hungary	203	22
Russia	46	1
Non-OECD		
India	4	1
China	3	<1
Hong Kong	48	280
Thailand	18	2
Peru	20	<1
Brazil	76	1
Nigeria	8	1
South Africa	84	3

[1] The types of motor vehicles that countries include in their passenger car statistics can vary, and may not refer to the same types of vehicles that the United States includes in its totals (i.e., light trucks). See footnote 4 in the text for more details.

SOURCES:
For United States: U.S. Department of Transportation, Federal Highway Administration. Various years. *Highway Statistics.* Washington, DC.
For other countries: American Automobile Manufacturers Association. *World Motor Vehicle Data, 1996 Edition.* Detroit, MI.

Figure 10-3.
Western European Passenger Transport Trends for Selected Modes



[1] Car and taxi totals typically include passenger cars (i.e., rental cars, taxis, jeeps, estate cars/station wagons, and similar light, dual-purpose vehicles) seating not more than 9 persons (including driver).
[2] Includes coaches, buses, and trolleybuses.

NOTE: Includes Austria, Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

SOURCE: Based on data supplied to the Bureau of Transportation Statistics by the European Conference of Ministers of Transport, Paris, France.

As shown in figure 10-3, passenger car pkt increased faster than that of rail and buses between 1970 and 1990. Despite their slower growth rate, buses and trains remain important forms of local and regional transportation in all Western European countries. Within urban areas, buses are the dominant public transit mode, but trams prevail in some medium-sized and large cities. In addition, many large cities—among them, London and Paris—have underground transit systems. At 424 billion pkt (263 billion pmt) in 1990, buses accounted for more European travel than did trains. (ECMT 1995c)

The importance of air transportation varies widely among European countries for economic and geographic reasons. Short intra-country distances mean air travel is primarily international. Even then, surface travel is favored between adjacent European countries. For international trips, the people of the United Kingdom, Ireland, Greece, and Finland are more likely to use air than surface travel, mainly because of geography.

Air transportation has been highly regulated in Europe. Reliance on national flag carriers has meant little domestic and reduced international competition, with market capacity and fares predetermined among airlines and governments. Bilateral deregulation began in 1984 between Britain and the Netherlands, and gradual deregulation under European Commission directives has been underway across Europe; the last phase began in 1997. Lower airline costs and fares are expected for scheduled services. While the fares of European scheduled carriers have been among the highest in the world, average passenger costs have been lower because charters have held a large market share. (Banister and Berechman 1993, 91) With fares about one-third those of scheduled carriers in the mid-1980s, charters annually carried 78 percent of the nearly 19 million people who flew from Britain to Spain, Portugal, Italy, and Greece.

European governments, individually and collectively through the EU, acknowledge the congestion and environmental problems resulting from the growing dominance of the private automobile. Many have used regulations, traffic management, and economic measures to hold down auto growth and modal share. Measures include vehicle taxes, fuel taxes, automobile exclusion zones in urban areas, and special road tolls during peak periods. France, for example, has raised tolls on motorways leading into Paris during the Sunday afternoon peak, as people return from weekend excursions. This has resulted in a more even traffic flow spread out during the day. Zurich has parking constraints and traffic controls to limit vehicle entry when an auto-

Box 10-2.
Bicycle Use and Transportation Policies in Selected Countries

Despite the increase in motorization worldwide, bicycles continue to be used for personal mobility, although their importance varies by country. In fact, bicycling is a component of national transportation policies in several countries. In some developed countries, ways are sought to encourage and facilitate switching from cars to bicycles, especially for short journeys, and improve the safety of cycling. In developing countries that are rapidly motorizing, the focus is on reducing the conflict between bicycles and cars.

The Netherlands

Bicycle use in the Netherlands declined during the late 1960s and early 1970s. In recent decades, the Dutch have made bicycling an important part of their transportation policy, linked to securing a sustainable society. The policy is based on the view that the bicycle is an alternative to the car. The relatively short distance of Dutch daily trips helps increase the viability of bicycling as an alternative mode. In the early 1990s, 20 percent of all car trips were shorter than 2.5 kilometers (1.5 miles) and 54 percent were shorter than 7.5 kilometers (4.5 miles). In towns and cities, trips longer than 7.5 kilometers are rare.

Auto traffic in cities, however, can make cycling unattractive and hazardous. Despite efforts to build cycling routes and special crossings, tunnels, and bridges, the total distance traveled by bicycles between 1992 and 1994 increased less than 1 percent, while car-kilometers traveled increased 3 percent. Despite a slight national decline, bicycle use in several Dutch cities is significant. In Groningen, for instance, two-thirds of all trip lengths are no greater than 5 kilometers (3 miles) and 76 percent are on foot or by bicycle. Dutch policies directed at increasing the use of bicycles include banning automobiles from inner-city cores, improving safety, protecting bicycles against theft, and improving trip-chaining opportunities.

China

Prior to 1979, the Chinese government rationed bicycles. They were viewed as high-status consumer goods, and only one person in four or five had a bicycle. As part of economic reforms begun in 1979, the government ended bicycle rationing, instituted employer-based bicycle subsidies, and set aside one-third of the road space for bicycles. In response, bicycle production, density, and usage rose. In 1990, China produced approximately 40 million bicycles, nearly 40 percent of global production and four times its 1980 production levels.

In Shanghai in 1990, there was one bicycle for every 2.2 inhabitants, one of the highest densities in the world. Due to the increased use of bicycles, the national government as well as many individual Chinese cities are reviewing policy options for new kinds of transportation concerns such as growing bicycle congestion and parking problems. In addition, due to the growth of motorization in China, mixed traffic problems (where nonmotorized and motorized modes share the road) are rising.

United Kingdom

Currently, 72 percent of all passenger trips in Britain are less than 5 miles in length, and half are less than 2 miles. In 1996, the Department of Transport issued a national cycling strategy stating that the bicycle had been underrated and underused and should be a part of the country's sustainable transport policies. The strategy is designed to double bicycle use by 2002 (over 1996) and double it again by 2012, both by capturing short journeys and by combining bicycle trips with public transportation for longer journeys. Various mechanisms have been identified to meet the increased-use objective, as well as other complementary objectives such as improving safety, reallocating road space for cycling, creating bicycle parking facilities, developing standards for cycle security devices, and initiating various promotional activities. Most action will take place at the local level. The Minister for Local Transport has established a National Cycling Forum to coordinate action, involve key players, and report on progress.

Box 10-2.

Bicycle Use and Transportation Policies in Selected Countries ***(continued)***

Peru

Bicycles are being promoted as an alternative mode of passenger transportation in Peru, where public transportation is often erratic or too expensive for many lower income citizens. This promotion is most evident in the capital city of Lima, where the national and local governments, in conjunction with the World Bank, established a pilot program in 1992 with the goal of increasing bicycle use from 2 percent to 10 percent of all trips. The project is estimated to cost $4.1 million, mostly for the construction of bikeways that link Lima's low-income areas with the city's urban center. Construction of 51 kilometers (32 miles) of dedicated bicycle lanes and 35 kilometers (22 miles) of bike paths on reconditioned roads is nearing completion. The project also established a credit facility to give out $100 loans, repayable over a 12-month period, for the purchase of a bicycle by those who live in the area of the bicycle network and who have annual incomes under $1,800.

Finland

Finnish policy aims to make cycling a distinctive part of traffic policy, to double bicycle trips from 12 percent in 1986 to 25 percent in 2000, and to cut the number of fatal accidents in half. Finland estimated that doubling bicycle use would generate "socioeconomic savings" of approximately ECU100 million to 200 million (US$125 million to $250 million) per year. A 1995 review of the status of the policy found the initial timetable to be too ambitious, but a national bike touring network of 22,000 kilometers (13,670 miles) was created, and the program has raised cycling's status. Finnish cycling interests are now working to obtain more national resources to support the program and encourage local initiatives.

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matic monitoring system indicates that congestion levels are too high. Other European measures include improving and expanding public transit services and, in some countries, encouraging bicycle use (see box 10-2).

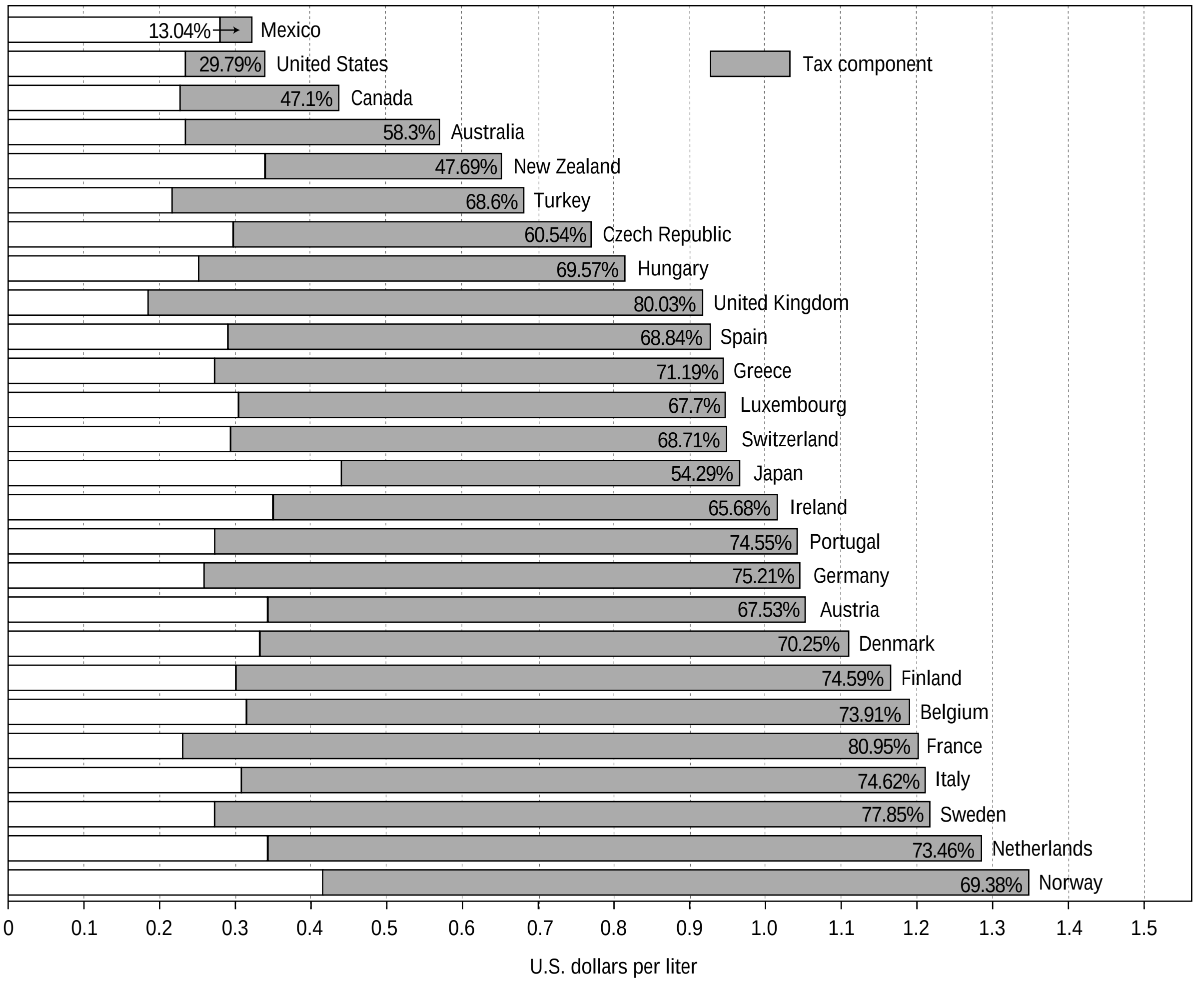
While many of these policies have been used in the United States, most have been applied more aggressively in Europe. Pedestrian-only zones are common in old, historic sections of European cities, and may be more applicable in those cities with their narrow streets than in American cities. Europeans are also more tolerant of high gasoline taxes and automobile fees. The average price of gasoline ranged from 90¢ to almost $1.40 per liter ($3.41 to $5.30 per gallon) in Western Europe and just over 30¢ per liter ($1.14 per gallon) in the United States in mid-1996.[11] Figure 10-4 illustrates that the price difference is primarily due to taxes, which can be more than four times greater than the price of gasoline in Europe.

European research suggests that policies aimed at reducing automobile use may have had only limited impact. The reasons include: 1) the cost of buying and maintaining a car and purchasing gasoline has declined over the last 20

[11] Converted at 3.785 liters per gallon.

Figure 10-4.
OECD Gasoline Prices and Taxes

In mid-1996



SOURCE: International Energy Agency. 1996. *Energy Prices and Taxes, 2nd Quarter 1996.* Paris, France: Organization for Economic Cooperation and Development.

years, while public transit costs have risen; 2) high fuel taxes seem to have caused people to switch to more fuel-efficient cars rather than from car to transit; and 3) improvements in bus service have been too modest to stimulate much added demand. (Salomon et al 1993) One policy that seems to have had some success is high taxes on automobiles. Denmark has the highest automobile tax and the lowest per capita ownership in Northern Europe. Cars are taxed twice: when initially registered (at 125 to 180 percent of the purchase price) and annually thereafter (based on the weight of the vehicle). A recent study concludes that no single measure—improving alternatives, awareness campaigns, parking fees, taxes, or urban planning—is successful if used in isolation. (ECMT 1996a)

Government policies in Europe have long affected rail usage. European railroads were originally built by entrepreneurs, as they were in the United States. As their dominant role in transportation gave way to roads, governments nationalized and subsidized rail networks, in part to preserve service. (ECMT 1995f) Today, subsidized European rail is confronted with economic, structural, and cultural changes, and European governments are again attempting to revive their railroads. (EC 1996) Returning rail operation to the private sector, as the United Kingdom, Germany, and the Netherlands are doing, is one option. In another effort to expand the role of railroads, Europe has been extending its network of high-speed trains (see box 10-3).

► Japan

As in Europe and the United States, automobile and air travel are increasing in Japan. In contrast, travel by bus and rail is growing much more slowly. Automobile use has grown 12 percent annually since 1960 while rail use grew 5.7 percent per year. (Japan Ministry of Transport 1996) Figure 10-1 shows modal shares for selected years.

The first Japanese expressway was completed in 1969. During the next two decades, the Japanese built roads, added passenger cars, and increased their driving at annual rates exceeding those in the United States (see figure 10-2). Today, 80 percent of Japanese households have at least one passenger car, up from 67 percent a decade ago.

Japanese commuters face particularly heavy congestion along expressways and arterial roads as they travel in Tokyo and its suburbs. The median commute time for Tokyo is 43.5 minutes, compared with the national median of 27.3 minutes. (Statistics Bureau 1983–93) The government has attempted to address congestion by adding roadways, a policy that may help to explain the small change in median commute times between 1983 and 1993.

Despite its slower growth rate, rail is still an extremely important mode of passenger transportation. In Japan, passenger rail has a higher modal share than in any other developed country, and rail pkt per capita are much higher in Japan than elsewhere in the world (see table 10-6). While rail travel commands a 35 percent modal share nationally, it is concentrated in the Tokyo-Osaka corridor, which is home to almost half of all Japanese. In Nagoya, outside this corridor, rail captures only about 10 percent of personal travel and in Kumamoto, less than 1 percent.

Rail and intercity and urban bus travel have suffered from competition with passenger cars. Most trams disappeared from Japanese cities in the 1960s, city buses felt the effects in the early 1970s, and in the late 1970s railways lost passengers. In 1987, because of continuing losses, Japan National Railway was privatized and broken up into six regional lines. The intercity market has grown with improved services, cost reductions, and lower fares (in real terms). Provincial railways, however, still depend on national and provincial subsidies. Hanging over the entire rail system is a $250 billion debt accumulated during its nationalization period, for which the government has yet to devise an acceptable repayment plan.

Air transportation has become increasingly important. From 1970 to 1990, domestic pkt grew 9 percent per year, gaining a 5 percent modal share. (Japan Ministry of Transport 1996) At about 490 pkt (304 pmt) per capita in 1994, Japanese travel domestically by air considerably less, on average, than Americans, who log approximately 2,400 pkt (1,500 pmt) per capita.

► Canada

Just as people in the United States, Europe, and Japan rely more on passenger cars for travel, Canadians also appear to do so. Unfortunately,

Box 10-3.

High-Speed Rail: International Perspectives

High-speed rail (HSR) systems link metropolitan areas that are 100 to 500 miles apart with operational speeds in excess of 124 miles per hour (mph) or 200 kilometers per hour.[1] HSR technologies fall into three broad groups, in order of increasing performance capabilities and initial infrastructure cost: 1) accelerated rail service, with operational speeds of 120 to 150 mph, consisting of upgraded intercity rail passenger service on existing railroad rights-of-way; 2) advanced steel-wheel-on-rail passenger systems on new rights-of-way that can attain operational speeds on the order of 200 mph; and 3) magnetic levitation (maglev) systems that employ magnetic forces to lift, propel, and guide a vehicle over a specially designed guideway, eliminating wheels and many other mechanical parts, minimizing resistance, and permitting faster acceleration, with cruising speeds expected to be 300 mph or higher.

The world's first HSR system—Japan's Bullet Train (or Shinkansen)—started running between Tokyo and Osaka in 1964. France became the second nation with HSR service when its TGV (Train à Grande Vitesse) Paris/Lyon line opened in 1983. Germany and Spain initiated HSR service in 1991 and 1992, respectively. Systems in Taiwan and South Korea are under development. Amtrak's Metroliner started HSR service in the United States in 1986[2] between New York and Washington. Amtrak's *American Flyer* service, will further improve on current performance speeds throughout the Northeast Corridor (Washington to Boston) when it begins operations in late 1999.[3]

Japan and Germany are developing maglev technologies and systems. Japan plans to test a commercial line in 1997, with a maximum speed of 342 mph. Germany's maglev system is technically different from Japan's and is targeted for operation between Hamburg and Berlin by 2010. Technical, route, and financing issues must still be resolved, however.

HSR can be competitive with automobiles and air travel if it offers comparable travel time and frequent and reliable service. Four years after the Paris/Lyon TGV route opened, rail passenger trips increased 90 percent for personal travel and 180 percent for business travel. Both increases came at the expense of air and automobile travel. France now has a national network of TGV service.

In 1994, France and the United Kingdom initiated London to Paris HSR service using the privately constructed and operated channel tunnel, or chunnel. Passenger and freight services are provided by the national railways of France, the United Kingdom, and Belgium. Le Shuttle carries freight trucks, buses, and passenger cars and their drivers between coastal points. A passenger line, the Eurostar, directly links London and Paris or Brussels. Surface travel time for the London to Paris route is four hours less than the traditional train and ferry journey. The trip is now 3 hours long, but will take 2½ hours when the high-speed tracks are completed on the U.K. side of the Eurostar route. British Airways reported a loss of 30 to 40 percent of its passengers on its competing one-hour London to Paris flight. P&O European Ferries carried 23 percent fewer passengers and 17 percent fewer vehicles during the first quarter of 1996.

The chunnel operation has not been smooth, however. Despite soaring revenues in 1995, its first full year of operation, losses increased so much that Eurotunnel (the management consortia for the chunnel) defaulted on interest payments and had to renegotiate its financing. Then, a fire in November 1996 on a Le Shuttle train carrying trucks severely damaged part of the tunnel. After two weeks, slightly reduced schedules for all other services resumed. Freight truck service, however, may not be resumed until late 1997. Despite these problems, usage increased. The number of Eurostar passengers increased 29 percent and freight tonnage was up 11 percent in March 1997 compared with March 1996. Passenger vehicles carried on Le Shuttle, however, declined 2 percent and buses carried declined 27 percent.

In the United States, various HSR options are being considered for passenger transportation in several corridors. (See figure 8-2 in chapter 8 for some locations under consideration.)

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[1] 100 miles per hour equals 161 kilometers per hour.

[2] Initial Metroliner operating speeds were 110 mph in 1969. These were increased to 125 mph (the HSR threshold) in 1986.

[3] These Amtrak improvements are dependent on $3 billion in additional expenditures by the federal government and Amtrak. (USGAO 1997)

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Table 10-6.
Passenger Rail Travel in Selected Countries

Country	Passenger-kilometers traveled per capita
Japan (1990)	3,134
Hungary (1992)	850
Bulgaria (1991)	541
India (1991)	370
Argentina (1991)	332
South Africa (1992)	286
China (1991)	252
United States[1] (1990)	163
Chile (1991)	86
Mexico (1991)	44
Nigeria (1991)	12

[1] U.S. passenger rail total includes Amtrak, commuter rail, light rail, and heavy rail.

SOURCES:
Japan Ministry of Transport, Transport Policy Bureau Branch, Information Research Department. 1996. *National Transportation Statistics Handbook 1995.* Tokyo, Japan. 15 February.
U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.
World Bank. 1994. *The Evolution of the World Bank's Railway Lending.* Washington, DC.

Canada does not regularly collect modal share data and, when it does, the data cover only intercity travel.[12] Comparisons with other countries are also difficult because data for passenger car use are often expressed in person-trips rather than pkt. Regular trend data in pkt are available for intercity travel by bus and rail.

Data show that, for intercity travel, automobile and domestic air use increased from 1984 to 1994, while bus and rail declined. (Statistics Canada 1995) Statistics Canada concluded in 1988 that the private automobile was the dominant form of transportation for short and midlength trips (under 800 kilometers or 497 miles), while commercial aviation nearly monopolized longer distance trips. (Statistics Canada 1988) In 1994, automobiles held 93 percent of all intercity person-trips, up from 89 percent in 1982. (Statistics Canada 1995)

The history of Canadian and American intercity passenger rail service is similar. While rail in both countries now has only about a 1 percent passenger modal share, rail was instrumental in the development of the western areas of both countries in the 1800s and dominated passenger mobility until the mid-1940s. As automobiles gained popularity, both national governments created quasi-public corporations to preserve what remained of passenger rail service. In the United States, this occurred in 1971 with the formation of Amtrak. The Canadian government created VIA Rail Canada in 1977. VIA Rail took over stations, maintenance operations, and equipment from the government-owned Canadian National Railway[13] and the private sector Canadian Pacific Railway. Concern about rising government subsidies led to organizational restructuring and reduction in some VIA Rail service routes. With 18 of 38 routes eliminated, intercity rail pkt dropped 46 percent to 1,392 million in 1990. Through 1994, intercity rail and bus growth was negligible. This suggests that Canadians substituted passenger car travel for at least some of the missing rail service. As this was a recessionary period in Canada, overall intercity travel may have been down as well.

Air transportation is important to Canadian mobility, particularly for long-distance travel. A February 24, 1995, U.S./Canadian open skies agreement provided increased opportunity for Canadian and American transborder passenger travel. Under the agreement, Canadian carriers gained unlimited route rights to any point in the United States, while U.S. carriers gained unlimited route rights to any point in Canada except

[12] Intercity travel is defined by Statistics Canada as one-way trips greater than 80 kilometer (about 50 miles).

[13] Canadian National Railway was subsequently privatized in 1995.

Toronto, Montreal, and Vancouver. Route rights to these three cities will be phased in over a three-year period. Since the agreement, more than 100 new scheduled connections have been established between Canadian and U.S. cities. (Transport Canada 1996b)

► Mexico

Passenger travel more than doubled in Mexico between 1980 and 1993. Road transportation, including passenger cars and buses, grew 6 percent annually, air travel rose 3.9 percent per year, while rail pkt declined 3.8 percent annually. By 1993, road transportation held 95 percent of domestic pkt, air travel 4 percent, and rail 1 percent. (SCT/IMT 1995)

Mexican statistics do not show a breakdown among road passenger modes, thus the relative importance of passenger cars and buses is not known nor is it known which contributed more to road transportation growth. OECD data show Mexican passenger car ownership growing at an annual rate of 5 percent (1980 to 1992), more than twice that in the United States. Still, by 1994, Mexico had only 92 passenger cars per 1,000 persons (see table 10-5). This suggests that buses are a major source of mobility in Mexico.

Former East Bloc Countries

Following the fall of the Berlin Wall in 1989 and the collapse of communism, FEB countries experienced serious structural economic adjustments, compounding the macroeconomic difficulties they had already faced in the 1980s. Despite economic downturns, people in the FEB have been switching to cars at the expense of public transport, which historically has been the backbone of the region's urban mobility.

Motorization in the FEB generally lags Western Europe by two or more decades. A modal share estimate for Eastern Europe in the early 1990s showed passenger cars at 10 to 20 percent, public transportation at 50 to 60 percent, and modes such as walking and bicycling at 30 to 50 percent. (Salomon et al 1993, 19) Growth in automobile usage is concentrated in urban areas. In some cities—notably Warsaw and Budapest—automobile ownership, but not use, has reached levels comparable to some Western European cities. Poland, for example, had only 170 cars per 1,000 inhabitants in 1992, but the rate for Warsaw, its largest city, was 322. (ECMT 1996b, 150) Bicycle use in FEB countries is low compared with some Western European countries, although walking seems to claim a higher proportion of journeys. (OECD/IEA 1995)

The two major factors influencing passenger modal shifts in FEB countries are the transition to market economies and a decline in government support for public transportation. From 1970 to 1990, annual growth in automobile ownership in Hungary, Poland, and Czechoslovakia[14] was 9, 13, and 22 percent, respectively. These rates are more than twice those in most of the OECD countries. The cost of acquiring a car in the FEB has been lowered by the importation of old, used automobiles from Western Europe, and from Japan to eastern Russia, but purchase and ownership costs are still high relative to incomes. The price of gasoline in the Czech Republic and Hungary is more than double the price in the United States (see figure 10-4), but per capita income is 85 percent lower. This disparity has most likely held down demand for and use of cars, and slowed the decline in transit even though its price has risen in real terms since 1989. (OECD/IEA 1995)

[14] On January 1, 1993, Czechoslovakia divided into the two separate, independent nations of Slovakia and the Czech Republic.

In Poland, prior to the 1990s, state-owned companies running trams, buses, and commuter rail carried 80 to 90 percent of nonpedestrian trips in main cities, but recovered only about 20 to 30 percent of their costs in fares. Now, with municipalities responsible for public transportation and central government subsidies declining, fares have increased. This, combined with the shift to passenger cars and high unemployment rates, meant a 7 percent annual decline in transit usage from the mid-1980s to 1993. Impacts include rapidly growing traffic congestion, parking problems, road surface deterioration, and increases in air pollution and noise in urban areas. (ECMT 1996b) For those with passenger cars in Poland, though, mobility increased 11 percent annually, as measured in vkt, from 1980 to 1992. Meanwhile, national rail pkt rose only 1 percent annually. (ECMT 1995c) Automobile use may be further encouraged, given the Polish government's decision in 1993 to construct 2,000 kilometers of motorways (a 6 percent increase over 1990) within 15 years. (IEA 1994b)

Private transportation is still a luxury good in countries of the former Soviet Union (FSU). The International Energy Agency (IEA) estimated that the Baltic States (Estonia, Latvia, and Lithuania) had the highest automobile ownership rates (about 150 per 1,000 in 1993). Growth in automobile ownership and use throughout the FSU will be constrained by the poor condition of roads and their limited extent. Total motorway length in the whole region is half that of Italy. (IEA 1996a)

In Russia's cities, public transportation (primarily buses) had an 85 percent modal share in 1991. With declining government subsidies, the physical condition of Russia's public transportation system is deteriorating. (World Bank 1993b) At the same time, ridership is declining as fares increase and service decreases. Few buses are being purchased, because of the lack of capital and foreign exchange. In addition, as buses get older, they often cannot be repaired because of the lack of spare parts.

Air transportation in Russia carries a high proportion of intercity travel. Russians have traditionally depended on airline travel because of the vast distances between cities, low fares, and the relative scarcity of intercity bus and automobile transportation. This situation is changing, however. In January 1993, the central government dropped passenger service subsidies; at the same time, energy costs began to increase. As fares have risen, demand for air transportation in Russia has decreased. Between 1992 and 1994, demand fell 57 percent. The decline may be a short-term effect, while the air transportation system adjusts to a market economy, but demand is not expected to reach 1990 levels for decades. (World Bank 1993b)

There is growth in the number of airlines, however, with 174 airlines registered for service in mid-1993. These new carriers supplement Aeroflot, which was controlled by the FSU central government but has now been divided among the former republics. It is unlikely that all of the carriers will survive over the long term. Aeroflot service in Russia has been beset by wholesale cancellation of flights because of drastic drops in demand and fuel disruptions.

Other Non-OECD Countries

Passenger travel trends vary greatly among developing countries. In some countries, such as China, India, and Brazil, passenger travel has rapidly expanded. In others, particularly many countries in Africa, growth in passenger transport has stagnated or declined. Economic, institutional, and political factors, in addition to the level and condition of infrastructure account for these differences.

Inadequate transportation infrastructure is evident in many developing countries. This affects both current levels and future expansion of passenger and freight traffic. Rail networks often cannot handle the demands of increasing volume, and road networks in many cases are poorly developed or maintained. Financing new transportation infrastructure and services, and finding the money to maintain what already exists, are challenges for most developing countries. Seventy percent of World Bank road funds now support maintenance and rehabilitation rather than new construction. (World Bank 1996)

Three interconnected themes define the growth of passenger mobility in developing countries. The first is increased passenger travel. The second is an ongoing shift from nonmotorized to motorized modes of transportation. The third is an emerging role for air passenger travel in countries with rapidly expanding economies.

Available data for developing countries show pkt growing much faster than population, and at rates higher than those in OECD countries. In China, pkt for all modes grew an average of 9.7 percent annually between 1982 and 1992. (Chinese Ministry of Communications 1992) In Brazil, pkt grew 3.6 percent per year between 1990 and 1994. (Ministerio dos Transportes 1995) In India, pkt in 1992 was over five times what it was in 1951, growing from 232 billion pkt (144 billion pmt) to 1,200 billion pkt (746 billion pmt). (World Bank 1996)

People in developing countries increasingly rely on private automobiles. Today, there is an average of only 20 cars per 1,000 people in developing countries compared with an OECD average of 382. From 1970 to 1993, however, the number of passenger vehicles in use grew more rapidly in developing countries (at 6.4 percent per year) than in OECD countries (3.5 percent), increasing non-OECD countries' share of the world's passenger cars from 11 percent to 19 percent. Large differences in cars per capita remain among countries, but the potential for continued growth is high in all of these countries (see table 10-5). As the number of motor vehicles in developing countries multiplies, their concentration in urban areas increases. Half of the automobiles in Iran and Thailand are in the capital cities.

Data also show that road transportation's modal share is increasing. In China, for example, as road transportation (including automobiles, buses, and taxis) grew 12.7 percent per year between 1982 and 1992, rail grew 7.2 percent. (Chinese Ministry of Communications 1992) Since 1990, road transportation pkt in China has been slightly higher than the once dominant rail. Road transportation, including passenger cars, taxis, motorcycles, and buses, accounted for 96 percent of pkt in Brazil in 1994. In some parts of Asia, motorcycles account for up to three-quarters of motorized passenger vehicles.

Despite relatively rapid growth in automobile use, people in developing countries still rely heavily on public and nonmotorized transportation, including foot travel. The balance between modes depends heavily on incomes. In Sub-Saharan Africa, much rural and urban travel is on foot. In Delhi, India, in 1992, 65 percent of the poorest residents walked to work, while only 10 percent of low-income and 3 percent of middle-income residents commuted on foot. The informal sector—operating jitneys, minibuses, and rickshas—is an important supplier of public transportation in many cities in Africa, parts of Asia, and Latin America. (World Bank 1996)

Nonmotorized vehicles (NMVs), such as bicycles and cycle rickshas, are particularly important in Asian countries. Because of urban congestion in many developing country cities, NMVs may provide greater mobility than other forms of transport. In the early 1990s, bicycles accounted for 50 to 80 percent of urban vehicle trips in China, with average journey times comparable to those in more motorized Asian cities (see box 10-2). (Replogle 1994) In India, there are roughly 25 times as many bicycles as motor vehicles, and in cities they account for 10 to 30 percent of all person-trips. Despite many positive attributes, however, such as low environmental damage, speed, and affordability, the modal share of NMVs has been falling in many developing countries with shifts to motorized transport.

Nonmotorized and motorized vehicles often exist uneasily side by side in urban areas, especially in cities where traffic discipline is lax. Some nations (such as Indonesia and Bangladesh) set policies to discourage NMVs. In Indonesia, for example, cycle rickshas have been suppressed through bans, taxes, licensing requirements, and confiscation. Other countries have tried to establish systems that enable the two transportation systems to coexist. In Chinese cities, motor vehicles and NMVs are increasingly separated at intersections by fences, and dedicated bicycle roadways (e.g., alleys) are being considered. Chinese cities have also been establishing bicycle-subway and bicycle-bus exchange hubs. Some Indian railway stations provide parking areas for thousands of bicycles. (See box 10-2 for further discussion of bicycle use in China and Peru.)

Railroads are particularly important to personal mobility in parts of Asia. Chinese and Indian railways each carry more passenger traffic than all Western European and U.S. railroads combined. (World Bank 1994b) In India, per capita pkt on rail is more than twice as high as in the United States (see table 10-6).

Air transportation is becoming more important in non-OECD countries. The geography of some countries, such as Peru and Nepal, has long made air transportation essential. In general, however, in the developing world, air transportation is still used more for business travel than for personal transport. Nevertheless, in some countries the air passenger market is expanding more quickly than other modes and more rapidly than in OECD countries. In East Asia, air pkt grew 9 percent annually from 1980 to 1990, faster than in other developing country regions. South Asia was second at 5.8 percent, while air travel in Latin America and Africa grew at annual rates of 3.7 and 2.4 percent, respectively, during this period.[15] In Latin America, in particular, air traffic growth is being stimulated by new alliances between U.S. carriers and newly privatized carriers in Brazil, Colombia, and other countries in the Americas. (Zellner and Mondel-Campbell 1997)

Increasing population, urbanization, and per capita income in non-OECD countries have affected demand for and the nature of passenger transportation. While population in OECD countries grew at less than 1 percent per year in the 1980s, the population of the rest of the world grew 1.9 percent annually. In many developing countries, the rate was significantly higher. Strong economic growth contributes to rising per capita income and the development of dynamic middle classes in many non-OECD countries. While the U.S. real average annual growth rate in gross domestic product per capita was 2.8 percent from 1970 to 1994, the rates for Brazil and India were greater while China was nearly three times as high (see table 10-4).

Internal migration over the past 25 years has caused urban populations in many developing countries to grow at very high rates (more than 6 percent annually). (World Bank 1996, 4) Of the 10 largest cities in the world, 7 are in developing countries. Three-quarters of the Latin American population now lives in cities and towns. In Asia, however, urbanization has not occurred so rapidly, and most people still live in rural areas, but the World Bank expects urban

[15] This regional data is for selected countries only. (IEA 1994a, 96)

areas to account for 50 percent of the total population in East Asia by 2005 and in South Asia by 2025. (World Bank 1993a, 10)

Urbanization has mixed impacts on mobility. It can stimulate demand for passenger transport, including private automobiles. If urban transportation infrastructure is inadequate to meet demand, however, constraints on economic growth and personal mobility can occur, with the poor affected the most negatively. Attracted to megacities by the possibility of employment, poor people often must live in the less expensive, outlying areas, which can mean long, expensive trips to work. For example, commuting by public transportation takes 14 percent of the income of the poor of Manila, twice that of higher income brackets. (World Bank 1996)

Transportation patterns in non-OECD countries are affected by both national actions and those of international funding agencies. State control of transportation services is beginning to ease, largely forced by international lending agencies as conditions for loans. Other national policies of developing countries have varied, but include taxes or subsidies on gasoline and diesel, tariffs on imported vehicles, often to protect local industry, and the traditional building of infrastructure. Brazil has a longstanding policy to help sugarcane growers by subsidizing ethanol as a vehicle fuel. In 1996, Brazil eliminated limits on the use of natural gas in vehicles to benefit employment and the environment, and to strengthen economic ties with other Latin American countries with significant natural gas reserves. (Philpott 1996) The Chinese policies of several decades ago that forced residences to be built near workplaces partly contributed to greater bicycle usage, although it was not until economic reforms were introduced in 1979 that bicycles appeared in larger numbers. A number of cities in Latin America have created special busways that carry large numbers of passengers.

In some countries, government policies combined with other factors have changed the way income levels affect automobile ownership. Singapore had only 106 cars per 1,000 inhabitants despite a per capita gross national product (GNP) of $23,360 in 1994. Singapore is a small city-state with extensive subway and bus systems, and government policies that have significantly raised the costs of automobile ownership. (USDOT BTS 1996b) In comparison, at 128 cars per 1,000 inhabitants in 1994, Malaysia had an ownership rate slightly above Singapore's, but a GNP per capita of only $3,520. IEA attributes Malaysia's high ownership rate to a well-developed road network and its domestic car assembly industry.

Trends by Region: Freight Activity

OECD Countries

This section reviews freight activity in the OECD, as represented by Western Europe and the countries of Japan, Canada, and Mexico.

► Western Europe

Domestic freight activity in Western Europe expanded 2.3 percent annually between 1970 and 1994, with great variation among countries. The average annual growth rate was faster in southern Europe; domestic freight traffic increased by 4 percent in Italy and 4.6 percent in Spain during the period (see table 10-7).

The most notable freight trend is the changing modal share distribution (see table 10-8 and figure 10-5). Road transportation is dominant, with a 71 percent share of mtk. Its growth averaged 3.7 percent annually from 1970 to 1994, measured in ton-kilometers. Road transportation now captures the majority of domestic freight markets in all European countries, except Austria and the Netherlands. (ECMT 1995b and 1996a)

Table 10-7.
Domestic Freight Activity in Western European Countries: 1970 and 1994
(Billion metric ton-kilometers[1])

	Total domestic freight		Rail		Road		Inland waterways		Pipelines	
Country[2]	**1970**	**1994**	**1970**	**1994**	**1970**	**1994**	**1970**	**1994**	**1970**	**1994**
Western Europe	839.3	1,430.0	249.0	226.6	420.6	1,010.2	105.8	107.6	65.3	85.6
Austria	17.7	29.3	9.9	12.4	2.9	8.1	1.3	1.8	3.6	7.0
Belgium	28.0	48.6	7.9	8.2	13.1	34.1	6.7	5.2	0.3	1.1
Denmark	9.7	12.6	1.9	2.0	7.8	9.5	U	U	U	1.1
Finland	23.1	38.4	6.3	10.0	12.4	24.8	4.4	3.6	U	U
France	174.8	200.2	67.6	49.7	66.3	122.1	12.7	5.6	28.2	22.8
Germany[3]	212.4	347.7	70.5	64.2	78.0	211.6	48.8	57.6	15.1	14.3
Greece	7.7	12.5	0.7	0.6	7.0	11.9	U	U	U	U
Ireland	U	5.7	0.6	0.6	U	5.1	U	U	U	U
Italy	86.3	222.6	18.1	22.9	58.7	187.5	0.4	0.1	9.1	12.1
Luxembourg	1.2	1.7	0.8	0.7	0.1	0.7	0.3	0.3	U	U
Netherlands	50.9	67.5	3.7	3.0	12.4	26.0	30.7	33.0	4.1	5.5
Norway	4.7	14.6	1.5	1.6	3.2	8.9	U	U	0.0	4.1
Portugal	U	11.8	0.8	1.8	U	10.0	U	U	U	U
Spain	63.0	186.9	10.3	9.1	51.7	172.3	U	U	1.0	5.5
Sweden	35.1	44.6	17.3	18.7	17.8	25.9	U	U	U	U
Switzerland	12.2	20.6	6.6	8.1	4.2	11.1	0.2	0.2	1.2	1.2
United Kingdom	112.5	164.7	24.5	13.0	85.0	140.6	0.3	0.2	2.7	10.9

[1] Excludes domestic air freight and coastal shipping.
[2] Data for 1994 for Western Europe for road, inland waterways, and total domestic freight are European Conference of Ministers of Transport estimates. Data for Belgium, Ireland, and Greece for 1994 were not available; 1991 data are used here. Data for the Netherlands, Portugal, and Sweden for 1994 were not available; 1993 data are used here.
[3] German data for 1970 include only the former Federal Republic of Germany and West Berlin. Data for 1994 were not available; 1993 data are used here. Data for 1993 are inclusive of both the former East and West Germany

KEY: U = data are unavailable.

SOURCES: European Conference of Ministers of Transport. 1995. *Activities of the Conference: Resolutions of the Council of Ministers of Transport and Reports Approved in 1995.* Paris, France: OECD Publications Service.
___. 1995. *European Transport Trends and Infrastructural Needs.* Paris, France: OEDC Publications Service.
___. 1996. *Transport: New Problems, New Solutions.* Paris, France: OECD Publications Service.

In contrast, freight rail experienced slow or negative growth and declining modal share in recent decades. Overall, domestic rail activity in Western Europe fell an average of 0.4 percent annually between 1970 and 1994, and its modal share fell from 30 to 16 percent. In a few countries (e.g., Austria and Switzerland), rail activity increased, although even in these cases, modal share fell. European governments and industries recognize the declining position of rail and the problems of sustaining freight rail (see box 10-4).

Transportation by inland waterways is less important than road or rail in Western Europe. The level of inland waterway transport remained almost constant between 1970 and 1994, but its modal share declined from 13 to 8 percent. For a

Table 10-8.
Domestic Freight Activity, Selected Countries and Regions
(In billions of metric-ton kilometers[1])

Country/ region	Year	Rail	Road	Inland waterways	Coastal shipping	Pipeline	Total domestic freight	Average annual growth rate in freight activity	Real average annual GDP rate
				OECD countries					
United	1970	[2]1,116.6	[3]602.0	[4]343.4	525.3	629.2	3,216.5	2.0%	2.8%
States	1994	[2]1,753.0	[3]1,326.0	[4]519.8	668.1	863.4	5,130.3		
Canada[5]	1984	[6]184.3	[7]43.6	[8]39.3	29.4	U	296.6	0.3%	2.5%
	1994	[6]193.2	[7]60.1	[8]29.6	22.6	U	305.5		
Mexico[9]	1980	41.3	82.2	U	18.3	U	141.8	2.5%	1.6%
	1993	35.7	139.7	U	19.4	U	194.8		
Japan[10]	1970	63.4	135.9	U	151.1	U	350.5	2.2%	4.2%
	1991	27.2	281.6	U	248.2	U	557.0	(1970–91)	(1970–92)
Western	1970	249.0	[12]420.6	[13]105.8	U	[14]65.3	839.3		
Europe[11]	1994	226.6	[12]1,010.2	[13]107.6	U	[14]85.6	1,430.0	2.3%	U

[1] Excludes domestic air freight. Includes domestic coastal shipping where applicable and when available.
[2] Class I railroads only. Rail figures are based on revenue metric ton-kilometers.
[3] Data are for intercity truck metric ton-kilometers only, and therefore are underrepresented.
[4] Great Lakes and inland waterway traffic.
[5] Data for 1970 were unavailable.
[6] Class I and Class II railroads only.
[7] Data are for for-hire Class I and Class II road carriers only, and therefore are underrepresented. The classification of Class I and Class II truck carriers changed between 1984 and 1994. In 1987, Class I and Class II establishments were those with gross operating revenues of CAD$350,000 and greater. From 1988 to 1989, Class I and Class II establishments were those with gross operating revenues of CAD$500,000 and greater. From 1990 to 1994, Class I and Class II establishments were those with gross operating revenues of CAD$1 million and greater. Because of these definitional changes, the level of domestic road activity in Canada may be underestimated.
[8] The majority of this activity is Great Lakes traffic.
[9] Data for 1970 and 1994 were not available.
[10] Data for 1994 were not available.
[11] Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Data for 1994 for road, inland waterways, and total domestic freight are Economic Conference of Ministers of Transport estimates. Data for Belgium, Ireland, and Greece for 1994 were not available; 1991 data were used for these countries, and included in the 1994 totals for Western Europe. Data for the Netherlands, Portugal, and Sweden for 1994 were not available; 1993 data were used for these countries, and included in the 1994 Western European totals. German data for 1970 included in the 1970 Western European totals were only for the former Federal Republic of Germany and West Berlin. German data for 1994 were not available; 1993 data were used in the Western European 1994 totals. German data for 1993 includes both the former East and West Germany.
[12] Road totals for 1970 do not include Ireland or Portugal.
[13] Inland waterway totals for 1970 and 1994 do not include Denmark, Greece, Ireland, Norway, Portugal, Spain, and Sweden due to inapplicability or unavailability of data.
[14] Totals for 1970 and 1994 do not include Finland, Greece, Ireland, Luxembourg, Portugal, and Sweden due to inapplicability or unavailability of data. Data for Denmark were not included in 1970 Western European totals, but were included in 1994 totals.

few countries, inland waterways remain vital. Germany and the Netherlands, with their proximity to the Rhine River, moved 17 percent and 49 percent, respectively, of their domestic freight by this mode in 1993. (ECMT 1995b and 1996c)

Economic growth, geography, and government policies (both national and trans-European) influence the level and nature of European freight transport. Relatively consistent and, in some cases, rapid economic growth contributed to the strong increase in freight activity in many countries between 1970 and 1990. Slower economic growth and a general recessionary environment between 1990 and 1994,

Table 10-8.

Domestic Freight Activity, Selected Countries and Regions ***(continued)***

(In billions of metric-ton kilometers[1])

Country/ region	Year	Rail	Road	Inland waterways	Coastal shipping	Pipeline	Total domestic freight	Average annual growth rate in freight activity	Real average annual GDP rate
Former East Bloc (FEB) countries									
Czech Republic	1970	U	U	U	NA	U	U		
	1994	23.2	22.7	1.3	NA	2.2	49.4	U	U
Hungary	1970	19.8	5.8	1.8	NA	1.0	28.4	2.6% (1970–85)	U
	1994	7.7	13.0	1.4	NA	4.2	26.3	–5.0% (1985–94)	U
Poland	1970	99.3	15.8	2.3	U	7.0	124.4	2.3% (1970–85)	U
	1994	65.8	45.4	0.8	U	14.3	126.3	–3.6% (1985–94)	2.2% (1970–94)
Russian Federation[15]	1970	1,706	116	168	412	243	2,645	3.4% (1970–89)	U
	1992	2,250	263	183	470	1,070	4,236	–5.5% (1989–92)	U
Non-OECD countries									
China[16]	1970	349.6	13.8	51.2	U	U	414.6		
	1992	1,157.6	375.6	422.2	U	61.7	2,017.1	7.5%	7.5%

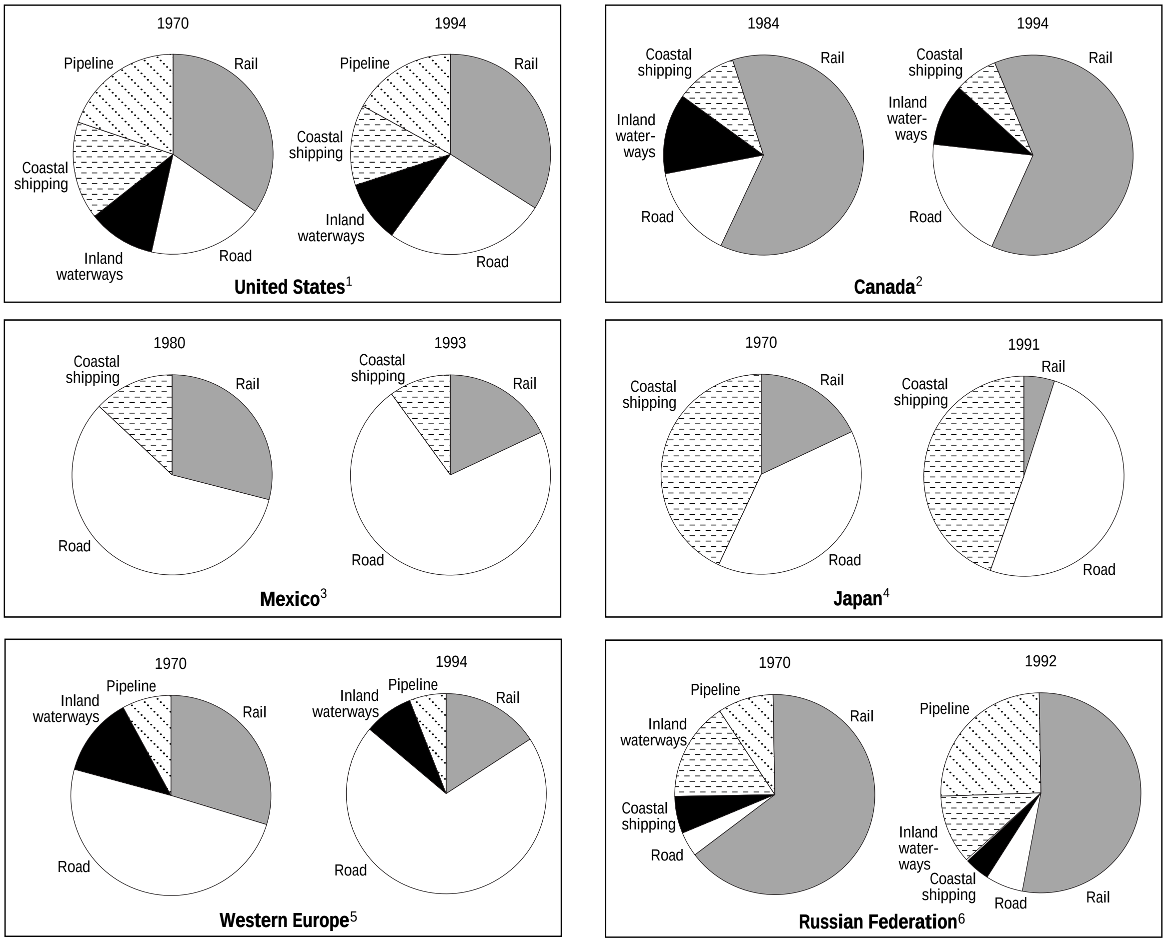
[15] Freight statistics are estimates derived by the World Bank from national statistics of the former Soviet Union. Data were not available for 1994.
[16] Data for 1994 were unavailable.

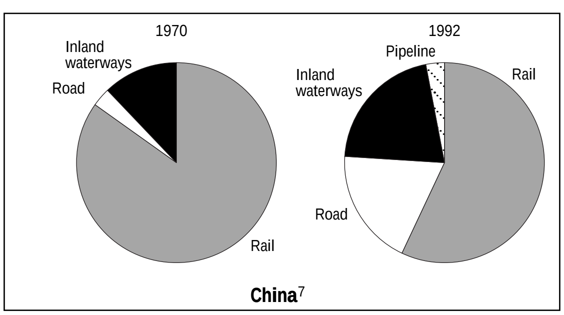
KEY: GDP = gross domestic product; NA = not applicable; U = unavailable.

SOURCES:
For GDP: World Bank. 1994. *World Development Report 1994: Infrastructure for Development*. New York, NY: Oxford University Press.
____. *World Bank Atlas 1996*. Washington, DC.
For the United States: U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997*. Washington, DC. December.
For Canada: Transport Canada. 1996. *T-Facts,* 1996-09-26. Ottawa.
For Mexico: Secretaria de Communicaciones y Transportes/Instituto Mexicano del Transporte. 1995. *Manual Estadistico del Sector Transporte 1993*. Mexico City.
For Japan: Japan Transport Economics Research Center. 1995. *Transportation Outlook in Japan, 1994*. Tokyo.
For Western Europe: European Conference of Ministers of Transport. 1995. *Activities of the Conference: Resolutions of the Council of Ministers of Transport and Reports Approved in 1995*. Paris, France: OECD Publications Service.
____. 1995. *European Transport Trends and Infrastructural Needs.* Paris, France: OECD Publications Service.
____. 1996. *Transport: New Problems, New Solutions.* Paris, France: OECD Publications Service.
For Russia: World Bank. 1993. *Transport Strategies for the Russian Federation.* Washington, DC: International Bank for Reconstruction.
For other FEBs: European Conference of Ministers of Transport. 1996. *Transport: New Problems, New Solutions.* Paris, France: OECD Publications Service.
____. 1995. *Activities of the Conference: Resolutions of the Council of Ministers of Transport and Reports Approved in 1995.* Paris, France: OECD Publications Service.
For China: Ministry of Communications. 1992. *Statistical Yearbook of China 1992.* Beijing.

Figure 10-5.
Domestic Freight Activity by Mode in Selected Countries and Regions

(Percentage of total metric ton-kilometers)





[1] See footnotes 2 and 3 in table 10-8.
[2] See footnotes 5, 6, and 7 in table 10-8.
[3] See footnote 9 in table 10-8.
[4] See footnote 10 in table 10-8.
[5] See footnotes 11, 12, 13, and 14 in table 10-8.
[6] See footnote 15 in table 10-8.
[7] See footnote 16 in table 10-8.

NOTE: Excludes domestic air freight. Includes domestic coastal shipping where applicable and when available.

SOURCES:
See sources in table 10-8.

however, led to diminished freight growth. Notably, though, as Europe's manufacturing industries became more dispersed, countries in southern Europe (e.g., Italy and Spain) experienced more rapid economic and freight activity growth than the European average. In addition, the small physical size of many European countries has influenced the relative importance of different modes.

Until recently, each country had its own transportation policy, despite recognition of the benefits of integration. In national markets, freight transportation has often been heavily controlled. In many European countries, state-owned entities operated freight transportation, especially rail. European countries have also limited truck haulage capacity and prices charged in national markets, although in many countries, such practices have changed significantly in the past 10 to 15 years. State-owned or controlled entities have been privatized, and price and market entry controls relaxed, especially in road transport. In 1987, the European Conference of Ministers of Transport (ECMT) agreed to the deregulation of international road haulage. In 1992, the transport of goods within a country by a nonresident hauler was liberalized.

In response to concerns about the growing dominance of road transportation, with associated congestion and environmental impacts, national governments and the EU have started to promote rail, inland waterways, and intermodalism. Notable are the rail and intermodal projects of the EU's Trans-Europe Transport Network initiative.[16] Many policymakers see intermodal transportation as improving the performance of rail and reducing the negative impacts of trucks. In 1995, the EU created the Task Force on Transport Intermodality in order to develop a consistent and effective European approach to intermodalism. Several studies have been conducted to determine the principal European opportunities for intermodal freight transport. In June 1996, an American rail company—CSX Corporation—joined forces with Dutch and German railways to form a joint venture, NDX International, which aims to create a door-to-door intermodal freight network in Europe. (*Railway Age* 1996)

[16] In December 1994, the European Council of Heads of Government established 14 transport network projects as priorities for the EU, at an estimated cost of US$500 billion.

► Japan

Japanese domestic freight activity expanded an average of 2.2 percent annually between 1970 and 1991 (see table 10-8). (JTERC 1995) The most notable trends are the rising dominance of road transportation and the continued importance of domestic coastal shipping. Together, trucks and coastal shipping account for 96 percent of Japan's domestic freight activity.

Road transportation grew an average of 3.5 percent between 1970 and 1991, capturing a 51 percent modal share in 1991, up from 39 percent in 1970 (see figure 10-5). (JTERC 1995) In this island nation, coastal shipping is vital to domestic freight transport. Although its recent growth (2.4 percent annually) has been slower than road transport, coastal shipping has held its modal share steady, at about 44 percent in both 1970 and 1991. In contrast, rail fell an average of 4 percent a year, and by 1991, rail held less than 5 percent of the freight modal share in Japan, down from 18 percent in 1970. (JTERC 1995)

Structural economic and manufacturing changes explain the differences in domestic freight markets in Japan between 1970 and 1991. Along with changes in manufacturing practices, the Japanese economy shifted from primary and raw materials production to high-technology manufacturing and services. The Japanese road transportation sector responded effectively to this shift and to shippers' demands for speed, reliability, and high levels of service.

Box 10-4.

The Challenge of Sustaining Western European Freight Rail

A notable trend in Western European transportation of the past 25 years has been the decline in rail freight. Rail haulage fell an average of 0.4 percent a year during this period, and in 1994 rail accounted for less than 16 percent of domestic metric ton-kilometers in Western Europe, compared with 30 percent in 1970 (see table).

There are several causes for the decline in rail market share. The changing business environment demands just-in-time deliveries and customer responsiveness often better suited to trucking. In addition, until recently little development and improvement of important trans-European rail routes has occurred, even though growth in international rail traffic has been notably stronger than domestic. Western Europe's collection of unintegrated rail systems and services makes expansion difficult. Spain and Portugal, for example, have a different track gauge from the rest of the European Union (EU). The prevalence of state-owned or controlled railroads has also made them less responsive to market conditions, and the coordination of trans-European rail policies and services has been difficult.

Some countries have continued moderate growth and high market share for domestic freight rail; in Sweden, Austria, and Switzerland, rail's share of domestic freight is approximately 40 percent. In other countries, notably Italy, Spain, and the United Kingdom, rail's share dropped to less than half of what it was in 1970, to stand at 10 percent

Domestic Freight Rail's Modal Share in Western European Countries

Country	Year	Percentage of total domestic mtk
Western European total	1970	30
	1994	16
Austria	1970	56
	1991	42
Belgium	1970	28
	1991	17
Denmark	1970	20
	1994	16
Finland	1970	27
	1994	26
France	1970	39
	1994	25
Germany[1]	1970	33
	1993	19
Greece	1970	9
	1991	5
Ireland	1970	U
	1991	11
Italy	1970	21
	1994	10
Luxembourg	1970	67
	1994	41
Netherlands	1970	7
	1993	4
Norway	1970	32
	1994	11
Portugal	1970	U
	1993	14
Spain	1970	16
	1994	5
Sweden	1970	49
	1993	42
Switzerland	1970	54
	1994	39
United Kingdom	1970	22
	1994	8

[1] German data for 1970 include only the former Federal Republic of Germany and West Berlin. German data for 1993 are inclusive of both the former East and West Germany.

KEY: mtk = metric ton-kilometers; U = data are unavailable.

SOURCES:
B. Banister, Capello, and P. Nijkamp. 1995. European Transport and Communications Networks: Policy Evolution and Change.
T. Carding. 1996. Brave Talk, Little Action. *Traffic World.* 26 August.
European Conference of Ministers of Transport. 1995. *European Transport Trends and Infrastructural Needs.* Paris, France: OECD Publications Service.
___. 1995. *Activities of the Conference: Resolutions of the Council of Ministers of Transport and Reports Approved in 1995.* Paris, France: OECD Publications Service.
___. 1996. *Transport: New Problems, New Solutions.* Paris, France: OECD Publications Service.
C.A. Nash. 1996. Integrating Transport Networks. *Transport: New Problems, New Solutions.* Paris, France: OECD Publications Service.

Box 10-4.
The Challenge of Sustaining Western European Freight Rail ***(continued)***

or less of total domestic freight movement by 1994. The differences between these countries are due to the interaction of a variety of factors including commodity mix, length of haul, and competitive conditions within rail and with other modes. Government policies also played a role. Switzerland and Austria, both important European freight transit[1] countries, have regulations that protect their domestic rail markets and reduce environmental emissions. Switzerland effectively banned most through truck traffic by imposing a maximum weight limit of 28 metric tons (31 tons) for trucks as opposed to the 40 metric ton limit (44 tons) to which member countries of the EU adhere. Subsequently, Switzerland and the EU agreed on a quota of 50 trucks of 40 metric tons per day, which can be surpassed only if all Swiss rail capacity has been used. Austria also instituted policies to promote rail transportation and limit road freight by banning non-Austrian truck traffic from its road network at night.

The ability of Austria, Switzerland, and Sweden to retain a significant market share for rail is an exception in Western Europe. European policymakers consider the decline in rail freight a disturbing trend. They hope that rail will regain some of its lost modal share through the development of additional rail infrastructure via Trans-European Network projects, the introduction of greater market incentives, and the expansion of railroads into the intermodal market.

[1] Transit in this case refers to goods or vehicles passing through a location.

In response to concerns about the growing dominance of road transport and its effect on the environment and congestion, the Japanese government initiated several efforts to promote rail freight and coastal shipping. Working with industry and the newly privatized railways, the government is promoting rail capacity expansion and making rail more convenient for shippers. The initiatives include developing intermodal facilities and increasing the number of cars per train and train speeds. In coastal shipping, starting in 1991, government implementation of an investment and improvement strategy for Japan's ports and harbors has included the further development of container terminals for domestic and foreign trade. Because these initiatives are coming at the same time that the Japanese government is relaxing regulations on road transportation (including simplification of licensing procedures and limited deregulation of rates), the ultimate impact on freight transportation is unclear.

► Canada

Domestic freight transportation in Canada expanded slightly between 1984 and 1994, although national statistics may not reflect the true level of activity.[17] Domestic freight activity increased an average of 0.3 percent annually between 1984 and 1994 (see table 10-8). Growth in Canada's dominant mode—rail—was limited, and inland waterways traffic (primarily on the Great Lakes) declined an average of 2.8 percent annually, while road activity increased 3.3 percent. (Transport Canada 1996a) Road and rail gained modal share between 1984 and 1994, with inland waterways and domestic coastal shipping losing. According to national data, rail accounted for approximately 63 percent of domestic freight activity in 1994, and road transport for 20 percent (see figure 10-5).

[17] Canadian rail figures include Class I and Class II railroads only, while road figures include only for-hire Class I and Class II carriers. Because of this, both modes, especially road transport, may be underrepresented. The classification of Class I and Class II truck carriers changed between 1984 and 1994. In 1987, Class I and Class II establishments were those with gross operating revenues of CAD$350,000 and greater. From 1988 to 1989, Class I and Class II establishments were those with gross operating revenues of CAD$500,000 and greater. From 1990 to 1994, Class I and Class II establishments were those with gross operating revenues of CAD$1 million and greater. Because of these definitional changes, the level of domestic road activity in Canada may be underestimated.

Several factors, including recent economic performance, government policies, and geography, help to explain Canadian freight activity. Slow economic growth in the late 1980s and early 1990s constrained domestic freight activity during this period. Canada also saw a limited shift in output and employment away from resource-based industries toward manufacturing, knowledge-based, and service industries, affecting the level of freight activity and the relative importance of modes. As the world's second largest country in land area, geography plays an important role in Canada's freight transportation. For trans-Canadian freight transportation, rail has obvious competitive advantages, while road transportation has been an important mode in the manufacturing centers and large cities in the eastern provinces.

The Canadian government has initiated several reforms that could affect the development of the country's domestic freight market. The changes are intended to stimulate greater competition and efficiency in freight transportation. In 1988, the National Transportation Act (NTA) and the Motor Vehicle Transport Act (MVTA) went into effect. The NTA reshaped the freight negotiating framework for shippers and railroads and granted new rights for shippers to access competing railroads. The MVTA reduced the licensing requirements for motor carrier drivers. In 1995, Canadian National Railway, the country's largest and state-controlled freight railroad, was privatized in the biggest equity offering in Canadian history, raising more than US$1.2 billion in cash, plus real estate valued at $300 million. In July 1996, Canada also passed a new Canadian Transportation Act, which is intended to modernize and streamline rail regulation, promote the formation of short-line railways, reduce unnecessary motor carrier regulations, and ensure shippers' access to competitive transportation. (Anderson 1996)

► Mexico

Road dominates freight transportation in Mexico to a greater degree than in most other countries discussed in this chapter (see figure 10-5). Rail and, for geographical reasons, coastal shipping account for most of the rest of Mexico's domestic freight market. As in many other countries, air freight is growing rapidly, but still accounts for less than 1 percent of domestic mtk. (SCT/IMT 1995) Overall, domestic freight activity expanded 2.5 percent annually between 1980 and 1993 (see table 10-8).

Between 1980 and 1993, domestic road transport grew, on average, 4.2 percent per year, increasing its modal share from 58 percent in 1980 to 72 percent in 1993. During the same period, rail activity dropped by 1.1 percent annually, reducing rail's share of domestic freight from 29 percent in 1980 to 18 percent in 1993 (see figure 10-5). (SCT/IMT 1995) The decline in growth can be attributed to several factors, including worldwide business and production changes that favored trucking. (Mexican data were not available to assess the impact on domestic freight activity of the December 1994 peso devaluation.)

Government policies and structural economic changes have influenced Mexican transportation. Reform of freight transportation began in the 1980s. The trucking sector, which had been organized into regional cartels with government-regulated tariffs, was deregulated in 1989. The World Bank estimated that efficiency gains (lower rates, higher quality service, and increased flexibility) from deregulation will amount to more than US$500 million annually. (World Bank 1995b, 57) Privatization and restructuring of domestic air transportation began in 1988, followed by deregulation of domestic airfares in 1991. Extensive privatization of Mexico's ports started in 1992, and privatization of the national railroad, Ferrocarriles

Nacionales de Mexico (FNM), officially began in 1996.

As part of privatization, FNM's rail lines were divided into five regional sections, with private firms allowed to bid on rights to the lines. Foreign companies have been allowed to bid for up to a 49 percent interest, and U.S. railroad companies are involved through alliances with Mexican investors and companies. In December 1996, an alliance between Transportacion Maritima Mexicana, Latin America's largest integrated transportation company, and Kansas City Southern Railway (KCS), a regional U.S. railroad, won the first operating concession under the FNM privatization. The alliance, known as Transportacion Ferroviaria Mexicana, will operate Mexico's Ferrocarril del Noreste for 50 years, with the option of an additional 50-year extension.

While rail infrastructure development has been limited until very recently, Mexico has engaged in intensive roadway development since the mid-1980s. Between 1989 and 1994, approximately 4,100 kilometers (2,548 miles) of new four-lane highways were constructed in Mexico. Because the government could not afford this level of investment alone, several public/private financing strategies were employed. State-owned banks and private construction companies financed and built the majority of new highways, which are primarily access-controlled toll roads. Construction costs have been estimated at $10 billion to $15 billion. (World Bank 1995b and LBJ 1995). Private sector consortia bid on concessions to finance, build, and operate toll roads. Generally, the government awarded concessions to companies that offered the shortest concession period, and many periods were quite short, some under 10 years. As a result, some of the private sector consortia charged relatively high tolls to recoup their initial investment in construction. Consequently, Mexico had some of the highest tolls in the world—an average of 18¢ per kilometer, second only to Japan at 20.5¢ per kilometer. (LBJ 1995) High tolls led to lower than expected traffic volume, particularly among truckers who continued to use the older, more direct roadways connecting population and manufacturing centers. Beginning in 1993, the Mexican government increased the concession periods for several of the country's major tollways, with mixed results so far.

Former East Bloc Countries

Domestic freight activity in FEB countries has fluctuated during the past 25 years, expanding an average of 2.2 percent annually in Poland, Latvia, and Russia, and almost 3 percent per year in Romania, Bulgaria, and Hungary between 1970 and the mid-1980s. Economic and political difficulties, however, contributed to a contraction and decline in freight activity since the late 1980s. Between 1985 and 1994, domestic freight mtk fell an average of 4 percent annually in Poland and Hungary, and 11 percent per year in Bulgaria, Romania, Lithuania, and Latvia. (ECMT 1995a) Russia experienced an average annual decline of almost 6 percent between 1989 and 1992 (see table 10-8). (World Bank 1993b)

Despite fluctuations, road mtk in several FEB countries had the most growth, increasing an average of 5 to 6 percent annually in Poland, Hungary, Latvia, and Russia through the mid- to late 1980s. These rates dropped slightly as overall freight and economic activity contracted between the mid- to late 1980s and 1994. Comparatively, however, road transportation's growth remained higher than other freight modes during this time. In Poland, for example, trucking continued to grow at an annual average of 5 percent between 1985 and 1994, while the sector's growth dipped slightly in Hungary to 3 percent annually. Trucking has increased its modal share in several FEB countries. Available data suggest these trends are continuing. (Chatelus et al 1996)

Like most western European countries, the FEB is shifting from rail to road for freight. Although still the dominant freight mode in many FEB countries, rail grew only slightly between 1970 and 1985, and then began a notable decline. For example, between 1985 and 1994, rail fell an average of 5 percent annually in Poland and Latvia, and almost 12 percent per year in Romania and Hungary. (ECMT 1995a) In Russia, rail expanded 2.3 percent annually between 1970 and 1989, but fell 4.8 percent per year from 1989 to 1992. (World Bank 1993b) Consequently, rail lost modal shares in these countries. (ECMT 1995a) Poland saw rail's modal share decline from 80 percent in 1970 to 52 percent in 1994. In Russia, rail's modal share fell from 65 percent to 53 percent between 1970 and 1992. Since 1991, rail has been affected by the dissolution of the FSU and the establishment of independent republics.

Government policies were foremost among factors influencing the level and nature of freight activity in the FEB between 1970 and 1994. Until the late 1980s, domestic and international freight transportation in FEB countries was heavily regulated. The Council for Mutual Economic Assistance (CMEA) controlled trade and industrial production in the FSU. Under CMEA's centralized planning system, priority was given to basic industries, rail transportation, and internal CMEA trade flows. In this environment, most shipments of bulk commodities were pre-planned and sent by rail. Demand for road transportation was usually limited to short feeder trips in and around centers of industrial production.

FEB governments have begun to develop and implement new transportation policies, particularly deregulation and privatization of state-owned or controlled transportation. Road transportation was one of the first sectors deregulated in the FEB, because of the relative ease of reorienting it to market practices. The number of road transport operators in most countries increased quickly following deregulation and privatization. For example, many state road transportation entities were privatized simply by selling vehicles to drivers. In Poland, there are now over 80,000 road haulage firms. (Chatelus et al 1996, 134) In contrast, privatization and deregulation of road transportation is moving much more slowly in Russia, where the government continues to regulate rates.

As production in many FEB countries shifts to manufactured goods, road transportation may have a greater competitive advantage as shippers demand more flexible and responsive service. Moreover, changes in the location of manufacturing centers have the potential to affect the rail sector drastically, because the rail networks were built to serve the original centers. Furthermore, economic integration with Western European economies could affect freight demand and modal splits. Prior to 1989, the volume of trade between Eastern and Western Europe was relatively low, consisted primarily of bulk commodities, and typically was shipped by rail or inland waterways. In 1990, one year later, exports from Eastern Europe to Western Europe jumped by 23 percent, and in 1991 rose again by another 25 percent. (ECMT 1995d, 100) Many analysts believe trade between Eastern and Western Europe will continue to increase for the foreseeable future. One estimate projects that this trade will increase 4.25 percent annually between 1991 and 2010. (Michalak and Gibbs 1993)

Infrastructure, however, could constrain both rail and road service. Rail and road networks need maintenance, upgrading, and in some cases, more capacity. (ECMT 1995d) Some view the need for electrification of rail networks to be particularly acute. (Hall 1993) In addition, the north-south orientation of rail networks in many FEB countries may slow the growth of western European trade by rail.

Other Non-OECD Countries

Because data are sparse for many non-OECD countries, this section concentrates on freight transport in China and India. Data for these countries show two broad trends: 1) an expansion of freight activity, although increases vary by country; and 2) an increasingly important role for road transportation, generally at the expense of rail. Similar to the passenger transportation trends in non-OECD countries discussed earlier in this chapter, economic, political, and institutional factors, and the level and condition of infrastructure interact to influence freight activity in both these countries.

► China

Freight activity in mtk expanded rapidly, at an average of 7.5 percent annually between 1970 and 1992, in step with the country's rapidly expanding economy (see table 10-8). (World Bank 1995a) During this period, starting from a low base, road transportation grew an average of 16.2 percent annually, and increased its modal share from 3 percent to 19 percent. Rail activity increased on average 5.6 percent per year, but its modal share dropped from 84 percent to 57 percent (see figure 10-5).

In addition to strong economic growth, government policies designating special export and regional trading zones and trade cities affected the level and nature of freight activity. The fastest growth in freight transport activity occurred in the coastal provinces, where the trade zones and cities are concentrated.

Moreover, shifts away from raw materials processing to the production of higher value and lighter products, often for export purposes, prompted increased demand for faster, more flexible transport. China's emerging road transportation sector, while limited by capacity and regulatory constraints, is beginning to meet these demands. Continued growth in road freight will depend on expanding the highway infrastructure, increasing the number of trucking operators, and fostering competition. In relation to its population and geographic area, China's highway network is among the smallest in the world, and many roads are in poor condition. Over the next several years, China plans to construct 14,500 kilometers (9,010 miles) of high-grade national highways as part of its National Trunk Highway System. (World Bank 1995a, 1) Competition among road transportation services will also affect demand; competition is currently limited by granting monopoly franchises along product and geographic lines.

Although rail's share of domestic freight has fallen over the last few decades, rail continues to be the backbone of China's distribution system, especially for bulk commodities. As the Chinese economy becomes more market-oriented and more geared to manufacturing, rail may lose modal share to road transportation. Rail, however, is likely to retain a strong role in bulk commodities and interregional transport, although limited infrastructure capacity may be a constraint. China already faces bottlenecks on several rail networks. The Ministry of Rail has started to expand the capacity of existing lines through double tracks and electrification, providing new locomotives and rolling stock, and building new lines, such as the Beijing to Hong Kong line. (World Bank 1994b and 1995a)

► India

Indian domestic freight activity has also expanded rapidly in recent decades, with intercity freight increasing an average of 5.3 percent annually between 1967 and 1987.[18] As in China, freight transportation in India is shifting from rail to road. (World Bank 1995b)

Intercity road transportation has led India's freight expansion, growing by 8.8 percent annually between 1967 and 1987. In 1985, intercity trucking overtook rail and accounted for approximately 52 percent (200 billion mtk or 137 billion ton-miles) of freight activity. Deregulation of intercity road transportation in 1986 spurred additional growth, with the modal share rising to 60 percent (384 billion mtk or 263 billion ton-miles) by 1992. The number of operators jumped after deregulation, and road transportation prices became more competitive with those of rail. (World Bank 1995b)

Rail growth was slower (3.3 percent annually between 1967 and 1987), and the sector's modal share declined from 48 percent of the domestic intercity freight market in the late 1980s to 39 percent in 1992. As rail's freight share declined, India's state-owned rail company focused more on passenger transport. (World Bank 1995b)

Lack of infrastructure may constrain the growth of road transportation. India's major urban areas are connected by high-density corridors (HDCs), totaling about 30,000 kilometers (18,641 miles) in length. They are straining to carry nearly 40 percent of passenger and freight traffic, while accounting for only 2 percent of the nation's total road length. According to the World Bank, India's road infrastructure, most particularly the HDCs, has not expanded sufficiently in the last 10 years. If trucking continues to dominate Indian freight, and if the passenger motor vehicle fleet continues to expand (as all signs indicate it will), there will be more congestion and bottlenecks. The government is considering a system of partially toll-financed express highways as a way to increase road capacity.

[18] National statistics on freight activity in India were not available. The World Bank estimates used here reflect only intercity freight transportation and therefore underrepresent domestic freight activity in India.

Implications of Changing Passenger Mobility and Freight Activity

With the exception of some very-low-income countries, passenger travel and freight activity are increasing worldwide. This increase in transportation activity has brought broad benefits to people in countries throughout the world, as well as some unintended consequences. People and governments worldwide are taking many steps to maximize benefits and minimize costs, some of which are highlighted below.

Economic and Social Effects

The transportation system in countries throughout the world has made possible an unprecedented level of mobility, which has enlarged the geographic choices available to people and businesses. This mobility has given many people more options about where to live, work, shop, find medical care, and enjoy leisure time than they had a few decades ago. Similarly, mobility has facilitated access of businesses to new markets, given firms more choices about where to locate facilities, broadened their range of suppliers, and increased the available pool of workers.

From the economic perspective, transportation is vital in any country. It supports jobs and economic activity, enables the transfer of goods, and expands the choices available to consumers to be able to purchase goods from other localities and countries. The trade facilitated by transportation has been a growing component of national income in many countries. The contribution of transportation to national economies varies from country to country. As discussed in chapter 2, transportation-related final demand has contributed about 11 percent to the U.S. GDP since 1989. Comparable estimates for other countries, based on the same methodological approach used by the United States in calculating transportation's share of GDP, are not available.

Consumer expenditures on transportation also signal the value of transportation to a society. In 1994, transportation accounted for 19 percent of total consumer expenditures in the United States. (USDOL BLS 1994) In the European Union in 1991, transportation averaged 14.6 percent of total personal consumption. (EC 1994, 16) Australian households were spending $3,045[19] on transportation in the early 1990s, about half of the U.S. household's average of $6,044 in 1994. (Australian Bureau of Statistics 1993)

Every nation invests in transportation infrastructure. Western European countries invested an average of 1 percent of GDP in the late 1980s, down half a percent from their 1975 level. (ECMT 1992) In the 1980s, Latin American countries invested 0.7 percent of their GDP in transportation infrastructure, down from 1.6 percent in the 1970s, while countries in East Asia and the Pacific invested 1.6 percent. The World Bank attributes the decline in investment in Latin America to the region's debt crisis in the 1980s. (World Bank 1994c)

Environmental Effects

Environmental impacts of transportation, particularly air pollution, are a continuing problem in the OECD and FEB countries and a growing problem for developing countries. Air pollution from motor vehicles can be severe in congested urban areas, and can contribute to health problems. Some countries with very high per capita passenger travel and freight activity, such as the United States, have reduced key categories of air emissions even as transportation has grown rapidly.

Success is uneven, however. For example, carbon dioxide emissions from motor vehicles are a major component of greenhouse gases, which have the potential to change the global climate (see chapter 4). Thus, growth in passenger travel and freight shipments, combined with a shift to road transportation, are key contributing factors to environmental problems. (For a comprehensive review of international trends in air pollution from motor vehicle use, see *Transportation Statistics Annual Report 1996*.)

Road Congestion

Congestion slows movement, inflicting direct and indirect costs on people, businesses, and nations. Congestion also increases pollutant emissions and fuel consumption.

In the last 20 years, vehicle speeds have declined in major OECD cities. (ECMT 1995e) Severe road congestion has been reported in non-OECD countries.[20] Urban traffic congestion in Latin America and other regions delays travel, affecting the efficiency of goods distribution and contributing to air pollution. (World Bank 1994c)

Countries employ a variety of strategies to reduce congestion, such as expanding infrastructure, traffic management, promoting public transportation, and implementing policies to minimize the attractiveness of cars. New infrastructure may decrease congestion, increase average speeds, and shorten routes, but some studies suggest that it may also encourage demand, caus-

[19] Converted from Aus$3,959 at 1.3 Aus$/US$ (as of January 6, 1997). The original figure was Aus$76.13 per week.

[20] For a complete discussion of the causes of congestion in developing countries, see *Transportation Statistics Annual Report 1996.*

ing increased driving and thus more emissions. (World Bank 1994d; Hook 1996) Some countries use regulations and incentives in their efforts to reduce motor vehicle use and curb congestion.

Safety

Inconsistencies in definitions and reporting criteria prevent a thorough comparison of transportation safety among various countries. Motor vehicle crashes tend to be less severe in the United States (with 13 fatalities per 1,000 casualties) than in other industrialized countries (15 to 48 fatalities per 1,000 casualties). (USDOT BTS 1996b) According to ECMT, deaths from road accidents in Western Europe between 1970 and 1993 were the lowest in 1985, when 54,000 people died. Fatalities then rose to an estimated 55,140 in 1992. (ECMT 1994)

Worldwide, an estimated 885,000 people died in traffic accidents in 1993. A majority of the deaths were in developing countries. A high proportion of the fatalities and injuries are suffered by pedestrians. (WRI 1996) In India, for example, only 5 percent of those killed or critically injured are in cars. The rate of fatalities per vehicle declines sharply as a country's income rises, with over 80 fatalities per 10,000 vehicles in low-income countries and under 10 fatalities per 10,000 vehicles in high-income countries. Fatalities per capita, however, tend to rise with income, with upper-middle-income countries having the highest rate (200 fatalities per million inhabitants). (World Bank 1996, 65)

Energy Consumption

Transportation is a major—and growing—consumer of energy, primarily petroleum. The major consequences of transportation energy use are the national costs of fuel imports and environmental impacts. Most countries are net importers of petroleum. The implications of oil import dependency are discussed in chapter 4.

Improving the efficiency of fuel use can mitigate both import costs and some environmental problems. Today's stock of motor vehicles, especially passenger cars, in OECD countries is newer and more energy efficient than is the stock in non-OECD countries. Despite this, overall energy use is lower in developing countries, where bus and rail still prevail and where incomes are low. Efficiency gains obtained by OECD countries are beginning to taper off as motorists shift to heavier cars, trip distances increase, and congestion grows.

Some non-OECD countries are beginning to implement fuel efficiency programs. For example, Slovenia has banned the import of cars that are older than three years. Some also have imposed taxes on gasoline fuels as high as those in Western Europe. Still, in 1994, the average price for premium gasoline in developing countries was half that of the Western European average. (World Bank 1996)

Countries worldwide are starting to make commitments to reduce emissions of greenhouse gases under the international Framework Convention on Climate Change. Japan, Germany, Switzerland, and the United Kingdom have established new transportation fuel efficiency reduction targets. The Ontario province of Canada has introduced a tax on new vehicle purchases, based on the vehicle's fuel consumption rate. (IEA 1996b)

Technology Solutions

The application of information technologies and intelligent transportation systems (ITS) has important implications for passenger travel and freight activity worldwide. The use of information technologies in the U.S. transportation system is discussed in detail in chapter 11. In Europe, the use of such technologies in transportation is called transport telematics (see box 11-5 in chapter 11). ITS has many potential applications in such areas as safety, congestion mitigation, and energy efficiency.

Although technology holds great promise for reducing costs and enhancing benefits of transportation, a combination of public policies, business practices, and personal choices will affect its implementation and use.

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Mobility and Access in the Information Age

The history of transportation is one of increasing speed, comfort, convenience, safety, and reliability, together with decreasing travel costs. Many people ascribe this historical progress to technological improvements in the two most visible components of the transportation system—vehicles and physical infrastructure. Indeed, the pace of technological advances has quickened in recent times, as successive waves of innovations—the steamship and locomotive, the electric streetcar, the internal combustion engine, the jet engine, containers, and the "megaship"—improved the quality and sharply lowered the costs of transportation. There also have been parallel advances in the physical infrastructure—tunnels, suspension bridges, railroads over all kinds of terrain, the U.S. Interstate Highway System, and modern airports and marine terminals. Although less visible, the institutional infrastructure, which is a third component of the transportation system, has facilitated the coordinated use of vehicles and the physical infrastructure. Institutional infrastructure includes knowledge, technical standards, procedures, and policies that guide the governance of transportation.

Generally, what has not been recognized about this progress is the increasing role played by information technologies in transportation operations and in equipment and infrastructure. These technologies provide vital information, enhancing responsiveness and efficiency, and often make possible other transportation innovations.

Such *knowledge-providing and enabling* technologies have historical antecedents in the sextant and the chronometer, which permitted more precise global navigation in the 18th century, the telegraph, which promoted transcontinental rail operations in the last century, and the radio and radar in this century, which are so critical to navigation. The current efflorescence of new information technologies is transforming transportation industries and their scope of services.

As used here, information technologies (IT) refer to a broad array of devices, functions, and supporting tools used in sensing, generating, processing, transmitting, communicating, and presenting information. The dramatic technological developments in computer hardware and software and telecommunications in recent years can be applied to many transportation operations. For example, IT can be used to coordinate activities across the physically distributed nodes of transportation networks, allowing such innovations as computerized transportation documentation and "quick response" intermodal freight shipments, and are critical to the development of intelligent transportation systems (ITS). Such capabilities can increase personal mobility, lower freight costs, and allow firms to develop customized transportation solutions.

This chapter concludes the *Transportation Statistics Annual Report* section on mobility and access by discussing current and potential advances in IT that offer benefits to travelers and to transportation firms and their customers. These benefits might include new transportation services that are less costly or have other favorable service attributes; the creation of new forms of customer, cost, and competitive relationships; and the substitution of telecommunications for physical movement, which may eventually redefine mobility and access needs that shape *demand* for transportation services. Such new relationships may develop within transportation firms (e.g., use of computerized reservation systems by airlines to achieve multiple objectives such as improved customer service and market positioning) or in enterprises served by transportation (e.g., global sourcing arrangements by manufacturing firms, faster response innovation systems, and networking for firms).

The chapter, after briefly examining the historical context, discusses key elements of IT, and the factors underlying their diffusion in transportation. IT's complementary role as an enabler, rather than a replacement for existing transportation hardware, is notable. This characteristic lowers barriers to the adoption of new technology and promotes rapid and continuously evolving applications of IT in transportation. The chapter then explores IT's implications for passenger and freight transportation services; for example, how are mobility and access affected as the supply of ITS increases? Then, the chapter discusses IT's influence on the demand for transportation mobility and access. The chapter also examines the available evidence on the impact of transportation IT on production enterprises.

Information Technologies and Transportation Services

IT in Transportation History

There is interaction and synergy between information and transportation technologies. As noted, enabling technologies such as IT have helped make transportation services more efficient over the years. And, throughout most of history, the capabilities of the transportation system dictated how quickly, easily, and efficiently information could be conveyed across long distances. In the pre-telegraphic era, information (in the form of letters, other written documents, and messengers) traveled only as fast as the available means of transportation would permit. Thus, in

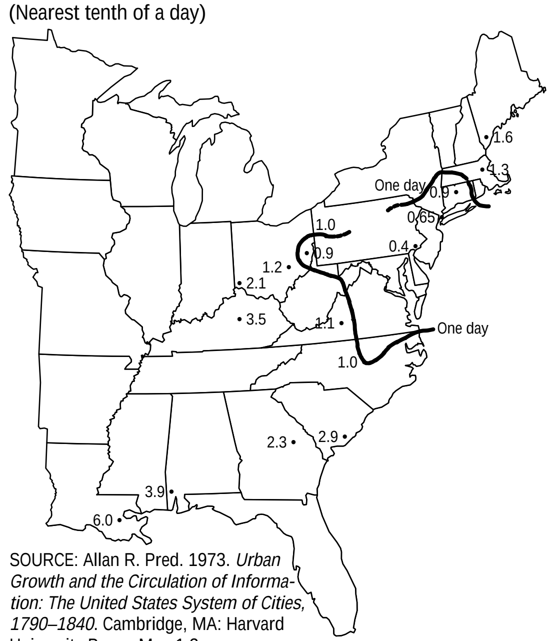
1799, the news of President Washington's death at his home in Mount Vernon, Virginia, took about two weeks to reach southern New England and over three weeks to get to southwest Ohio (see figure 11-1). Three decades later, in 1830, the "express" relay of President Jackson's State of the Union message, given in Washington, DC, took only a day and a half to reach southern New England and over two days to arrive in southwest Ohio (see figure 11-2).

The telegraph, first demonstrated by Samuel Morse in 1844, was a major departure from the historic dependence on transportation to communicate over long distances. The telegraph not only made possible almost instantaneous communications between distant locations but also separated the message from the messenger.

The telegraph had rapid and far-reaching impacts on communications and on the development of transportation in the 19th century. As railroads spread across the continent, an unprecedented volume of goods were shipped at unprecedented speeds on schedules often measured in days and hours, not weeks (see box 11-1).

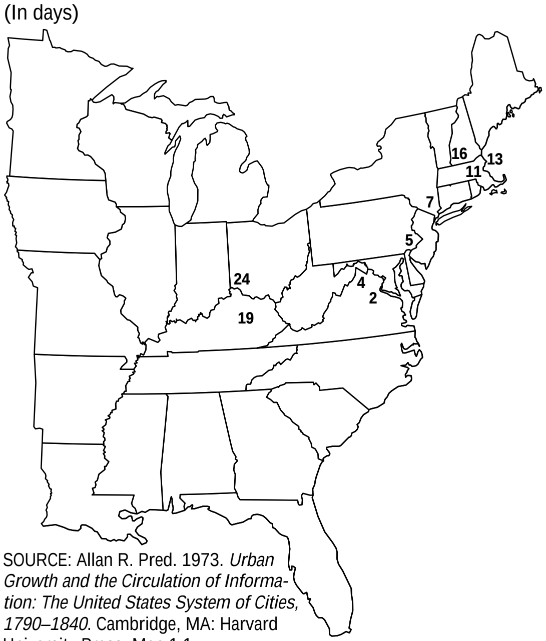
The telegraph, while highly influential, was only one in an impressive procession of information technologies developed in the last century. Figure 11-3 identifies many of the major communications technologies that have appeared since the telegraph. More recently, new information and associated technologies have arrived which, like their earlier counterparts, are improving operation, control, and management of transportation, and transforming many organizational processes involved in the provision of transportation.

Figure 11-2.
Time Lag in "Express" Relay of President Andrew Jackson's State of the Union Address: 1830
(Nearest tenth of a day)



SOURCE: Allan R. Pred. 1973. *Urban Growth and the Circulation of Information: The United States System of Cities, 1790–1840.* Cambridge, MA: Harvard University Press. Map 1.2

Figure 11-1.
Time Lag of Public News of George Washington's Death: Dec. 14, 1799
(In days)



SOURCE: Allan R. Pred. 1973. *Urban Growth and the Circulation of Information: The United States System of Cities, 1790–1840.* Cambridge, MA: Harvard University Press. Map 1.1

Box 11-1.
The Telegraph, Railroad, and 19th Century Business Innovations

The railroad and the telegraph developed together in 19th century America, linking the often widely separated cities of the United States. The telegraph, built along the railroad rights-of-way, provided instantaneous information about train movements. This information was especially important for directing traffic along the single-track lines typical of most early U.S. railroads. Both the railroad and the telegraph expanded rapidly.

Railroads pioneered many managerial innovations to coordinate the flow of shipments and movement of passengers from hundreds of origins to as many destinations across the vast spaces of the United States. These innovations included the line and staff system of administration, new accounting and internal control systems, new financial instruments, and the development of technical standards and organization procedures to facilitate interline flow of goods and people. Some innovations, such as railroad timetables and time zones, had broad social effects, standardizing the way people thought of time.

Innovations by the railroads, where the large modern corporation first appeared, paved the way for the creation of the large modern corporations in other industries. Wholesalers used the new transportation and information technologies to reduce risks, lower inventory costs, and deliver an increasing volume of goods on a more precise schedule. This evolution in the distribution sector continued as new kinds of retailers (e.g., department stores and mail-order houses) arrived later in the 19th century.

SOURCE: A. Chandler. 1973. Decisionmaking and Modern Institutional Change. *Journal of Economic History* 33:1-15. March.

The New IT: Key Elements

Most transportation uses of IT depend on the often-transparent and inseparable integration of many technologies and capabilities. In some cases, cost and performance improvements in one technical area may make a new range of applications or services available. The potential for IT to affect mobility and access in modern society is rooted in a small set of building blocks:

- telecommunications;
- computer hardware and software;
- navigation and positioning systems;
- surveillance, sensing, and tagging technologies; and
- data exchange and fusion capabilities.

► Telecommunications

The ability to make real-time operational information available throughout a transportation system, no matter how geographically dispersed, and to combine this information with data from other sources, carries powerful benefits for operators, managers, and users. The ease and relatively low cost of telecommunications have made this capability a practical reality. Some examples include satellite-based and fiber optic communications channels, cellular telephone systems, and network linkages epitomized by the Internet's "anywhere-to-anywhere" communications.

Not all telecommunications functions involve long-range communications. A very important function is electronic data interchange, which can occur over a very short range: between trucks and wayside inspection stations, highway vehicles and toll collection stations, or cargo containers and port logistic systems.

Telecommunications potentially play another more fundamental role: replacement of the need for some physical transportation. The ability to communicate readily with distant organizations and services permits access that otherwise would depend on physical mobility. Telecommuting, teleshopping, video conferencing, and other "telesubstitutions," although still in relative infancy, may become significant factors shaping mobility and access in the years to come. These approaches are discussed further in this chapter,

Figure 11-3.
Telecommunications Services Between 1847 and 2000

1847	1877	1920	1930	1960	1975	1984	2000
Telegraph	Telegraph	Telegraph	Telegraph	Telegraph	Telegraph	Telegraph	Telegraph
	Telephone	Telephone	Telex	Telex	Telex	Telex	Telex
		Sound	Facsimile	Data	Medium-speed data	Packet-switched data	Wide-band data
			Telephone	Facsimile	Low-speed data	High-speed data	Packet-switched data
			Sound	Telephone	Facsimile	Switched-circuit data	Switched-circuit data
			Television	High-fidelity stereo	Telephone	Telemetry	Telemetry
				Color television	High-fidelity stereo	Facsimile	Word processor networking
				Mobile telephone	Color television	Word processor networking	Text facimile
					Mobile telephone	Videotext	Facsimile
					Personal paging	Telephone	Electronic messaging
						Video conferencing	Newspaper teleprinting
						Sound	Videotext
						High-fidelity stereo	Voice facsimile
						Color television	Telephone
						Mobile telephone	High-fidelity telephone
						Personal paging	Teleconferencing
							Video conferencing
							Video telephone
							High-fidelity stereo
							Quadrophony
							Color television
							Stereophonic television
							High-definition television
							Mobile video telephone
							Mobile telephone
							Mobile text
							Mobile facsimile
							Mobile data
							Mobile videotext
							Personal paging

SOURCE: A Jagoda and M. de Villepin. 1993. *Mobile Communications.* Chicester, England: John Wiley & Sons. Figure 3-2.

while the complex relationship between telesubstitution and travel demand was discussed in chapter 6.

► Computer Hardware and Software

The price of computer processing power has dropped at approximately 30 percent per year for the last two decades. Such dramatic cost reduction now permits highly sophisticated sensors and computer-based control systems to be built into most transportation vehicles, from automobiles to airplanes. As discussed in box 11-2, many recent advances in automotive safety involve onboard computer-based technologies.

Computer processing power can be used to improve many transportation system functions, such as traffic control and management, and to simulate complex transportation operational systems. Concepts of artificial intelligence and expert systems represent software approaches that can be very effective in particular situations.

Box 11-2.

Smart Cars

Digital electronics and computer chips have been used in cars for decades for fuel injection, security systems, and climate control. In recent years, new automated functions have appeared, such as antilock braking systems. Initially, these innovations have been relatively expensive, and thus found primarily in luxury cars. With likely price reductions, most can be expected to permeate the overall fleet in the near future. Examples of features now available or actively pursued in the laboratory follow.

In-vehicle navigation. Navigation aids are typically based on Global Positioning System (GPS) location determination, powerful computing capabilities, and CD-ROM digital maps. These aids can provide turn-by-turn navigation instructions, via display or spoken advisories. Some include an electronic directory of restaurants, gas stations, and recreation facilities. While initially an after-market option, navigation aids are now offered directly by vehicle manufacturers in some car models. These systems can be coupled to broadcast real-time traffic and weather.

Emergency services. At the push of a button, systems now available can communicate via cellular telephone with a response center, imparting information about vehicle location, emergencies, and equipment failure, as well as direct voice communication. Automatic activation in the event of airbag deployment can be included. One variation permits the response center to remotely unlock a car when a motorist has inadvertently been locked out.

Vehicle suspension and control. Some systems go beyond the electronic sensing of traction that underlies antilock brakes. Computer-controlled dampers can adjust the ride from soft to firm to match road and operating conditions. Some systems measure the roughness of the road and adjust the operation of the antilock braking system to assure the most effective response.

Steering enhancement. Another system compares how the vehicle responds to movements of the steering wheel to the sensed rate that the vehicle is turning. If available traction has been exceeded, as indicated by less turning occurring than was called for, brakes are applied to slow the car to the point at which there is sufficient traction to follow the intended curve.

Collision warnings. Devices based on radar or other sensors are being considered to alert drivers to situations in which collision is imminent. Some trucks and school buses are equipped with radar to detect people behind the vehicle (when reversing) or situations in which there is an excessive closing rate with the vehicle ahead. Other sensors can detect vehicles in typical blind spots on both sides of a car. Intelligent cruise control may soon be available—instead of holding a constant speed, the car maintains a constant distance from the vehicle ahead.

Operator inattention. Driver fatigue or inattention is a frequent factor in accidents. Methods are being explored to detect drowsiness and other behaviors so that the operator can be alerted.

Vision enhancement. The technology of enhancing night vision has long been applied in defense and security settings. Systems are now being explored using radar or thermal imaging to enhance the operator's view, particularly in adverse weather and darkness, and to project an image on or near the windshield.

Entertainment and communications. Intel Corporation has announced business partnerships to integrate a standardized computing platform into motor vehicles to perform many computing and communications tasks. These include: wireless telephone, fax, and mail services; Internet access; speech recognition and synthesis for user interaction; linkage to public and private traveler information systems; multimedia entertainment applications for passengers; and user-customized driver information displays. Some products could reach the market as early as 1998.

Enormous databases can be accessed directly using compact disc storage technology.

► Navigation and Positioning Systems

Navigation has always been central to long-distance transportation, particularly for the marine and aviation modes. From the invention of the sextant and chronometer to current radio-based systems, improved means of determining position have represented major transportation advances. Navigation is now being transformed by the Global Positioning System (GPS), based on 24 earth-orbiting satellites emitting precisely timed signals. GPS makes possible convenient, real-time, three-dimensional position information throughout the world with great accuracy and at very low cost.

As technological accuracy improves—dropping from hundreds of meters to a meter or less—and prices fall, new applications become feasible, such as en route navigation for highway vehicles. Many applications involve position determination equipment on the vehicle, with that information communicated (often via satellite link) to a central computer for fleet or traffic management functions. Precise knowledge of location can support functions as disparate as placing and retrieving containers in a port storage area, identifying the whereabouts of a stranded motorist for response vehicles, and assuring safe separation of trains on shared tracks. Tracking techniques are now used by the private sector and the U.S. government to monitor shipments and keep in touch with personnel (see box 11-3).

Just as early navigators needed charts and astronomical almanacs in order to derive their position using a sextant and chronometer, GPS and other modern systems fulfill their potential only in concert with digital maps of high precision, based on a standardized geodetic reference system. More generally, geographic information systems (GIS) have many transportation applications that support operations, maintenance, planning, system analysis, and other functions. A major use of positioning and map technologies is computer-based route guidance, which facilitates navigation in both urban and rural regions. Multiple systems can be used to achieve satisfactory positional precision, reliability and integrity, as when automobile GPS outputs are supplemented by comparison to electronic maps, or an aircraft uses satellite navigation in conjunction with an inertial system.

► Surveillance, Sensing, and Tagging Technologies

IT applications are used to identify a vehicle's location, characterize its environment, or permit the exchange of information. Closed-circuit television—monitored by computers—has a growing role in detecting incidents and congestion on freeways. Railroads tag freight cars for wayside identification and aircraft continually exchange identification numbers, altitude, and other information with the air traffic control system. High-performance computer chips and sophisticated pattern recognition software can increasingly carry out complex sensing and surveillance tasks. Tagging of freight-carrying vehicles and of the cargo itself is revolutionizing logistics, as tags become capable of storing situation-specific data (like container contents and destination) and of being read over long distances—via satellite in some cases. A truck with a GPS-enabled tag and cellular or satellite communications capability can be tracked anywhere in the country, reporting vehicle and cargo status wherever it goes. "Onboard intelligence" is emerging in the freight system, or in what perhaps should be called the intelligent freight transportation system.

A final aspect of surveillance is the use of vehicle-mounted sensors, such as radar, to detect potential hazards. The sensors are coupled to computers and displays that provide warnings and suggested responses. Collision-avoidance systems of this type have been used in aircraft for many years, and federal and private research programs are currently actively pursuing crash prevention for highway vehicles.

► Data Exchange and Fusion Capabilities

Above and beyond the specific transportation functions that various information technologies support, the broad impact of IT on transportation is to produce a much more knowledge-rich

Box 11-3.

Vehicle Tracking for Safety and Efficiency

Global Positioning Systems (GPS) and other information technologies that keep track of a vehicle's identity and location have become powerful tools for managing assets and resources, transforming transportation logistics. The U.S. Department of Defense, for example, uses information technologies to achieve "Total Asset Visibility"—timely and accurate information on the location, movement, status, and identity of personnel, equipment, and supplies moving by military or civil transportation services. Real-time tracking and management of these resources was important in deployments to Saudi Arabia and Somalia.

The Defense Transportation Tracking System (DTTS) is used to monitor and expedite routine domestic shipments of arms, ammunition, missiles, and explosives. DTTS uses automated satellite-based information to monitor and expedite 4,000 shipments per month, with 600 vehicles in transit at any time, and to support rapid response to incidents or emergencies. A similar system has been established for the movement of hazardous or toxic fuels. To enforce United Nations sanctions on goods shipments into Serbia and Montenegro, the U.S. Department of Transportation established a tracking and information system for the State Department using satellite communications and a data center in Massachusetts that provided real-time information to teams at border crossings in the former Yugoslavia.

Trucking companies use GPS and satellite and/or cellular telephone communications to monitor the location and status of fleets and to communicate with vehicles and drivers. Communications permit responses to special situations, optimized routings, and help keep customers informed. One firm reports fuel savings of over 10 percent, based on more than halving idling time. One version of the system permits drivers to use Internet electronic mail to communicate with dispatchers and family members. Globally, more than 200,000 trucks are equipped with such systems. Linkage to metropolitan and other traffic management and information services also will soon allow drivers to cope more effectively with congestion and adverse weather, choose optimal routes, and generally improve the reliability and efficiency of pickup and delivery services.

GPS systems also can be used for routing vessels at sea and between and within ports. In 1996, the U.S. Coast Guard brought the differential Global Positioning System (dGPS) online. With reference stations built about every 200 miles along the coast, dGPS enables ships with special receivers to identify their position to an accuracy of 5 to 10 meters compared with 100 meters using other positioning systems. This is a critical advance, especially for large ship navigation, as some channels are less than 100 meters wide. GPS, local and remote radar, management information databases, very-high-frequency radio, and other information technologies can be linked to create comprehensive harbor information systems. The Coast Guard's Ports and Waterways Safety System, now under development, is intended to improve waterway safety (including the avoidance of environmentally damaging spills) and support enhancements of waterways management and efficiency.

Applications are diverse: GPS receivers are being placed in the approximately 1,000 boats that operate on the canals of Venice. Motorboats traveling at excessive speed produce wakes that weaken the foundations of the city's buildings. Satellite-based position reports are automatically radioed from each boat to a central facility every few seconds, providing immediate identification of boats traveling above the 5-mile-per-hour limit. As a fringe benefit, the system will also improve safety, particularly in fog, and will collect engine and operational data enabling more efficient fleet management.

system, in which all participants—users and providers alike—can make decisions and perform tasks on the basis of greatly enhanced understanding of the likely consequences. The combination of often disparate information from diverse sources is central to many IT applications, including real-time operations, inventory and process management, system characterization, and provision of user services. Beyond technical interoperability and establishment of institutional and organizational relationships for effective data exchange, the new discipline of "data fusion" has emerged—the design of computer systems that can facilitate convenient, flexible, and adaptable blending of information from a wide range of independent sources.

Many current and potential transportation applications exist for data fusion, such as evaluation of large databases to identify possible aviation safety problems.

Factors Underlying Rapid Diffusion of Transportation IT

Two sets of factors underlie the current rapid progress of IT in the transportation sector. From the supply side, IT's enabling role facilitates its application in the transportation sector. From the demand side, numerous market-driven opportunities for IT investment are being created as the American economy undergoes rapid transformation. Such opportunities arise from the dematerialization of the economy (i.e., the proportion of high-value products being transported is rising relative to that of bulky materials), the globalization of production, industrial restructuring, and such institutional changes as deregulation and privatization, which have created an hospitable economic environment for IT investment.

Enabling and Complementary Role of IT

Unlike some propulsion, vehicle, and infrastructure technologies that supplanted prior generations of technology, IT can be incorporated into transportation operations in an evolutionary fashion. There are four general characteristics of this process.

- *Rapid technical progress.* Driven by markets across all economic sectors, IT is developing very quickly—dropping sharply in cost, while simultaneously increasing in performance. Not only are the basic information technologies advancing, but understanding of how best to use them continues to grow rapidly.
- *Continuous evolution.* IT offers the potential for continuous improvement in the performance of existing transportation equipment and infrastructure, extending its reach, power, and quality of service. As an evolving technology, it does not face as many barriers to use as can be the case when new transportation technologies must supplant older but still functional equipment (e.g., replacement of steam with diesel locomotives).

  The iterative prototyping process of "design a little, build a little" that is common to software can be translated to IT. Major changes based on IT can sometimes be implemented incrementally, as specific technology elements, introduced as a minor tool or convenience, make the transition to critical tool or business necessity. In this manner, the introduction of IT can proceed relatively rapidly compared with the typically very lengthy phase-in of new types of vehicles or structures.
- *Process reengineering.* Full realization of the benefits of IT in transportation may require the redesign of operational processes throughout an enterprise, accompanied by substantial redefinition of work functions. As with other innovations, the pace of IT adoption is determined primarily by the ability of workers and organizations to incorporate the new technology.
- *Ubiquitous applications.* Information technologies applied in the transportation sector are generally those also used across the economy and society for a variety of purposes. The broad appeal of IT markets fosters its high rate of improvement in cost and performance, and facilitates large-scale integration and optimization among transportation suppliers and users.

Further, use of information technologies throughout the economy fosters the development of linkages between business processes. For example, the initial focus of the ubiquitous bar code—the Uniform Product Code—was improved speed and accuracy in accomplishing retail sales transactions. Success in this effort led to linkage of point-of-sale computers (no longer simple "cash registers") to inventory databases, and supported a shift to greater reliance on just-in-time logistic practices and marketing strategies. With this information infrastructure in place, some supermarkets and other retail stores offer remote computer-based ordering, via Internet or PC-modem connections, coupled to home delivery—a step that, if it becomes widespread, has significant transportation implications.

Economic Environment for Transportation IT

Broad, ongoing economic changes offer a fertile ground for transportation sector investment in information technologies. These changes in the economy are both transforming transportation activities, and are, in turn, themselves transformed by transportation.

The increasing role of information and knowledge in the economy. As incomes rise, knowledge-intensive industries and services have become increasingly important components of the economies of the United States and other highly industrialized countries. While the phenomenon of an information economy has been noted for some time (Machlup 1962; Porat and Rubin 1977), the implications of this shift for transportation have received little attention. Some rapidly growing high value-adding industries move only a small amount of tonnage while accounting for a disproportionately large share of total value of freight carried.

The globalization of markets and resources. With the recent expansion of trade (growing three times as fast as gross domestic product (GDP) in the United States) and the development of flexible production systems, economic activity is increasingly geared to serving global markets. Production inputs may be assembled from supply points around the globe. Markets for raw materials, components, capital, labor, and final products are increasingly global and flexible, requiring more responsive and efficient transportation of goods and people. Globalization has been accelerated by jet aircraft, containerized shipping, and satellite and fiber-optic communications.

The emergence of more market-oriented relationships among economic actors. Globalization and the intense competitiveness produced by a multiplicity of sources and markets are generating new relationships among all players in the economic system, public and private. These relationships take a variety of forms such as partnerships and networks. The resulting organizational networks are enabled by associated communications and transportation links.

The beginnings of seamless integration of (intermodal) transportation into the overall production processes. Competitive pressures on price and service, accompanied by just-in-time manufacturing, outsourcing, and on-demand delivery, have focused attention on how to better integrate transportation functions into the overall production process.

Long-term lowering of intensity of material and energy use (dematerialization). Recently, new technologies have led to more efficient and energy-saving production processes. This has lowered the material and energy intensity of the overall U.S. economy. As a consequence, the long-term trend in the United States is a drop in the intensity of use of some industrial materials—as measured by kilograms per dollar of GDP, in constant dollars—such as steel, cement, and paper. Further, the energy use per unit of GDP has also been dropping over time.

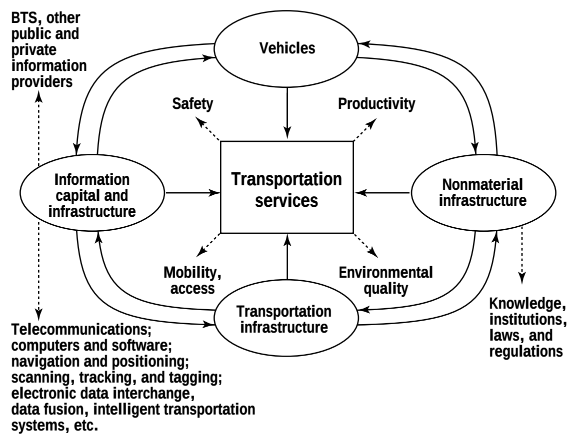
The transportation implications of dematerialization are evident in the 1993 Commodity Flow Survey (CFS) conducted by the Bureau of Transportation Statistics and the Census Bureau (see chapter 9 for a detailed discussion). While an enormous quantity (in terms of tons and ton-miles) of natural resources, including energy and industrial materials, are transported in the growing U.S. economy, the dollar value of such cargo is relatively low. According to the CFS, materials valued at or below $1,000 per ton account for just under 96 percent of the weight, but only 46 percent of the total value of the goods moving over the U.S. transportation network in 1993. The remaining freight (a little over 4 percent of the weight and 54 percent of the value) is made up of eight categories of high-value goods. These include instruments, finished leather and apparel products, machinery, and transportation equipment. Businesses and consumers are willing to pay a premium for fast and reliable service for high-value commodities. Information technologies help provide such services.

The Transformation of Transportation Services by IT

To better understand the broad impacts of IT on the emerging quality and quantity of transportation services, it may be useful to clarify the systemic nature of transportation services. Societal needs for mobility—and hence transportation—have traditionally been met by a combination of four basic system elements (see figure 11-4):

1. vehicles of all kinds;
2. the physical or material infrastructure (e.g., roads, railroads, and airports) used by the vehicles;
3. the information network infrastructure; and
4. an operational framework or infrastructure: people acting within a framework of processes and knowledge (e.g., policies, rules, regulations, and institutions) who design, build, operate, and maintain the vehicles and infrastructure, and plan and shape the governance and future evolution of the entire enterprise.

Figure 11-4.
Components of the Transportation System



The quantity, variety, and quality of transportation services are jointly determined by these four elements, and the interactions among them. Information technologies are being adopted throughout the economy in ways that are fundamentally affecting the nature of society's needs and desires for mobility and access. Today, people around the world can choose among fax, electronic mail, and overnight express for movement of documents, or debate whether an intercity trip might be avoided with a conference call. Options such as these are affecting commercial operations and the daily life of individuals in all spheres of activity. Transportation-related enterprises, like all businesses, are fundamentally affected by IT—at every step from research through manufacturing of goods and operation of services.

Beyond those more visible effects, fundamental changes are occurring in how transportation works and is used. The "bottom line" in transportation applications of IT is determined by the balance between cost and service. IT can affect both strongly. The acquisition and processing of operational, financial, and related data directly support higher system capacity, greater labor and capital productivity, improved efficiency, more effective resource allocation, and better integration of the many processes and activities that cumulatively produce transportation services.

Detailed understanding of system operations also enables design and implementation of innovative operational concepts and practices. The overnight package delivery service, for example, could hardly exist today without a myriad of computers, digital tags on items, and extensive communications links. It is difficult to imagine operating the nation's commercial aviation system—with well over 1 million airline seats to be filled daily at market-driven prices for several thousand origin-destination pairs—without the technology that underlies and links modern computer reservations systems.

More recently, information technologies are beginning to transform the interface between the service provider and the customer or user. Many ITS applications provide real-time status information about local highways and transit systems, potentially with guidance as to optimal choices for any particular trip. An individual with access to the World Wide Web can find the status of an overnight package in seconds. With a highly controlled and visible transportation system, manufacturers can safely integrate their suppliers into just-in-time production systems and tailor their outputs to short-term customer needs.

Less direct, but potentially of greater impact, are the ways in which information technologies alter the need to travel or the type of transportation consumed. A film can be seen by traveling to a theater, accepting what is available from television broadcasters, traveling to a video film rental store, or staying home but ordering a specific choice for direct cable delivery. A trip for a business meeting may be replaced by a joint telephone call or video conference, and personal purchases may be made by traveling to a store, or by ordering (over telephone or Internet) and relying on a delivery service. Aided by modem-equipped computers, fax machines, and online services, a growing segment of the population finds it feasible—and often preferable—to work from home, either as a telecommuting employee or as an independent business or contractor.

Many of these changes are not of a type that is readily captured in traditional transportation measures and indicators, and are thus particularly difficult to characterize quantitatively in their current infancy; assessment of what is happening is still subjective and largely anecdotal. Speculative literature sometimes presents an exaggerated and possibly misleading picture of a future "cyber-society," but an underlying reality is that the full impacts of this IT evolution on transportation will emerge only slowly in coming decades, and often will not be separable from the effect of other societal changes.

The Supply of IT-Based New Transportation Services

Information technologies are changing the availability and supply of transportation services, with concomitant changes in the ways that mobility and access needs are satisfied. The most direct and visible impact of IT lies in reduced cost, improved capacity, shorter trip times, expanded availability, better service and convenience, and new functions. These direct user benefits may also be accompanied by minimization of adverse environmental and other social impacts.

Cross-Modal and Intermodal Transportation

► Urban / Suburban Passenger Transportation

A variety of advanced traffic management and travel information systems are being applied to road and public transit operation in urban and

Box 11-4.

Advanced Travel Management and Information Systems

Advanced travel management and information systems include three major components: traffic management, traveler information services, and management of public transportation system operations. Typically, many public sector agencies and commercial service providers collaborate to implement these systems.

Traffic management systems are used to manage freeway operations, monitor and control traffic, collect tolls electronically, and respond to conditions that affect traffic. Since 1995, state transportation agencies have deployed more than 20 systems that use a variety of detection, communication, and information technologies (IT) to manage traffic flows. More than 2,000 miles of roadways—primarily high-traffic freeways or arterials—have been equipped with more than 2,100 ramp meters, 600 changeable message signs, 375 closed-circuit TV cameras, and other devices.

For the 1996 Olympic Games in Atlanta, video cameras along freeways, city arterials, and at key intersections helped officials monitor traffic conditions, refine control strategies, and respond rapidly to breakdowns and crashes. Through this surveillance, incidents that might otherwise not be apparent for 5 or 10 minutes could be detected in a minute or less.

The Santa Monica Smart Corridor project in Los Angeles includes an 18-mile stretch of the busiest freeway in the nation and five parallel arterials highways. Automated incident detection is coupled to a decision support system that develops real-time responses for addressing traffic problems. Drivers may be prompted to try alternate routes by variable message signs and broadcasts on highway radio, and changes in ramp metering and traffic signal timing may reduce congestion. When completed in 1998, the project is expected to reduce intersection delay, motorist travel time, and fuel use.

Traveler information services, which can be provided by both public and commercial enterprises, enable individuals to make better use of the transportation system, based on real-time and the projected status of the highway network and transit system. Information on what means to use and, possibly, when to travel is provided to en route passengers and individuals making a pre-trip decision. For the Atlanta Olympics, many delivery techniques were used: Internet sites, highway advisory radio, changeable message signs, interactive kiosks, hotel room TV, and electronic bulletin boards. Schedules, route instructions, weather forecasts, and other tourism and special event information proved popular, and enabled people to make optimal travel choices. Other beneficiaries of better information include the customers and providers of delivery vehicles, taxis, and shared-ride services.

In many cities, any individual with Internet access can get virtually real-time data and even images of traffic on critical roadways. Timely and route-specific traffic conditions are available in the Boston area for a free conventional or cellular telephone call; this is a commercial service, funded by public agencies as a means of improving local mobility.

Management of public transportation services through IT can improve transit operations, reduce the cost of system maintenance, and generally provide better service and en route information to patrons. Examples include use of IT in the operation of flexible-route and scheduled transit vehicles to give buses priority at traffic signals, to enhance personal security for travelers, and to collect or pay fares electronically.

During the last four years, automatic vehicle location (AVL) systems have come to be widely accepted and sought as key components—along with geographic information systems and wireless communications—for improved operational management of bus fleets. Such information also can be linked with traveler information services to update transit riders about expected arrival times of buses.

AVL systems are now operational in at least 28 transit systems and are being installed or planned in 36 other systems in North America. Most of the newer systems use or plan to use satellite-based location determination. For a $2.3 million investment in AVL technology, Kansas City reduced the number of buses needed and saved $400,000 per year in operations, as well as avoided $1.5 million in new rolling stock. Baltimore and Milwaukee saw 23 percent and 28 percent improvements, respectively, in on-time performance.

Other technologies have proven beneficial even in their early application. Portland, Oregon, found up to an 8 percent reduction in bus travel times using bus priority technology at four intersections. Transportation authorities from New York to California have estimated that benefits of electronic fare collection will be in the millions of dollars annually, based on reduced handling costs, improved security, and less fare evasion.

suburban areas (see box 11-4). In the United States, a partnership between public agencies at all levels and the private technology and transportation industries is stimulating major investments in ITS, ranging from research and development, through operational tests and demonstrations, to real-world deployment. In January 1996, then-U.S. Secretary of Transportation Federico Peña announced Operation Timesaver, an initiative to deploy basic intelligent transportation infrastructure in 75 of the nation's largest metropolitan areas within 10 years.

Box 11-5.

Intelligent Transportation Systems in Europe and Japan

The infusion of information technologies into transportation, commonly referred to in the United States as intelligent transportation systems (ITS), is a global phenomenon. In Europe, the term more often used is "transport telematics," the latter word implying the combination of information and telecommunications technologies. Prominent considerations in the development and use of ITS in Europe are the high percentage of passenger travel and freight transportation crossing national borders, and the wide variety of road infrastructure found across the European Union.

Over the last decade, European programs have produced many disparate systems based on a variety of overall system architectures—a result that impedes integration of the various technologies proposed or in use. European governments, however, have been supportive of setting specific technical standards for ITS.

The technologies that comprise transport telematics are viewed by both the public and private sector as important elements in coping with traffic congestion, safety, and transportation-related environmental impacts. The PROMETHEUS program, a 1987 to 1994 private sector initiative, was aimed at developing a uniform European traffic system using telematics. One of the goals of the program was to reduce traffic casualties by 50 percent by the year 2000. Increasingly, traveler's preferences and choices also are being recognized as critical in the evolution of telematics.

Much like Europe and the United States, the public sector in Japan has focused ITS development and use on reducing congestion, improving safety, and protecting the environment. Government funding of several major programs through the mid-1980s led to rapid development of advanced route guidance, hazard and warning displays, and in-vehicle information systems. Since then, private industry also has taken a strong role in advancing these technologies.

Although Japan does not have the problem of transnational interoperability and standardization that is found in Europe, there are many governmental bodies, independent coordinating organizations, and major corporate participants involved in development efforts. As a result, harmonization is highly complex.

Traffic control systems have been in use in 74 major Japanese cities since 1985; changeable-message signs and roadside radio assistance have been operational since the 1970s. In addition, automated toll collection is widely used.

Congestion and complex urban road systems have generated strong demand for in-vehicle guidance systems. This market is served by at least 16 major manufacturers, with sales of 350,000 units in 1994. An estimated 1.5 million vehicle guidance systems are now in operation, with 2.8 million anticipated by 2005. Japanese auto manufacturers are aggressively pursuing "smart car" technologies, particularly navigation for the domestic market, and safety, communications, and antitheft systems, which tend to dominate consumer interest in the United States.

Most existing route guidance systems are "static," that is, they do not incorporate real-time traffic conditions, but always offer the same routings. Dynamic guidance systems that adjust routes to accommodate current circumstances require a parallel comprehensive realtime traffic data infrastructure, necessitating major involvement of the public sector. With the exception of a few American and European cities, only Japan is now beginning to provide this infrastructure, which must be based on national standards for widespread utility. More than 60,000 dynamic route guidance systems are now operational in and around Tokyo, with expansion of the service to other areas anticipated in the near future.

Government ITS research in Japan typically has a long time horizon. Several agencies are conducting research directed toward fully automated driving, including vehicle control, and support of fiber optic and satellite communications infrastructure as early as 2010.

(USDOT 1996) Japan and Europe also have significant activities underway (see box 11-5).

Centralized and coordinated management of highway traffic and transit operations—bus and light, heavy, and commuter rail—is a central ITS element, as are advanced systems for providing convenient and comprehensive information to travelers concerning the current and projected status of all components of the local transportation system. Electronic collection of tolls can greatly reduce peak-hour delays at highway toll booths in urban areas. ITS offers a path to reduced congestion, shorter trip times, lowered urban air pollution, and improved highway safety, with drivers able to make informed travel choices and system managers better positioned to deal with special or unexpected circumstances.

Only limited success has been achieved over the years in bridging the gap between taxicabs (with a high level of service but relatively high cost) and fixed-route buses (inflexible and often infrequent service at low cost). Merely providing reliable and accurate information at bus stops (and by phone or Internet) could make service significantly more attractive. The relative ease of knowing vehicle location (both onboard and at a central dispatching center) may make feasible a variety of intermediate modes, such as buses that can make modest diversions from the standard when pick-up or drop-off is requested.

Demand responsive paratransit services (e.g., dial-a-ride, shared-ride taxi, and vanpooling) have been used across the United States since the 1970s, but the cost-service characteristics have generally restricted them to specialized functions, such as transportation for the elderly and persons with disabilities. Technology advances, however, in position location, navigation, automated dispatching (centralized or onboard), and local communications may yield more efficient and less labor-intensive results that greatly expand the viability of this concept.

► Freight Transportation and Logistics.

Just as information technology has emerged as a critical tool for specific transportation systems, it is also rapidly being applied to the broader management of freight logistics. Combinations of computer and satellite communications technology now make it possible to track the location of a shipment or vehicle virtually anywhere in the world, and for onboard and central computers to exchange any information relevant to the operation. The widespread adoption of just-in-time manufacturing and delivery to wholesalers and retailers necessitates tracking individual shipments and continual adjustments throughout the enterprise to respond to changing circumstances. The net effect is an increasingly tight integration of the entire chain from raw materials and components to manufacturing and delivery to the final customer. Only by providing the ability to track and control shipments precisely can the transportation system achieve the flexibility to respond to the continual changes and quality-of-service demands that characterize the modern global economy.

The attachment of highly informative and easily read digital tags to cargo is an especially valuable mechanism for facilitating intermodal freight movements. Data describing origin, destination, and contents—whether encoded on the tag or contained in a linked database—can substantially improve the speed and reliability of modal transfers while minimizing errors. Even for the large quantity of goods moving without tagging, extensive networks for electronic data interchange permit paperless exchange of invoices, customs documents, bills of lading, and other materials that can significantly reduce delays and costs.

Air Transportation

For many people, the computer reservation system (CRS) used by airlines is one of the most visible interactions with transportation information infrastructure. The CRS permits travelers to arrange, often within minutes, airline flights and related services at most of the world's major airports. It tracks price, availability, seat assignments, and meal preference. More than a convenience, this system is now a necessary element in operating the aviation system at its current and anticipated levels. Beyond the basic seat reservation function, the CRS is key to airline yield management techniques, in which pricing is continually adjusted to match airline offerings to market demand for air travel. The net effect of the CRS is intended to be more-profitable flights, improved industry efficiency, and lower ticket prices overall.

Another IT aviation application of special interest to the traveler is the air traffic control (ATC) system—an enormously complicated mix of hardware, software, procedures, and people—that lies at the heart of both safety and air system performance. The dramatic growth of air travel in the 1950s and 1960s led to the creation of an airspace structure—regions in which commercial and other aircraft would fly under controlled conditions including minimum vertical and horizontal separation—based on radar surveillance by ATC centers. The technological and functional evolution of this system can be protracted because it is so critical for safety and because the transition to new facilities and operations must be seamless and as transparent as possible.

The advances, however, have been sufficient to support a quadrupling of domestic passenger-miles flown between 1970 and 1995, with steady improvement in safety and efficiency. (USDOT BTS 1996, table 1-7) By aggregating information on all flights in U.S. airspace, plus weather data, it is possible to move from ATC to air traffic management by holding flights at originating airports to avoid expensive inflight holds (stacking) in the vicinity of congested terminal areas. One sophisticated IT-based advance—now also being examined for highway applications—is onboard collision avoidance technology, providing pilots with alerts of other aircraft potentially on a collision course. As is discussed in chapter 3, onboard Global Positioning Systems (GPS) to avoid impending collisions into terrain are now being installed by U.S. airlines.

Plans and systems are currently being developed for transition to a conceptually new approach—free flight—in which aircraft location is determined onboard by augmented GPS technology, rather than by ground radar facilities, with greatly increased flexibility given to crews in choosing routes. Substantial economic benefits are foreseen. Satellite-based positioning technology is also expected to permit reduced separation standards—hence, higher en route capacity—and improved low-visibility landing capabilities to minimize delays due to bad weather.

Many onboard and air-ground cooperative computer-based systems are used to assist the crew in most flight management functions. Now referred to as a "glass cockpit" (reflecting the adoption of computer-driven displays of information in place of traditional electromechanical gauges), the modern flight deck offers great improvements in the flexibility and type of information conveyed to the crew, and the manner of its display. The glass cockpit is one of the most visible manifestations of the many automated functions that contribute to safety and reduced pilot workload, and have permitted an economic gain through reduction to two- rather than three-person crews in large airliners. Related systems also provide useful real-time inflight information to the operating airline.

The design process for the latest entry into the commercial fleet, the Boeing 777, was greatly facilitated by extensive use of computer-aided-design technology, flight-deck simulators, and formation of widely separated but digitally linked subsystem engineering teams. The crews for this and other new aircraft receive much of their initial familiarization training on highly sophisticated cockpit simulators.

Rail Transportation

The current renaissance in freight rail transportation in the United States has been driven by a powerful combination of regulatory reform, innovative operating concepts, and the application of technical advances. Railroad companies must deal with dispersed moving and fixed assets—involving not only the trains a given company operates and its track network, but also the free exchange of rolling stock with other railroads. Railroads have thus been among the leaders in the business world in applying information technologies to their operations. In the 1970s, the railroads implemented optical tags and scanners to identify freight cars as they entered terminals; more recently, railroads have moved to a microwave transponder system. Classification yards, in which several thousand freight cars are received in inbound trains and reassembled into outbound traffic, have long been highly automated in their operation.

The need to coordinate disparate activities over a vast geographic area has meant that railroads have always had a strong interest in communications technology. The telegraph, a key element in creation and operation of 19th century rail empires, has long since given way to extensive and highly sophisticated dedicated fiber optic and microwave digital communications facilities. Traffic management (train dispatching) is now often accomplished from control centers responsible for thousands of miles of rail system, with graphic display of track occupancy and infrastructure status.

Fundamental safety functions—primarily train separation—are still based on the century-old track-circuit concept. As discussed in chapter 3, the Federal Railroad Administration and the industry are now exploring “positive train control” approaches as a safety feature. These approaches are based on the use of locomotive GPS position determination and onboard track geometry data, with digital communications to a control center. These and other concepts using wayside transponder beacons for location appear to offer substantial safety and traffic capacity benefits, although the necessary investment would be quite large. Just as in other modes, GPS also plays an important role in track and other physical plant surveys.

Intercity Highway Transportation

Many of the most promising highway uses of information technology were noted above in connection with cross-modal urban and suburban applications. Many elements of ITS, however, apply equally to non-urban environments. One example: “mayday” systems—devices that sense an accident, or can be activated by the vehicle operator, and automatically communicate the situation (typically using satellite or cellular systems) to an emergency response agency. When implemented as a commercial service, that agency will also have access to a database containing information about the individual involved. By incorporating a GPS receiver, this system is able to provide precise location information to the responder.

Route navigation systems, typically based on GPS access with a CD-ROM map database, are already popular in Japan, although still relatively costly. They are of greatest value in urban areas, particularly when accompanied by effective routing algorithms, but can also be very useful to the intercity traveler. In addition to navigation functions, such systems can contain information on restaurants, hotels, and services, as well as local traffic problems or—of particular interest on rural roads—warnings of approaching adverse weather conditions. More localized meteorological information can provide warnings and countermeasures quickly, effectively, and efficiently. Indeed, in some regions of the country, it is estimated that substantial savings of taxpayer dollars could result by reducing the number of snowplow drivers called to duty for severe storms that do not materialize.

To a large degree, onboard computing devices simply represent improved ways to achieve traditional functions, and their presence is relatively invisible to the driver. Innovations now being actively explored offer even more dramatic change. Various night vision technologies, originally developed primarily for defense applications, may be a powerful means of coping generally with the high rate of nighttime accidents, and with the decline in night vision inherent to the aging process. Similarly, appropriately placed radar and other sensors appear capable of providing advance alerts and warnings to drivers for a wide range of potential collision situations.

Maritime Transportation

A modern cargo ship is an extremely valuable asset of a highly competitive industry. Information technologies are now widely used in assuring maximum operational efficiency and economic yield. Navigation has always been particularly critical in the marine environment for both safety and finances. GPS and steady improvements in oceanic meteorological sensing and forecasting provide the foundation for efficient routing between ports. Continual communication among corporate headquarters, customers, and ships similarly enables economic optimization in routes, schedules, and cargoes. Highly automated port facilities contribute to minimization of the time spent loading and unloading, further improving ship utilization. High-precision augmentations of GPS in harbors and other critical regions (used in concert with digital charts), radar for collision avoidance, and radio communications provide the basic framework for marine safety, which includes avoidance of environmentally damaging spills.

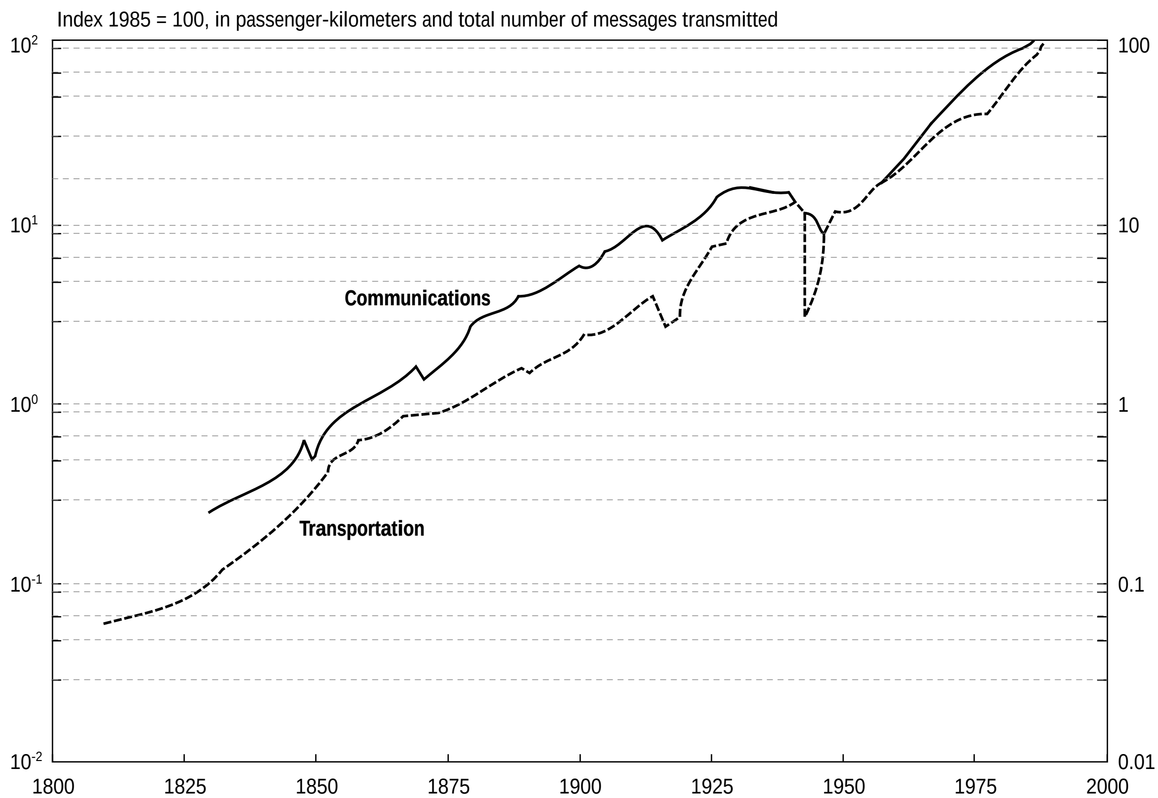
The economics of shipping also benefits from the high degree of automation now applied to ship operations as a result of minimized crew requirements. As is the case for air crews, highly sophisticated simulators play a key role in training bridge officers in the intricacies of handling 100 ton ships.

IT and the Changing Demand for Transportation

The changes described above suggest the degree to which information technologies can complement and facilitate transportation functions, yielding more attractive cost and service characteristics that often affect, to some degree, the choices made by users and customers. Less obvious, however, but potentially of greater direct impact, is an IT-driven shift in the underlying spectrum of demand for transportation services based on the substitution of telecommunications for physical movement. This is often referred to as "tele-substitution."

Mobility and access needs and desires can be met in many ways. The place at which products are produced is similarly subject to a wide range of choices. The need for transportation is often discretionary, and, when it is needed, alternative means can be found. One common consequence of the introduction of information technologies is to change the options and the decision criteria applied to them. The brief discussion that follows suggests some of the many ways in which IT substitutes for transportation, stimulates or eliminates the need for it, alters user travel or mode choices (including facilitation of public

Figure 11-5.
Growth of Passenger Transportation and Communications in France



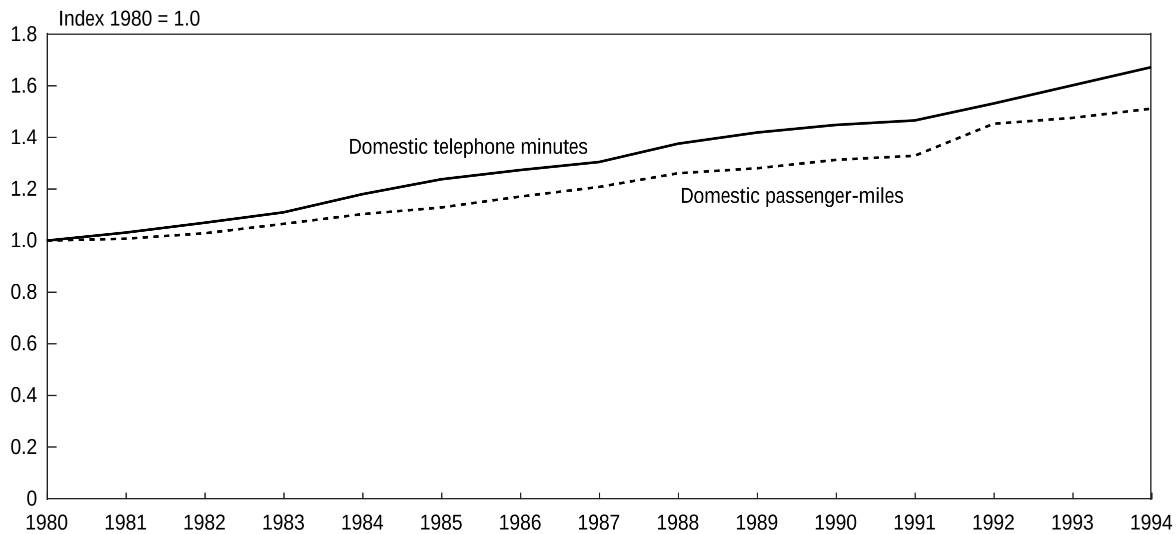
SOURCE: A. Grübler. 1990. *The Rise and Fall of Infrastructure: Dynamics of Evolution and Technological Change in Transport.* Heidelberg, Germany: Physica-Verlag. Figure 4.5.2, p. 256.

sector travel demand management strategies), or substantially changes the nature of the transportation services needed. The extent (if any) of substitution of movement by communications is still speculative. Evidence from the United States and France suggests that both transportation and communications have been growing in parallel—with little support for substitution (see figures 11-5 and 11-6). Since some of these effects are not readily quantifiable, this discussion is necessarily anecdotal and descriptive in nature.

Local Mobility and Access

For many people, mention of the impact of information technologies on transportation most often conjures up the image of telecommuting—replacing the trip to one's workplace by digital tools and communications links that permit working from home. Some futurists expand on this image, envisioning a "wired world" in which most people spend much of their time at home. Working, shopping, entertainment, social interactions and other activities are to be accomplished largely through digital links. Even if this relatively extreme view is not realized, there is some reality to the expectation of significant

Figure 11-6.
Growth of Passenger Transportation and Telecommunications in the United States: 1980–94



SOURCES: Federal Communications Commission. 1996. *Statistics of Communications Common Carriers, 1995/1996 Edition.* Washington, DC.
U.S. Department of Transportation, Bureau of Transportation Statistics. 1996. *National Transportation Statistics 1997.* Washington, DC. December.

potential changes in personal and corporate activities. This evolution will carry with it the likelihood of parallel alterations in the provision of mobility and access, particularly in the urbanized areas, which account for 75 percent of the population and almost two-thirds of national passenger car mileage.

Telecommuting is already a fact of life for many people, but so far with only modest transportation impacts beyond those who practice it. The most common situation is that individuals still travel to the regular workplace two or three days per week. The growth rate for this style of work appears to be rapid, although difficult to measure, and it remains to be seen at what point it may either accelerate or level off. Although it is popular to characterize more than half of the nation's jobs as "knowledge functions" or as employing "information workers," the suitability of many such positions to telecommuting is questionable, as is the desire, ability, or willingness of some individuals to work at home (or at local remote worksites). Transportation effects are limited, since trips to and from work only represent about one-third of urban travel, and often include other errands that would require local travel in any event. Thus, for the foreseeable future, direct impacts of "pure" telecommuting are expected to be modest.

The more general phenomenon of home-based work, however, with telecommuting as a subset, has much broader implications. Establishment of a fully functional home office now requires only a relatively modest investment for capabilities, including fax machine, copier, Internet (with a World Wide Web site) and electronic mail capabilities, voice mail, and multiple telephone lines. These tools, plus a powerful desktop computer running commercial small business software can support a substantial business activity in a fully professional manner, with operating costs far below the level associated with rented quarters. The net effect is to ease entry into the marketplace.

A variety of societal trends are encouraging self-employment: voluntary or forced early retirements, contracting for services formerly performed by employees, need to tailor work to responsibilities to care for family members, aversion to large and impersonal work situations, a need or preference for flexibility in work style and hours, the wish to pursue several types of work simultaneously, or the desire to make one's choice of residence independent of workplace. Information technologies enable and stimulate realization of goals such as these.

Although eliminating trips to an external workplace, home-based workers such as field representatives, salespeople, or service technicians with no formal office may generate trips to customers and suppliers. The home-based worker, however, is more likely to be able to schedule travel in off-peak hours for business as well as other activities, thus increasing personal mobility. Transportation implications include the reduction in work trips, as well as some degree of congestion relief in periods of peak travel. The broader and more speculative impact is the potential to increase urban sprawl and migration to more rural suburban areas as a consequence of improved mobility.

No matter where employed, many people are attracted to the convenience of shopping from home, whether via catalog, television, Internet, or other means. This phenomenon has already contributed significantly to the growth of businesses well attuned to it, including those that can provide the rapid and efficient delivery services on which the entire process depends. This approach is now being introduced by many supermarkets, so that groceries can be ordered without leaving one's home, for next-day delivery. A related development that markedly improves access to many services as well as goods is the relatively low cost to many businesses of providing 24-hour phone service, now being supplemented by posting catalogs and accepting orders via the Internet. The World Wide Web also offers direct access at any time to many documents, forms, tickets and reservations, and general information resources that otherwise might require a significant effort, during business hours, to obtain.

Information technologies also can affect access and mobility in a very different way by providing the means for implementation of demand management and congestion mitigation measures by public authorities. Given the political will and necessity, IT can greatly facilitate the management and control of motor vehicle access to urban areas through road pricing (adjustment of electronically collected tolls) or prohibition of entry for some or all vehicles.

Long-Distance Mobility and Access

The telephone has provided a partial alternative to some types of business travel, especially in the form of conference calls that involve numerous participants, but is often not a good substitute for face-to-face meetings. Video conferences—with television cameras and monitors at each location providing the visual contact that is so important to human discourse—have been available in some fashion for decades, but problems of cost, availability, and performance have limited their use. Technology advances have now begun to generate interest in "virtual" meetings. The steady decline in equipment and telecommunications costs, accompanied by significant performance and ease-of-use improvements, is producing a growing willingness to consider video conferences as a possible replacement for some single-location meetings.

Several forces in addition to reductions in the cost and functionality advances of IT itself are driving this trend. Most organizations are increasingly cost conscious. The expense of air tickets, plus salaries and incidental expenses can make the cost of a half-day meeting very high. Interactions between two or several decentralized businesses can involve people from many locations, often in other countries.

Although not a replacement for physical presence, video meetings, if used effectively, have several important strengths beyond their potential for cost savings. They are easier to schedule and can involve more people, often from more places. Systems are now becoming available that, at moderate cost, can enable even a conventional desktop personal computer to operate as a video terminal. Should this capability reach sufficient acceptability in cost and performance to become relatively standard, the accessibility of business colleagues for digital face-to-face meetings would become substantially greater. Personal relationships could become significantly easier to establish and maintain, even while travel budgets shrink. (Realization of this scenario could have significant impact on airlines, dependent on business travel for almost half of their passengers and about two-thirds of their revenue.)

Access Beyond the Scope of Transportation

The preceding discussion addressed ways in which information technologies can affect the need for physical mobility, substituting for transportation or making it unnecessary. Telesubstitution can also apply to situations in which the distances, travel costs, or other impediments are so great that physical transportation is not practical. Thus, telecommunications and associated technologies can effectively remove distance or locational remoteness as a constraint on access to education, libraries, and some medical care services and consultation. For example, the Internet permits people with common interests in virtually any subject to gather (electronically) for discussions, debate, and exchange of information—no matter how esoteric the subject or geographically dispersed the participants may be. An absence of like-minded individuals in a person's local community need not be an impediment to actively follow a particular interest, whether professional or amateur, intense or casual. As valuable as this type of access is in general, it is of special importance to people who, for whatever reason, may be unable to travel physically and would otherwise be precluded from the activities and services enabled by IT.

Information technologies are also creating opportunities well beyond the realm of simple telecommuting or home-based self-employment. Some types of work—such as telemarketing, invoice processing, and software development—do not require physical presence at a particular location. Businesses requiring these services now can and do seek them anywhere in the world, based primarily on economic considerations. At the same time, individuals and whole communities gain a significant degree of access—that would not exist without IT—to very distant commercial and employment markets in any activity that does not entail substantial physical movement of resources or products.

Transformation of Production

The growing investment in transportation IT has not only affected the supply of new services and changed demand for transportation, but also affected the type and level of competition and the structure of management in transportation and production firms. The use of IT promoted broad restructuring and strategic changes in these industries, which facilitated the entry of small firms into new markets, creating economic activities such as global sourcing arrangements and business networking. By changing production processes and products, IT also can trigger job redesign, restructure work flows, or alter the place of work—thereby changing employment patterns.

Because IT has been used to automate and speed up production processes, improve reliability and flexibility, and lower costs, widespread productivity payoffs in the economy are expected. Yet many macroeconomic studies report no substantial gains in productivity. This is referred to as the productivity paradox. One explanation for this paradox is that national statistics on industry productivity do not capture aspects of service quality in terms of how well transportation and logistical companies serve their customers. Further, the benefits of IT use by transportation firms may accrue to and be reflected in the productivity benefits of manufacturing firms and other customers.

An historical example of the productivity paradox draws attention to the long time lag between the advent of the dynamo—a broad technology with pervasive effects like the computer—a century ago and its impacts on the economy, reflecting the time needed for the new technology to penetrate the economy widely. (David 1990)

Enterprise-Level IT Effects

IT applications focused initially on consolidating operations and lowering the costs of paper-intensive activities, such as purchasing and accounting. Now IT is used to offer flexibility in rapidly evolving business environments, preserving or raising market share, and improving the quality of services and customer interactions. For example, computer reservation systems are used not only for cost reduction and revenue enhancement, but also to offer new customer services. Also, logistical firms use IT to offer management services to production firms on a worldwide basis, which can lower the cost of production, thus blurring boundaries between transportation and production firms.

Increasingly, key assets in transportation and logistical firms are knowledge assets. They include a knowledge base about customers and markets embodied in the firm's IT and supporting systems, and the knowledge and professional skills acquired by workers and management as they develop flexible response capabilities and use IT to improve the firm's internal decision-making.

Industry-Level IT Effects

Transportation is one of the more frequent users of IT. In the air transportation industry, for example, IT has a major impact on sales, marketing, load management, logistics planning, safety systems, air traffic control, and other activities. The effect on operations is enormous.

It is important to note that in the air transportation and intermodal logistics industries, IT is associated with increasing complexity and customization, as these industries become more transaction-intensive, and increase the scale and variety of their linkages with other enterprises. In this process, transportation IT is altering the existing relationships among end-users, manufacturers, wholesalers, and retailers. Intermediaries are often bypassed, producers may sell products directly to end users, and new businesses may arise.

Workforce-Level IT Effects

In an environment of intense global competition, there is an organizational need for flexibility, the capacity to respond or change quickly, and the ability to experiment often. Workers need to know how to construct queries, analyze and interpret information, draw inferences, and act. (NRC 1994)

IT comprises tools that affect what workers do and how they do these activities. In this context, IT can help redesign the work process, facilitating the separation, the reorganization, and recombination of work activities without regard to space and time. The outcomes of such redesign of the workplace are increased worker knowledge, decentralized decision authority that allows more autonomy and broader tasks at lower organizational levels, and networked organizations. The levels and extent of supervision will also change.

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List of Acronyms

AFV	alternative fuel vehicle
APTA	American Public Transit Association
ATC	air traffic control
ATS	American Travel Survey
AVL	automatic vehicle location
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BTS	Bureau of Transportation Statistics
Btu	British thermal unit
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CARB	California Air Resources Board
CBD	central business district
CFCs	chlorofluorocarbons
CFIT	controlled flight into terrain
CFOI	Census of Fatal Occupational Injuries
CFS	Commodity Flow Survey
CMEA	Council for Mutual Economic Assistance
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CRS	computer reservation system
CRS	child restraint systems
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DTTS	Defense Transportation Tracking System
EAS	Essential Air Service
ECMT	European Conference of Ministers of Transport
EDI	electronic data interchange
EGPWS	enhanced ground proximity warning system
EIA	Energy Information Administration
EMS	emergency medical service
EPA	U.S. Environmental Protection Agency
EU	European Union

FAA	Federal Aviation Administration
FEB	former East Bloc
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FSU	former Soviet Union
FTA	Federal Transit Administration
FTP	Federal Test Procedure
FWI	fixed-weighted index
FY	fiscal year
GA	general aviation
GAO	U.S. General Accounting Office
GATT	General Agreement on Tariffs and Trade
g/bhp-hr	grams per brake horsepower hour
GDP	gross domestic product
GGE	gallons of gasoline equivalent
GIS	geographic information system
GPRA	Government Performance and Results Act
GPS	Global Positioning System
HC	hydrocarbon
HDC	high-density corridors
HSGT	high-speed ground transportation
HSR	high-speed rail
ICC	Interstate Commerce Commission
IEA	International Energy Agency
I/M	inspection and maintenance
IRI	International Roughness Index
ISTEA	Intermodal Surface Transportation Efficiency Act
IT	information technologies
ITS	intelligent transportation system
JIT	just-in-time
km	kilometer
LOS	level of service
LPG	liquefied petroleum gas

MA	metropolitan area
maglev	magnetic levitation
MARAD	Maritime Administration
mmbd	million barrels per day
mpg	miles per gallon
mph	miles per hour
MPO	metropolitan planning organization
MSA	metropolitan statistical area
MSW	municipal solid waste
MTBE	methyl-tertiary-butyl-ether
mtk	metric ton-kilometer
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAFTA	North American Free Trade Agreement
NEPA	National Environmental Policy Act
NGL	natural gas liquids
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NIPA	National Income and Products Account
NMHC	nonmethane hydrocarbon
NMV	nonmotorized vehicle
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
NPTS	Nationwide Personal Transportation Survey
NTD	National Transit Database
NTL	National Transportation Library
NTPMS	national transportation performance monitoring system
NTSB	National Transportation Safety Board
OECD	Organization for Economic Cooperation and Development
OES	Occupational Employment Statistics
OPEC	Organization of Petroleum Exporting Countries
pkt	passenger-kilometers traveled
PM-10	particulate matter of 10 microns in diameter or smaller
pmt	passenger-miles traveled
PSR	Present Serviceability Rating

RFG	reformulated gasoline
RSPA	Research and Special Programs Administration
RTMs	revenue ton-miles
RTECS	Residential Transportation Energy Consumption Survey
SAMIS	Safety Management Information Statistics
SFTP	Supplemental Federal Test Procedure
SIC	Standard Industrial Classification
SO_2	sulfur dioxide
STB	Surface Transportation Board
TCM	transportation control measure
TEU	20-foot equivalent container unit
TIUS	Truck Inventory and Use Survey
TRB	Transportation Research Board
TSA	Transportation Satellite Account
TSAR	*Transportation Statistics Annual Report*
TSAR94	*Transportation Statistics Annual Report 1994*
TSAR95	*Transportation Statistics Annual Report 1995*
TSAR96	*Transportation Statistics Annual Report 1996*
TSP	total suspended particulates
TTI	Texas Transportation Institute
vkt	vehicle-kilometers traveled
vmt	vehicle-miles traveled
VOC	volatile organic compounds
V/SF	volume-service flow
VTS	Vessel Traffic Services

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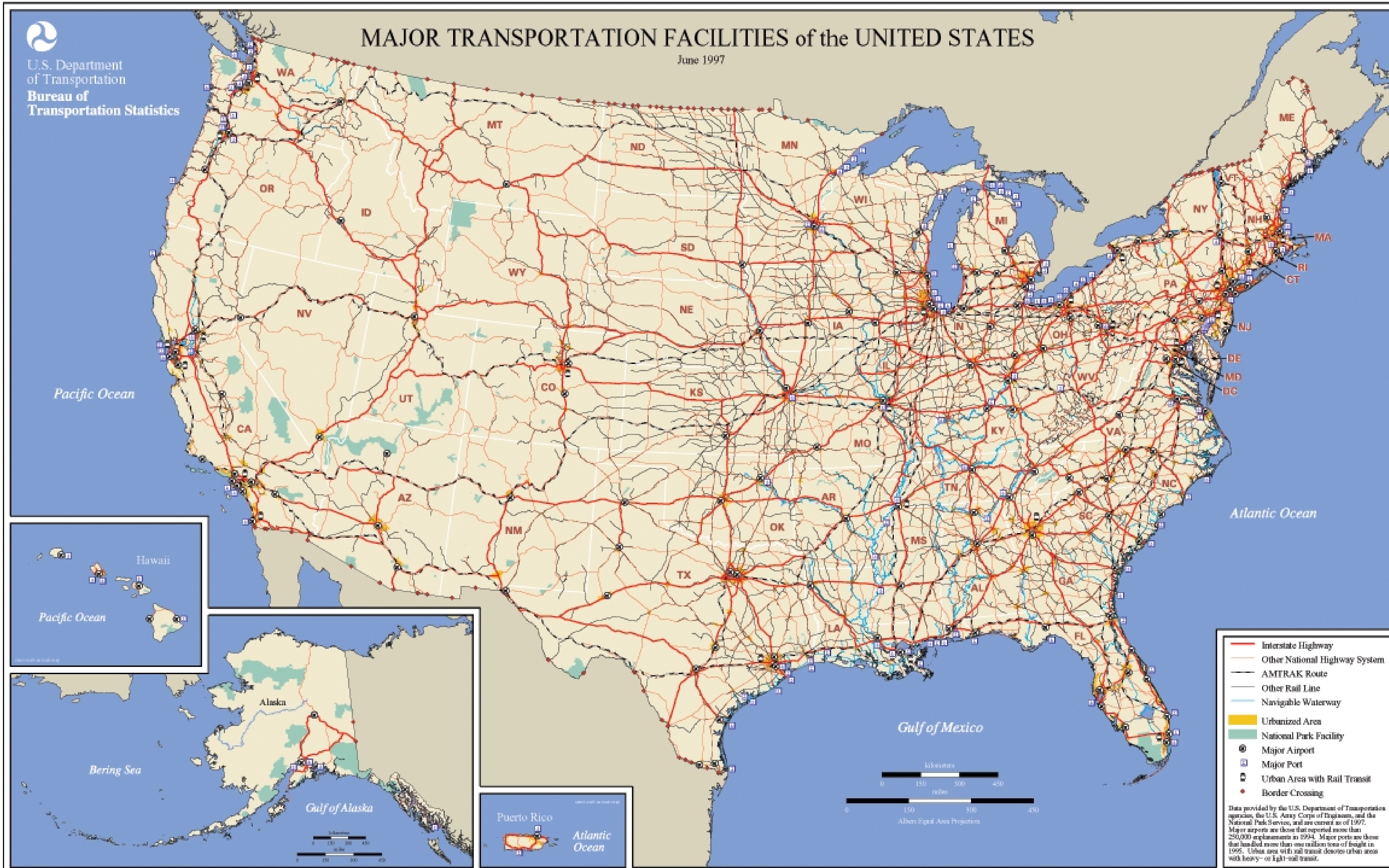
MAJOR TRANSPORTATION FACILITIES of the UNITED STATES
June 1997
U.S. Department of Transportation
Bureau of Transportation Statistics
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miles
0 150 300 450
Albers Equal Area Projection
Interstate Highway
Other National Highway System
AMTRAK Route
Other Rail Line
Navigable Waterway
Urbanized Area
National Park Facility
Major Airport
Major Port
Urban Area with Rail Transit
Border Crossing
Data provided by the U.S. Department of Transportation agencies, the U.S. Army Corps of Engineers, and the National Park Service, and are current as of 1997. Major airports are those that reported more than 250,000 enplanements in 1994. Major ports are those that handled more than one million tons of freight in 1995. Urban area with rail transit denotes urban areas with heavy- or light-rail transit.

The *Transportation Statistics Annual Report 1997* is a summary of the state of the nation's transportation system and the state of transportation statistics. This year's report includes an indepth discussion of mobility, access, and the transportation system.

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