Transportation Statistics Annual Report 1998

Long-Distance Travel and Freight

Bureau of
Transportation Statistics

U.S. Department of Transportation

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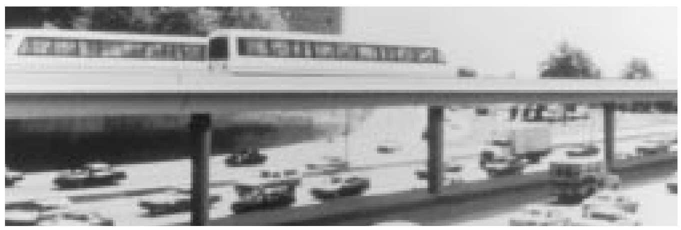
Preface

This *Transportation Statistics Annual Report 1998* is the fifth annual report prepared by the Bureau of Transportation Statistics (BTS), as required by law [49 U.S.C. 111 (j)]. As in prior years, the report brings together under one cover information about how the transportation system is used, how well it works, its economic contributions and costs, and its unintended consequences for safety, energy import dependency, and the environment. This year's report also contains a detailed analysis of long-distance passenger travel and freight activity, drawing on the American Travel Survey and the Commodity Flow Survey conducted by BTS in cooperation with the U.S. Census Bureau.

This report was initially developed under Dr. T.R. Lakshmanan, the Bureau's first Director, who returned to teaching in January 1998, and was completed under the administration of Deputy Director Robert A. Knisely.

Summary



This fifth *Transportation Statistics Annual Report* assesses the nation's transportation system and the state of transportation statistics. The report, mandated by Congress, is prepared by the Bureau of Transportation Statistics (BTS).

PART I: THE STATE OF THE TRANSPORTATION SYSTEM

The first four chapters of Part I examine the state of the transportation system, its economic impacts, and unintended consequences for safety, energy, and the environment. The fifth chapter summarizes the quality of information underlying this assessment.

The Transportation System

In 1996, the interlocking elements of the U.S. transportation system—a combined public-private enterprise—supported 4.4 trillion miles of passenger travel and about 3.7 trillion ton-miles of goods movement. The system included, among other elements, over 5.5 million miles of public roads, railroads, waterways, and oil and gas pipelines; over 18,000 public and private airports; and 230 million motor vehicles, railcars, aircraft, ships, and recreational boats. Table 1-1 in chapter 1 details key elements of each mode.

Use of the transportation system grew very quickly between 1980 and 1996: passenger-miles traveled increased more than 50 percent and ton-miles more than 25 percent. In some modes, demand grew faster than some physical components. For example, annually, highway lane-miles grew 0.2 percent, while vehicles-miles traveled increased 3.1 percent. In addition, urban highway congestion increased.

Use of Class I freight railroads increased, while track-miles owned by Class I railroads declined. Between 1980 and 1996, revenue ton-miles increased by 48 percent, from 0.92 trillion to 1.36 trillion ton-miles. During the same period, miles of track owned decreased by one-third, from 271,000 to 177,000 miles.

Air transportation has grown rapidly. The number of domestic enplanements in 1996 (about 538 million) and planes in certificated service (about 6,000) were about twice their 1980 level. Enplanements on international flights of U.S. carriers also doubled over the period, reaching 55 million in 1996. Over the last decade, the condition of runways at the country's most important airports improved. Performance based on on-time arrivals, involuntary boarding denials, and mishandled baggage has deteriorated in recent years. For example, in 1996, 75 percent of flights arrived on time, compared with 83 percent in 1991.

Not all modes experienced major increases in use, however. Urban transit capacity measured by vehicle-miles operated increased 13 percent between 1985 and 1995 to nearly 2.4 billion, but the number of trips declined from 8.3 billion to 7.3 billion during this period. Passenger-miles traveled remained the same at about 38 billion over the same period, suggesting that trip lengths are increasing.

International gateways—points of departure and arrival in the United States—have taken on added importance in recent years, reflecting growth in international travel and trade. Canada and Mexico account for the majority of both short-term (day) and long-term (at least one night) passenger travel to and from the United States. Because of this, surface modes convey most international passenger traffic through gateways in such areas as Detroit, Buffalo, El Paso, and San Ysidro in California. The airports that serve as the largest international passenger gateways are in New York, Miami, Los Angeles, Chicago, and San Francisco. On the freight side, the top five international gateways (in terms of value) are Kennedy International Airport, the Port of Long Beach (water), the Port of Detroit (land), the Port of Los Angeles (water), and San Francisco International Airport.

As the volume, value, and importance of international merchandise trade to the U.S. economy continue to expand, so does the impact on the nation's transportation systems. In particu-

New in This Edition

The fifth edition of the *Transportation Statistics Annual Report* has several new sections and special features:

- Chapter 1 has sections on the importance of international gateways and domestic water transportation for passengers and freight transportation.
- Chapter 2 inaugurates the Transportation Satellite Accounts, a new perspective on the contribution of in-house transportation services to the value generated by the U.S. economy.
- Chapter 3 has a section on transportation safety and the elderly.
- Chapter 4 features a discussion on deicing and anti-icing at airports.
- Chapter 5 reviews transportation data needs in the post-ISTEA era.
- Chapters 6 and 7 continue the tradition of a theme section. This year, the focus is on long-distance passenger travel and long-haul freight. Two recent BTS-sponsored surveys, the 1995 American Travel Survey and the 1993 Commodity Flow Survey, provide much of the data for the analysis.

lar, many physical components of that system act as critical infrastructure gateways for trade by maritime, surface, and air modes. The map below shows the leading foreign trade gateways, based on value, for the United States. Exports and imports in excess of $30 billion passed through each of these land, air, or maritime ports in 1996.

Many people think of import and export of goods in maritime trade as the primary function of commercial water transportation. Yet, nearly as much tonnage moves on the domestic water transportation system (1.1 billion tons in 1996). The domestic system includes the inland and intracoastal waterways, the Great Lakes-St. Lawrence Seaway system, and domestic offshore and coastwise shipping.

Among events in 1997 that had notable transportation impacts, four are discussed in chapter 1: flooding in the Upper Midwest, strikes affecting the United Parcel Service and the Bay Area Rapid Transit District, and freight rail service problems in the West. All of these events disrupted transportation services, and prompted users to seek alternative ways of meeting their transportation needs.

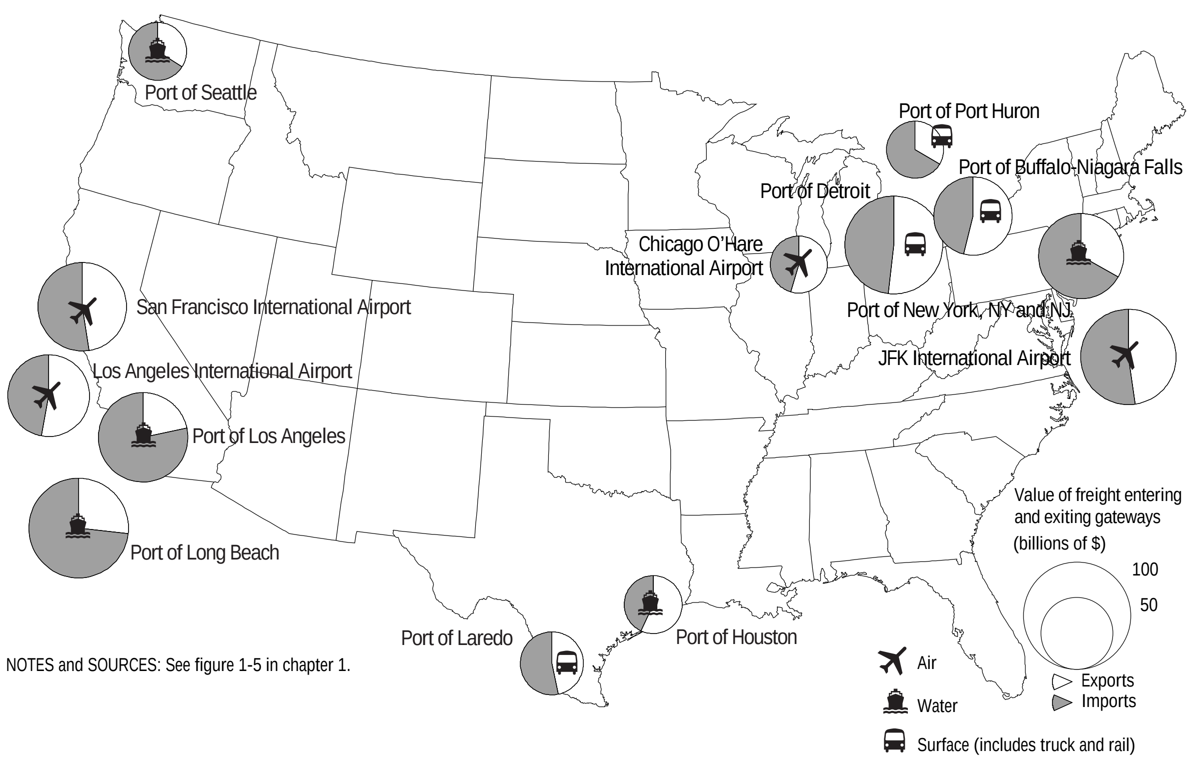
Transportation and the Economy

Transportation plays a vital role in the American economy, providing jobs and income, and supporting economic activity throughout the country. It also generates revenues for all levels of government, which, in turn, spend or invest public funds on transportation, mainly for infrastructure.

In 1996, the United States produced $847 billion of transportation-related goods (e.g., cars

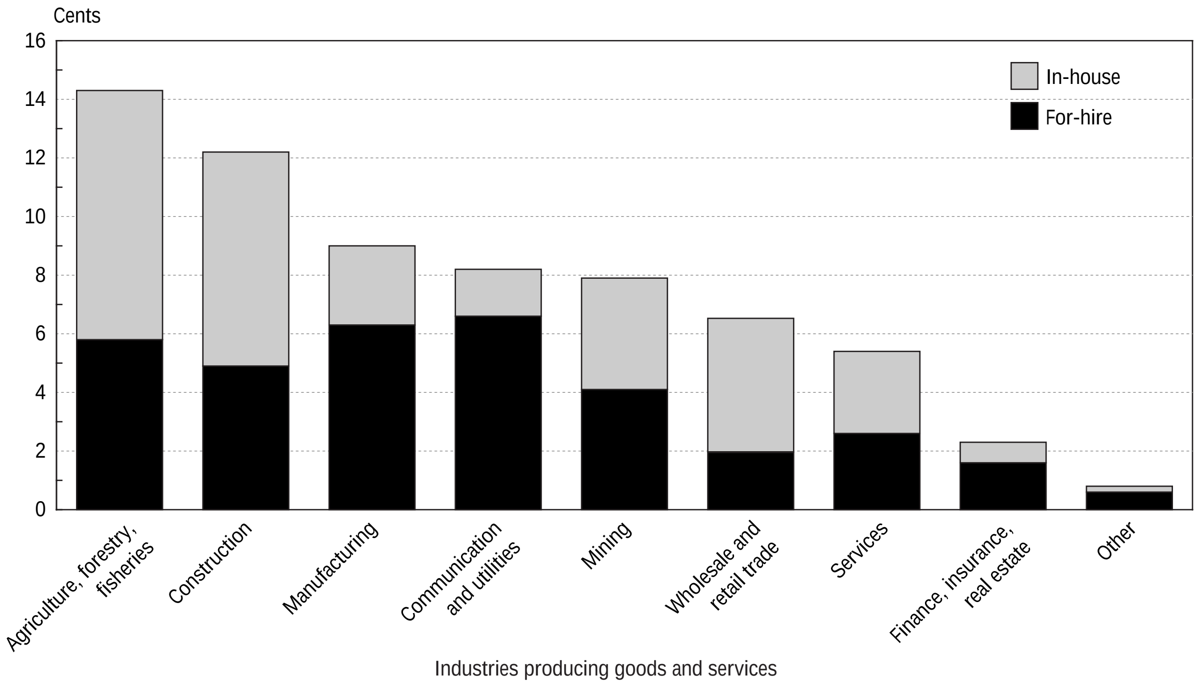
Top Foreign Trade Gateways by Shipment Value: 1996

(Ports with exports/imports exceeding $30 billion, in current $)



NOTES and SOURCES: See figure 1-5 in chapter 1.

Cost of Transportation Services in a Dollar of Purchases by Consumers and Other End-Users: 1992



SOURCE: See figure 2-3 in chapter 2.

and gasoline) and services (e.g., trucking and auto insurance), some of which were exported. This amount, called "transportation-related final demand," represented about 11 percent of the Gross Domestic Product (GDP).

This demand measure is one of the broadest indicators of transportation's role in the economy. Since 1991, transportation has ranked fourth among the six major societal functions in the magnitude of final demand, behind housing, health care, and food, and ahead of education.

A narrower measure is the value-added by transportation services, both for-hire and in-house. This supply measure is comprised only of services that move people and goods on the transportation system. Until now, national measures of transportation services only counted the value of for-hire transportation services, ignoring the sizable contribution of in-house transportation by nontransportation firms. For example, many retail companies use their own truck fleets to move goods from their warehouses to their retail outlets. A new accounting tool, called the Transportation Satellite Accounts (TSA), now provides a way to measure both for-hire and in-house transportation services. The TSA was developed jointly by BTS and the Bureau of Economic Analysis of the Department of Commerce.

Together, in-house and for-hire transportation services contributed about $313 billion, or 5 percent of the value generated by the U.S. economy in 1992. This is roughly comparable to the value-added by the wholesale/retail trade or health industries. Trucking alone accounts for 65 percent of the total value-added of transportation services.

The inclusion of in-house transportation reveals that transportation's impact on the production of goods and services is greater than previously documented. For example, 14¢ of every dollar of agricultural output is attributable to transportation—more than twice the previous estimates based on for-hire services only. This shows that the costs of goods and services are more sensitive to transportation costs.

Transportation's economic importance is felt strongly by consumers. In 1995, the average American household spent about $6,000 on transportation—nearly one-fifth of household spending. Historically, households in the West have spent more on transportation than those in other parts of the country, and data suggest that transportation expenditures by rural and urban households have fluctuated over time. Since 1984, however, expenditures in the Midwest and South have increased faster than in the West and Northeast. In 1995, urban household expenditures for transportation went up, while rural expenditures went down. Across the nation, when Americans traveled out of town, well over one-third of their travel expenditures were for transportation.

Government spending on transportation grew steadily between fiscal year (FY) 1984 and FY 1994. In FY 1994, federal, state, and local governments spent a total of $124.5 billion, or 1.8 percent of GDP, on the nation's transportation system. In contrast, transportation revenues for all levels of government for FY 1994 were $86 billion. Between FY 1984 and FY 1994, however, government transportation revenues grew by 6.2 percent annually on average.

Highways continued to get the dominant share of funds from 1984 to 1994, but spending on transit increased at a higher rate than other modes. Highways generated the most government transportation revenues in FY 1994 (about 71 percent of the total). In the same year, a very large portion (93 percent) of federal revenues was given to states and localities as grants, of which more than three-quarters went to highways and 15.8 percent to transit.

A large portion of government transportation expenditures is concentrated on investment, particularly for infrastructure. From FY 1984 to FY 1994, government investment in transportation doubled, and investment in infrastructure grew 7.4 percent a year. In FY 1994, about 84 percent of investment funds were spent on infrastructure, and the remainder on equipment. Investment in air transportation grew the fastest, tripling in amount during the 1984 to 1994 period. Government investment in transit infrastructure also increased significantly during the 10-year period to 9.1 percent annually.

Employment and labor productivity are also indicators of transportation's importance to the economy. Between 1986 and 1996, the number of persons employed in for-hire transportation industries grew by 2.8 percent annually, compared with the 1.6 percent annual growth rate for total U.S. employment.

Transportation Safety

Transportation crashes and accidents claimed the lives of 44,505 people in 1996 in the United States, slightly under half of all accidental deaths. Almost 95 percent of all transportation fatalities involved motor vehicles. Although estimates are approximate, roughly 3.5 million people were injured in highway crashes in 1996.

Of the 2,600 transportation fatalities in 1996 that were not highway vehicle-related, more than half (1,340) involved recreational boating and general aviation (e.g., private planes for individual and business use). Combined, commercial passenger carriers (airlines, trains, waterborne vessels, and buses) accounted for about 1,200 fatalities. This count includes more than 500 bystanders and others outside vehicles.

Despite the high toll, most transportation modes are safer today than they were three decades ago. Highway fatalities have declined from their high point in 1972, and the 1996 fatality rate (1.7 fatalities per hundred million vehicle-miles) is about one-third the level reported in the late 1960s. Commercial airline travel is also much safer, with fatalities per hundred thousand trips far below their 1970 level.

As total travel continues to increase, indicators of improved safety have leveled off. The number of highway fatalities has risen from its recent low in 1992, and fatality rates show little or no improvement. Similarly, commercial aviation rates (when adjusted for year-to-year fluctuation) have been flat for even longer.

As discussed in chapter 3, transportation crashes may have multiple causes, making it difficult to isolate a single factor. Human factors are implicated in a high proportion of crashes or accidents in many modes, but often in combination with another factor. For example, between 1985 and 1994, human factors were present in 90 percent of crashes, and equipment failures accounted for 38 percent of crashes of all major air carriers.

Clearly, many fatalities and injuries arising from motor vehicle crashes could have been prevented. In 1996, more than 17,000 people died in alcohol-related motor vehicle crashes (i.e., a driver in either vehicle or a fatally injured nonoccupant had some alcohol in their blood). About 36 percent of pedestrians aged 14 or older and 30 percent of drivers killed in motor vehicle crashes were intoxicated (with a blood alcohol count of 0.10 or more). Exceeding the speed limit or driving too fast for conditions was a factor in 30 percent of fatal crashes. Only about two-thirds of Americans use safety belts, despite evidence that safety belt use saves lives and reduces injury severity in crashes.

Safety issues and demography interact in complex ways. Last year's safety chapter focused on children using the U.S. transportation system. This year, the chapter features safety and older Americans, especially those over 70 years of age. As the population ages, it is probable that there will be more older drivers than ever before. Older Americans continue to have a great need for mobility even after they leave the labor force. With the dispersion of housing, shopping, and services that has accompanied suburbanization, traditional transit options are often not practical for many older Americans, most of whom continue to live in places where they brought up their children. Hence, they must provide for their own mobility, unless new, more flexible alternatives become available.

Energy and the Environment

► Energy

Transportation energy consumption is determined by two factors: activity level and energy efficiency. For example, highway vehicle-miles increased 3.2 percent annually between 1970 and 1996. Vehicle fuel economy gains, however, have leveled off. Although new passenger car fuel economy increased dramatically after the 1973–74 oil price shock, only slight new car economy gains were realized after 1982, and no significant gains have been realized since about 1987.

Rail and aircraft efficiency have improved steadily over the past few decades, but these advances have had little overall effect because of highway vehicles' (especially light-duty passenger vehicles) dominating share of energy use. Light-duty passenger vehicles consumed more than 60 percent of all transportation-related energy in 1996.

Minimal gains in highway vehicle efficiency prevail in spite of rapid development of vehicle and engine technologies over the past decade.

Fuel-injected engines, lockup torque in transmissions, four-valve engines, and other technologies have been used to produce vehicles that are heavier and more powerful without lowering efficiency. Increased light-duty truck purchases have tended to offset efficiency gains, because these vehicles are considerably less efficient than passenger cars.

Increases in U.S. energy demand and declines in U.S. oil production have led to continued dependence on oil from foreign countries. In 1997, the United States imported 8.95 million barrels per day of crude oil and petroleum products, slightly more than the previous record high reported in 1977. About 53 percent of U.S. demand is supplied by relatively secure Western Hemisphere countries. The Organization of Petroleum Exporting Countries (OPEC)—the group of oil producing countries that cooperated in the 1970s to force up world oil prices—controls about 42 percent of the world's oil supply.

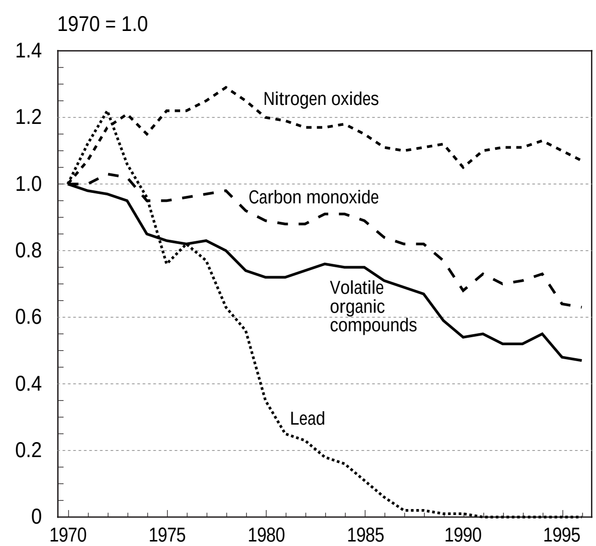
The less dependent the United States is on petroleum, the smaller the impact rapid price increases would have on the economy. Transportation's oil demand, which accounts for approximately two-thirds of total U.S. petroleum consumption, is less price elastic than other economic sectors. While other sectors of the economy have reduced oil use, transportation currently consumes more petroleum today than in 1973. In fact, more than 95 percent of transportation's energy comes from petroleum. Thus, the nation's dependence on imported petroleum is more than ever a result of transportation's reliance on oil. The small fraction of energy from other sources is growing, primarily from efforts to reduce air pollutant emissions—yet it appears that transportation will remain petroleum dependent for some time to come.

► Environment

Transportation activity, energy use, and infrastructure produce negative impacts on the environment. Air pollution is the most evident impact, although transportation also results in water and noise pollution, solid wastes, and damage to wildlife habitat and ecosystems. In addition, transportation produces greenhouse gas emissions, which have the potential to contribute to global climate change.

Largely due to engine emissions control technologies, efforts to reduce several key air pollutants from transportation have been quite successful. Overall estimated emissions decreased (substantially in some cases) between 1970 and the present, despite an approximate doubling of transportation activity. Transportation-related lead emissions have been virtually eliminated. The reduction in transportation air pollution has contributed to the steady improvement in the nation's air quality over the past two and a half decades.

Selected Transportation Air Emissions Index: 1970–96



SOURCE: See figure 4-8 in chapter 4.

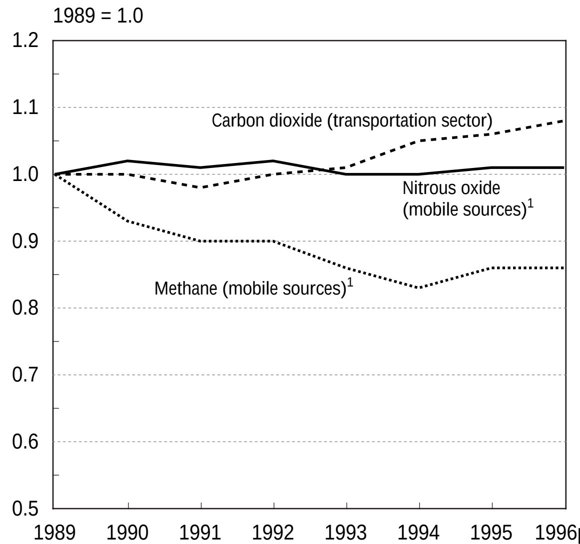
In 1997, the Environmental Protection Agency (EPA) tightened national ambient air quality standards for particulate matter and ground-level ozone, citing recent research on the negative health effects of very fine particulate matter (PM) and ozone at lower exposure levels than previously realized. Currently, it is unclear to what extent these new PM and ozone regulations will affect transportation-related sources.

Over the last two decades, a major effort has been made to reduce the exposure of people in neighborhoods that surround commercial airports to aircraft noise. Exposure to day-night airport noise levels of 65 decibels or greater decreased from 7 million persons in 1975 to 1.7 million in 1995, despite a 75 percent increase in commercial aircraft departures during the same period. These reductions are due to increasingly stringent aircraft noise certification standards.

The use of ethylene and propylene glycols to deice and anti-ice runways and aircraft have prompted environmental concerns in recent years. At least half or more of the glycols sprayed on aircraft fall to the ground where they may enter stormwater drains, seep into the ground, or mix with snow moved off the pavement. These highly soluble chemicals increase the biological oxygen demand of receiving waters and threaten oxygen-dependent aquatic life, and ethylene glycol is toxic to mammals at relatively low concentrations.

Recycling continues to be an important way to reduce solid waste generation from transportation vehicles, parts, and infrastructure. New applications and technologies for recycling scrap tires have significantly decreased the number of these tires that are added to stockpiles or landfills or dumped illegally. About 250 million tires are scrapped annually in this country. Other parts of highway vehicles are also routinely recycled or refurbished and reused. Highway pavement, guardrails, and signs are also being recycled in varying amounts by states, and most of the rail infrastructure is recycled or reused. Although the amount of aircraft recycling is unknown, scrappage rates are much lower than that of automobiles.

Transportation-Related Greenhouse Gas Emissions Index: 1989–96



[1] Mobile sources include emissions from farm and construction equipment, in addition to transportation sources.

KEY: p = preliminary.

SOURCE: See figure 4-7 in chapter 4.

Mounting concern exists about anthropogenic releases of greenhouse gases (GHGs), primarily in the form of carbon dioxide (CO_2), from the combustion of fossil fuels and their potential to contribute to global climate change. The transportation sector accounted for about one-third of total CO_2 emissions from anthropogenic sources in the United States since 1990.

In 1997, representatives of 159 countries meeting in Kyoto, Japan, reached an international agreement on reducing GHGs. Many issues remain unsettled and the U.S. Congress must ratify the agreement before it becomes binding. There are many ways to reduce GHG emissions, some of which (such as improving vehicle efficiency or use of alternative fuels that contain less carbon) involve transportation.

Finally, transportation and land use interact in complex ways. Transportation improvements often lead to urban sprawl, which also can increase the demand for transportation relative to more compact development patterns. The interactions between transportation and land use are poorly understood and difficult to quantify.

The State of Transportation Statistics

Data-collection efforts since 1991 have filled many of the key transportation information gaps decisionmakers faced when BTS was created, but critical challenges remain. Moreover, the speed of technological, economic, and social change has increased the pressure for more timely and more geographic and demographic-specific data. Also, concerns about public sector accountability, most notably through the Government Performance and Results Act of 1993,[1] have created demands for information on the performance of the transportation system and how transportation performance is affected by government programs.

The complete picture of the transportation system and its consequences requires accurate and comprehensive information on freight activity, passenger travel, and vehicles; transportation facilities and services; and pertinent economic, safety, energy, and environmental data. The information gaps for each of these topics are summarized in chapter 5, and treated more fully in the BTS report, *Transportation Statistics Beyond ISTEA: Critical Gaps and Strategic Responses.*

With the enactment of the Transportation Equity Act for the 21st Century (TEA-21)[2] in June 1998, Congress added several new topics and functions for BTS to pursue in the coming years. The concluding section of chapter 5 briefly highlights the Bureau's new mandates under TEA-21.

PART II: LONG-DISTANCE TRAVEL AND FREIGHT MOVEMENT

Few conveniences of modern life are so taken for granted as transportation. Even in small towns, Americans can buy fresh fruits and vegetables in midwinter, send packages across the country for overnight delivery, or fly from coast to coast to celebrate a holiday with relatives and return home the next day. U.S. businesses are able to draw on supply and distribution networks that are global in scope. Among working couples, it is not uncommon for a spouse to take a new job hundreds or even thousands of miles from home, frequently returning home for a long weekend until the other spouse finds employment at their new location. These developments, unheard of a century ago, are now so ordinary that they come to public attention mostly when an unexpected disruption—a dramatic snowstorm or a breakdown in the system—delays accustomed movements from one place to another, prompting television crews to interview travelers stranded at airports or film traffic halted on a road.

The great mobility and access to goods that Americans enjoy would not be possible without the advanced transportation network that has developed in the United States. This national system links all regions, connecting small and large cities, and urban and rural areas. The importance of this national network is highlighted by the statistics on long-distance travel and nonlocal freight shipments discussed in detail in Part II.

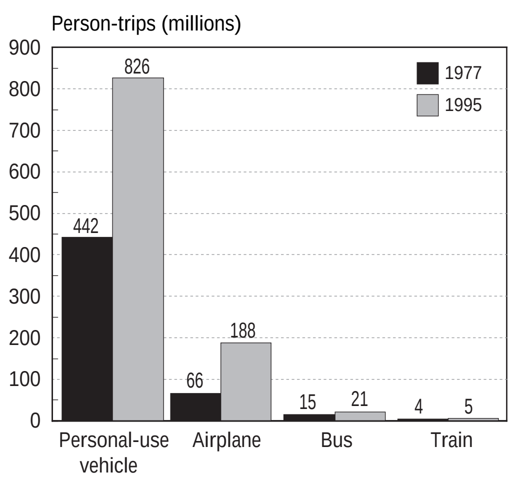
[1] Public Law 103-62, 107 Stat. 286 (1993).
[2] Public Law 105-178, 112 Stat. 107 (1998)

Long-Distance Travel in the United States

Long-distance travel has grown phenomenally over the past 20 years. The American Travel Survey shows that, in 1995, Americans traveled 827 billion miles domestically on over 1 billion long-distance trips (those more than 100 miles from home). This was nearly twice the number of trips taken in 1977 (the last year for which comparable data are available) and more than twice the 1977 travel-miles. Americans averaged about 4 long-distance roundtrips in 1995, compared with 2.4 trips in 1977, and these trips accounted for more than one-fifth of all passenger-miles traveled. Individuals averaged over 3,100 miles on domestic long-distance trips in 1995, up from 1,700 in 1977.

The increase in long-distance trips has been spurred by such factors as income growth, greater vehicle availability, an increase in the number of married couples without children, and, to a small extent, growth in the number of people in age cohorts that are most likely to travel. Other factors, like increasing regional economic interdependency and lower airfares, have also contributed to the growth of long-distance travel.

Long-Distance Trips by Mode: 1977 and 1995



SOURCE: See figure 6-2 in chapter 6.

Long-distance travel is concentrated in several markets. Intraregional travel includes trips under 500 miles one way. Concentrations of such trips include major linear corridors (e.g., Northeast, California, Pacific Northwest), triangles (Florida and Texas), and local hubs (such as around Atlanta). Interregional trips range in length from 500 to 1,500 miles one way. Some of the largest interregional flows are from the Northeast corridor to Florida (particularly to Miami, Orlando, Tampa, and West Palm Beach), Chicago, and Atlanta; from California to the Pacific Northwest; and from Chicago to Texas. There are several transcontinental markets between places that are more than 1,500 miles apart one way. The largest markets are those between New York and California (Los Angeles and San Francisco). The top 10 city pairs are shown in the box below.

Cars, light trucks, and recreational vehicles are the dominant means of transportation for long-distance trips, reflecting their widespread availability and the relatively low operating costs (once a vehicle is purchased and insured). In 1995, they accounted for about 80 percent of person-trips, about the same as in 1977. Air travel, the second most popular means of transportation, grew in market share, accounting for 18 percent of trips in 1995, up from 12 percent in 1977.

Top 10 Long-Distance Travel Flows

Between		Person-trips
Los Angeles	San Diego	10,467,000
Las Vegas	Los Angeles	9,120,000
New York	Philadelphia	8,476,000
New York	Washington, DC	7,773,000
Los Angeles	Los Angeles	7,575,000
Los Angeles	San Francisco	7,050,000
Sacramento	San Francisco	5,338,000
New York	New York	5,202,000
Philadelphia	Washington, DC	4,679,000
Dallas	Houston	3,097,000

Long-distance trips taken for social (i.e., non-business) reasons, outnumber business trips, but the relative importance of business trips has increased. Moreover, a greater proportion of social trips are consumption-oriented (e.g., vacations, attendance at sports events, or shopping). As a result, the economic impact of long-distance travel has increased over the past two decades.

Holiday travel places the most concentrated demand on the passenger transportation system. On the Sunday after Thanksgiving in 1995, for instance, Americans made 13.7 million long-distance trips, compared with the annual daily average of 5.5 million. Nearly all of the Sunday after Thanksgiving trips were made by automobile (about 11.5 million) or air (nearly 2 million).

With the near doubling in number of trips since 1977, travelers are spending far more nights away from home, an important fact for hotels, restaurants, and many other businesses. In 1995, the number of person-nights spent in hotels, motels, bed and breakfast establishments, or resorts was 1.3 billion, 600 million more than in 1977. Still, people are more likely to stay overnight with friends or relatives.

More than half of domestic long-distance trips in 1995 were made to out-of-state destinations. Not surprisingly, states with large populations attracted and generated the most long-distance travel. People living in less populated states make the most long-distance trips per capita. Tripmakers in western states with large land areas travel the most miles. People in highly urbanized, eastern states and in poorer states take comparatively few trips.

Access to transportation—whether geographical, financial, or physical—is not uniform, and as a result mobility outcomes vary by social and demographic group. Higher income people can afford to purchase more transportation, and also may have more opportunities for vacations and other leisure activities involving long-distance travel. People in households earning more than $50,000 a year made 6.3 long-distance trips on average in 1995, four times the 1.6 trips made on average by people in households earning less than $25,000.

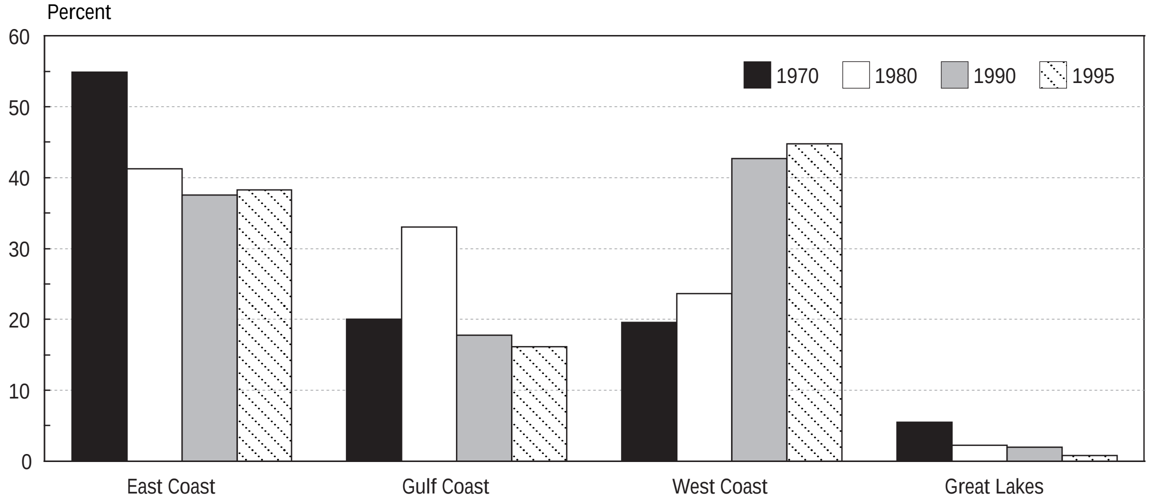
Women traveled less than men in 1995, taking, on average, 3.5 domestic trips covering 2,900 miles compared with men's 4.5 trips covering 3,700 miles. The disparity between the sexes is virtually unchanged since 1977, because long-distance travel has grown at the same rate for both groups. Women, therefore, continue to account for about 45 percent of all long-distance trips and person-miles.

In 1995, whites made more than twice the number of long-distance trips as blacks (4.4 person-trips per capita versus 1.9) and twice as many as Hispanics (2.2 trips per capita). The disparity appears to have declined as tripmaking by some minority groups increased faster than that by whites between 1977 and 1995.

Among age groups, people aged 45 to 54 showed the highest propensity to travel, taking 6 trips per capita, followed by those 55 to 64, and 35 to 44. The youngest (under 18) and oldest (75+) members of the population traveled the least. All age cohorts traveled more in 1995 than in 1977, but the travel behavior of different age cohorts has changed quite dramatically over this period.

Future trends in long-distance travel will depend on many factors, including demographic change, income growth, and economic change. A key question is how much and by what means the growing elderly population will travel, particularly after 2010 when the first baby boomers reach 65. Travel by medium- and low-income households can be expected to grow if their income grows or if the price of transportation falls relative to income. Women's long-distance travel could grow relative to men, depending on such factors as earnings, family

Regional Shares of Oceanborne International Trade by Shipment Value: 1970–95



SOURCE: See table 7-6 in chapter 7.

size, business travel, and the number of single-parent families headed by women.

Long-Distance Freight Transportation

Freight shipments of more than 100 miles account for over 91 percent of the ton-miles moved in the United States. U.S. domestic establishments covered in the Commodity Flow Survey (CFS) shipped materials and goods weighing over 12 billion tons and generated over 3.6 trillion ton-miles on the nation's freight transportation system in 1993. Because of the robust U.S. economy, these shipments are likely to have grown in the intervening years.[3]

Ton-miles have risen greatly since 1970, because of increased tonnage moved over longer distances, growth in the domestic economy, changes in supply-chain and production systems, and increases in international trade. International trade has affected transportation activity within the United States in many ways, such as geographic shifts in the direction of some domestic freight flows.

U.S. businesses appear to be shipping more freight over longer distances. Factors affecting this increase include, among others, geographic dispersion of production activities, more use of centralized warehouses and distribution centers to improve supply- chain efficiency, reliance on imported parts for high-value manufactured products, and adoption of global marketing strategies by many companies. It is not unusual today for dozens of companies at far-flung locations to be involved in the production, assembly, marketing, and sales of products. Often, each step in the process requires transportation over appreciable distances, thus generating a large number of ton-miles.

Reliable freight transportation enables connections between businesses and suppliers and markets throughout the United States, and facilitates regional specialization. For example, lumber and wood production is highly concentrated in the Pacific Northwest and southeastern states, while transportation equipment is concentrated in East North Central and Pacific states. Inexpensive

[3] The Commodity Flow Survey was repeated in 1997. Information from this latest survey is scheduled to become available beginning in the Fall of 1998 and will be presented in *Transportation Statistics Annual Report 1999*.

freight transportation also can help regions attract new business, such as motor vehicle assembly plants in southeastern states.

Growth in international trade directly impacts domestic freight activity and places demands on the nation's transportation system for access to ports and connections to the interior. A few countries maintain a large share of total U.S. trade, and thus have a larger impact on domestic freight activity. In 1997, Canada and Mexico accounted for nearly one-third of U.S. goods trade. Since the signing of the North American Free Trade Agreement in 1994, land freight movements between the United States and Canada and Mexico have increased. In 1996, over $410 billion worth of goods moved by land between the three countries, an increase of 21 percent since 1994.

PART I:

The State of the Transportation System

The Transportation System

In 1996, the U.S. transportation system supported 4.4 trillion miles of passenger travel and 3.7 trillion ton-miles of goods movement (USDOT BTS 1998). This incredible mobility is made possible by a vast transportation system of over 5.5 million miles of road, railroads, waterways, and pipelines; over 5,000 public-use airports and nearly 13,000 private airports; and more than 230 million motor vehicles, railcars, aircraft, ships, and recreational boats (see table 1-1). 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*. This year's report profiles in detail water transportation and international freight and passenger gateways. The chapter concludes with a discussion of selected transportation events that occurred in 1997: flooding in the Upper Midwest, labor strikes (involving the United Parcel Service and Bay Area Rapid Transit Authority), and rail freight service problems.

PASSENGER TRAVEL

The results of two major surveys conducted in 1995—the American Travel Survey (ATS), which focused on intercity travel, and the Nationwide Personal Transportation Survey (NPTS), which focused on local travel—confirm that passenger travel continues to grow. The ATS estimates that long-distance travel (trips over 100 miles one way) nearly doubled between 1977 and 1995 and that miles traveled

Table 1-1.
Major Elements of the Transportation System: 1996

Mode	Major 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* [2] 46,036 miles of Interstate highways 112,467 miles of other National Highway System roads 3,760,947 miles of other roads *Vehicles and use* 130 million cars, driven 1.5 trillion miles 69 million light trucks, driven 0.8 trillion miles 7.0 million commercial trucks with 6 tires or more, driven 0.2 trillion miles 697,000 buses, driven 6.5 billion miles
Air	Airways and airports; airplanes, helicopters, and other flying craft for carrying passengers and cargo	*Public-use airports* 5,389 airports *Airports serving large certificated carriers* [3] 29 large hubs (72 airports), 417 million enplaned passengers 31 medium hubs (55 airports), 89 million enplaned passengers 60 small hubs (73 airports), 37 million enplaned passengers 622 nonhubs (650 airports), 15 million enplaned passengers *Aircraft* 5,961 certificated air carrier aircraft, 4.8 billion miles flown[4] *Passenger and freight companies* 96 carriers, 538 million domestic revenue passenger enplanements, 12.9 billion domestic ton-miles of freight[4] *General aviation* 187,300 active aircraft, 3.5 billion miles flown
Rail[5]	Freight railroads and Amtrak	*Miles of track operated* 126,682 miles by major (Class I)[6] railroads 19,660 miles by regional railroads 27,554 miles by local railroads 24,500 miles by Amtrak *Equipment* 1.2 million freight cars 19,269 freight locomotives *Freight railroad firms* Class I: 9 systems, 182,000 employees, 1.4 trillion ton-miles of freight carried Regional: 32 companies, 10,491 employees Local: 511 companies, 13,030 employees *Passenger (Amtrak)* 23,000 employees, 1,730 passenger cars,[7] 299 locomotives,[7] 19.7 million passengers carried[7, 8]

(Continued on following page)

Table 1-1.
Major Elements of the Transportation System: 1996 *(continued)*

Mode	Major elements	Components
Transit[9]	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 heavy 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, the Intracoastal Waterway, and ocean shipping channels; ports; commercial ships and barges, fishing vessels, and recreational boating	*U.S.-flag domestic fleet*[10] Great Lakes: 730 vessels, 58 billion ton-miles Inland: 33,323 vessels, 297 billion ton-miles Ocean: 7,051 vessels, 408 billion ton-miles Recreational boats: 11.9 million[11] *Ports*[12] Great Lakes: 362 terminals, 507 berths Inland: 1,811 terminals Ocean: 1,578 terminals, 2,672 berths
Pipeline	Crude oil, petroleum product, and natural gas lines	*Oil* Crude lines: 114,000 miles of pipe (1995), 338 billion ton-miles transported (1996) Product lines: 86,500 miles of pipe (1995), 281 billion ton-miles transported (1996) 160 companies,[13] 14,500 employees *Gas* Transmission: 259,400 miles of pipe Distribution: 952,100 miles of pipe 20.0 trillion cubic feet, 138 companies, 171,600 employees

1 U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: 1996).
2 Does not include Puerto Rico.
3 Large certificated carriers operate aircraft with a seating capacity of more than 60 seats. U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, *Airport Activity Statistics of Certificated Air Carriers, 12 Months Ending December 31, 1996* (Washington DC: 1997).
4 Preliminary data.
5 Except where noted, figures are from Association of American Railroads, *Railroad Facts: 1997* (Washington, DC: 1997).
6 Includes 891 miles of road operated by Class I railroads in Canada.
7 Fiscal year 1996. Amtrak, *Twenty-Fifth Annual Report, 1996* (Washington, DC: 1997).
8 Excludes commuter service.
9 Data for 1995. U.S. Department of Transportation, Federal Transit Administration, *National Transit Summaries and Trends for the 1995 National Transit Database Section 15 Report Year* (Washington, DC: 1997).
10 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, *Transportation Lines of the United States* (New Orleans, LA: 1998). Ton-miles data from U.S. Army Corps of Engineers, *Waterborne Commerce of the United States 1996* (New Orleans, LA: 1997).
11 U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington, DC: 1996).
12 Data for 1995, from U.S. Department of Transportation, Maritime Administration, *A Report to Congress on the Status of the Public Ports of the United States, 1994–1995* (Washington, DC: October 1996).
13 Regulated by the Federal Energy Regulatory Commission.

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

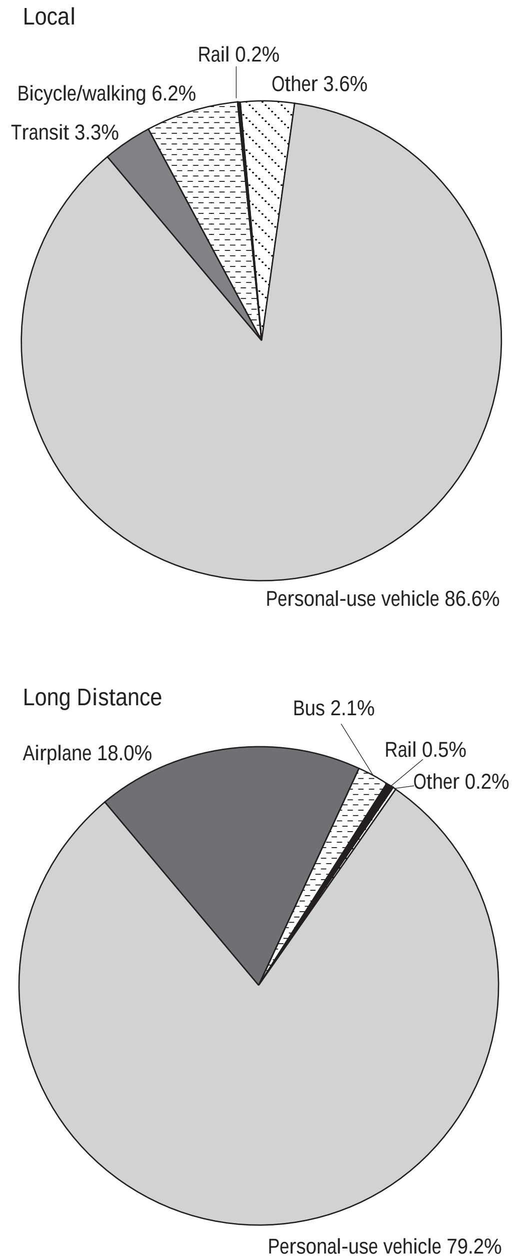
domestically on such trips in 1995 averaged 3,100 per person. The NPTS estimates that the number of all trips (both local and long distance) increased by 43 percent between 1977 and 1995, and that miles traveled per person for all travel in 1995 averaged about 14,000 (USDOT FHWA 1986, 1993, 1997).

Many factors influenced the growth in passenger travel between 1977 and 1995, including a 19 percent increase in population, a 36 percent increase in the labor force, and a 33 percent rise in real disposable income per capita. Higher income contributed in part to the increasing availability of personal-use vehicles (cars, light trucks, and recreational vehicles). While average household size declined from 2.86 to 2.65 between 1977 and 1995, the number of vehicles per household increased from 1.59 to 1.78 (USDOT FHWA 1997). Over that period, the number of vehicleless households declined from 11.5 million to 8 million, with a corresponding increase in households with at least one vehicle. The increase in long-distance travel resulted from these factors and from others such as the decreasing cost of air travel, increasing business travel, and the increasing globalization of production and tourism (see chapter 6).

Most passenger trips are taken in personal-use vehicles (see figure 1-1). The NPTS found that in 1995 on a typical day, about 80 percent of local trips were made by personal vehicles, 6 percent by bicycle or walking, and 3 percent by transit. The ATS found that nearly 80 percent of long-distance trips were made by personal vehicle, 18 percent by air, and 2 percent by bus. Less than 1 percent of both local and long-distance trips were made by rail.

Traveler motivations for taking short- and long-distance trips vary. Short trips are much more likely to be taken for personal business (35 percent of short trips and 14 percent of long trips), and somewhat more likely to be for leisure (37 percent versus 31 percent). Trips to visit

Figure 1-1.
Person Trips by Mode: 1995



SOURCE: U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey data; U.S. Department of Transportation,Bureau of Transportation Statistics, American Travel Survey data, October 1997.

friends and relatives are a much greater share of long-distance trips (33 percent versus 8 percent). Business-related trips (including commuting and business travel) account for about the same proportion of both short and long-distance trips (just over one-fifth of both types of trips).

FREIGHT TRANSPORTATION

Freight transportation in the United States, measured in ton-miles, grew an average of 2 percent annually from 1970 to 1996, when it reached 3.7 trillion ton-miles.

Demand for freight transportation is rising due to the continued expansion of the economy and higher consumer incomes. Freight movement is also affected by the geographic dispersion of people and industry, and changes in business practices. Companies may have manufacturing production, assembly, and distribution facilities in many different locations around the world. Moreover, with improvements in information technologies, a growing number of industries make use of order-cycle time reduction strategies, such as just-in-time, make-to-order, and quick-response freight services. These services result in small and frequent shipments that generate more freight vehicle-miles.

Information from the 1993 Commodity Flow Survey (CFS) shows the dominance of trucking in U.S. freight shipments.[1] Trucks moved 72 percent of freight by value and 53 percent by tonnage.[2] Trucks were particularly important for shipments under 500 miles, accounting for 81 percent by value and 71 percent by tonnage (USDOC Census 1996).

Although rail moved only about 4 percent of shipments measured by value, the commodities moved by rail accounted for 13 percent of all tonnage and 26 percent of the ton-miles, slightly more than the ton-miles moved by trucks. Rail carries not only large, bulk commodities like grain, coal, and mineral ores across the nation, but also time-definite[3] goods such as automobile parts and food and kindred products (e.g., orange juice from Florida to markets in the Northeast).

The Bureau of Transportation Statistics (BTS) estimates that in 1993 waterborne transportation moved 4 percent of shipments by value, and 24 percent of ton-miles, accounting for 18 percent of tonnage. Waterborne freight in the United States is transported between coastal ports, on the Great Lakes, and on inland waterways. (See the section on water transportation later in this chapter for a detailed discussion.) Pipelines carried 3 percent of shipments by value, 16 percent of ton-miles, and 11 percent of tonnage.

Air cargo is an important part of the freight industry, moving high-value time-definite and time-critical[4] goods. Air carrier shipments, which move primarily by a combination of truck and air, accounted for 2.3 percent of the value of shipments in 1993. Some air freight moves by the parcel, postal, and courier services industry, which in 1993 carried over $560 billion worth of shipments, 9 percent of all shipments by value.

Although air freight has a relatively small share of total freight, the share is growing in both domestic and international markets (USDOT BTS 1996). From 1970 to 1996, the revenue ton-miles of domestic air freight grew more than sixfold, reaching 13 billion in 1996

[1] The CFS was conducted again in 1997, but data are not yet available.

[2] These estimates are based on information from the 1993 CFS plus additional information on shipments by water and pipeline not fully covered in the CFS (see USDOT BTS 1996).

[3] Time-definite service means that delivery is guaranteed by a specific time, for instance, tomorrow by 10:00 a.m. or by the close of business on a particular day.

[4] Time-critical service implies that the shipment is urgent and the carrier guarantees as early a delivery time as possible. All time-critical traffic is time-definite, but not all time-definite traffic is time-critical.

(but only 0.3 percent of all ton-miles in that year). Imports and exports shipped by air also grew rapidly, from 11 percent of the value of all international trade in 1970 to 27 percent in 1996 (USDOC Census 1990 and 1997).

TRANSPORTATION NETWORK EXTENT AND USE

Highways

Road building and road widening continue to slowly increase the extent of the public road system and the length of lane-miles open to the public. Since 1980, miles of road increased only 1.5 percent, although lane-miles increased twice as much (3.2 percent) (USDOT FHWA various years). Lane-miles of the higher functional systems (Interstates and other arterials) increased more than lower systems. Interstate lane-miles, for instance, increased 14 percent between 1980 and 1996 (see table 1-2).

The number of vehicles using the highways has increased much faster than the building and widening of roads. There were nearly 50 million more highway vehicles in 1996 than in 1980, a 30 percent increase. Of the 210 million highway vehicles in 1996, nearly one-third—69 million—were light trucks, a far higher proportion than in 1980. Automobiles are still more numerous, however, accounting for 130 million vehicles or 60 percent of the fleet. There were also 7 million freight trucks, 20 percent more than in 1980 (USDOT FHWA various years, v-94). The number of vehicles is indicative of the increasing use of highways, a fact borne out by highway vehicle-miles traveled (vmt) data (see table 1-3). Between 1980 and 1996, urban vmt rose 78 percent and rural vmt rose 43 percent. Urban Interstate vmt increased at the fastest rate over this period—5 percent annually. Nevertheless, arterials other than Interstates still carry the most vmt.

Urban Transit

Urban transit capacity, measured by vehicle-miles operated, increased 13 percent between 1985 and 1995 to nearly 2.4 billion. Although buses experienced the lowest percentage increase during this period (9 percent), they still accounted for about two-thirds of all urban transit

Table 1-2.
Lane-Miles by Functional Class: 1980 and 1996

	1980	1996	Percentage change 1980–96
Total	7,922,174	8,177,823	3.2
Interstate	179,438	204,740	14.1
Other arterials	840,771	982,155	16.8
Collector	1,576,395	1,603,572	1.7
Local	5,325,570	5,387,356	1.2

SOURCE: U.S. Department of Transportation, Federal Highway Administration, table HM-260, unpublished data.

Table 1-3.
Vehicle-Miles Traveled by Functional Highway Class: 1980 and 1996

	1980	1996	Percentage change 1980–96
Urban			
Total	855,265	1,522,139	78.0
Interstate	161,242	351,937	118.3
Other arterials	484,189	833,623	72.2
Collector	83,043	128,501	54.7
Local	126,791	208,078	64.1
Rural			
Total	672,030	960,063	42.9
Interstate	135,084	232,447	72.1
Other arterials	262,774	378,812	44.2
Collector	189,468	241,037	27.2
Local	84,704	107,767	27.2

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

vehicle-miles in 1995. Among transit rail modes, heavy rail had the most vmt (522 million), followed by commuter (217 million) and light rail (34 million). Despite the relatively low number of light rail vehicle-miles operated in 1995, it was more than twice the number operated in 1985 (USDOT FTA various years).

The number of urban transit vehicles in rush hour service increased 5 percent between 1985 and 1995; the number of buses increased by 3 percent from 42,600 to 44,100, and rail vehicles increased 11 percent from 11,800 to 13,100. The largest percentage increases occurred in light rail and commuter rail vehicles, 37 percent and 22 percent, respectively, while heavy rail increased by 4 percent. In addition, route mileage serviced overall increased 14 percent to 163,900 miles in 1995. Of those miles, 96 percent were bus route-miles, 2.5 percent were commuter rail, 1 percent were heavy rail, and 0.3 percent were light rail (USDOT FTA various years).

Unlinked passenger trips decreased between 1985 and 1995 from 8.3 billion to 7.3 billion, but pmt remained the same at about 38 billion. Trips on heavy rail decreased by 9 percent and trips by bus decreased by 16 percent. Light rail and commuter rail both experienced increased ridership over this period, by 56 percent and 28 percent, respectively. Figure 1-2 shows rail and bus pmt for the nation's largest urban transit systems in 1995.

Air Transportation

Certificated airports (serving air carriers that operate with aircraft seating more than 30 passengers) numbered 671 in 1996, down from 730 in 1980. Of the 671 in 1996, 577 were civil airports and 94 were military. General aviation airports numbered 17,621 in 1996. Of all airports in 1996, 5,389 were public-use airports, 575 more than in 1980. The remaining 12,903 were airports not open to the public. These private-use airports include airports associated with among other things hospitals, industrial facilities, farms, and recreational flying. Only about one-third of these had paved runways, and only 6 percent had lighted runways. In 1996, nearly 75 percent of public-use airports had lighted runways and/or paved runways (USDOT FAA various issues).

The number of air carrier aircraft more than doubled since 1980, increasing available seat-miles by 90 percent (Lampl 1997). By contrast the number of general aviation aircraft (planes for private and business use) in 1996 was 187,000, about 15,000 fewer planes than in 1980 (USDOT FAA annual issues).

Air travel on commercial aircraft has increased dramatically. Between 1980 and 1996, domestic enplanements increased from 275 million to 538 million, and enplanements on international flights of U.S. carriers rose from 27 million to 55 million. Passenger-miles on certificated domestic flights increased to 434 billion in 1996, more than twice the 1980 passenger-miles. Enplaned passengers at large hubs[5] increased 40 percent between 1986 and 1996. Over these years the biggest absolute increases in passengers were at Atlanta (+9.0 million), Las Vegas (+8.7 million), Chicago (+8.4 million), Dallas/Fort Worth (+8.3 million), and Los Angeles (+7.1 million). Newark (–1.5 million), Denver (–800,000), and New York (–250,000) lost passengers (USDOT BTS OAI 1996) (see figure 1-3).

Domestic air cargo nearly tripled between 1980 and 1996, from 4.5 billion ton-miles to 12.9 billion ton-miles. International air freight on U.S. carriers grew even more quickly over this period, from 3.4 billion ton-miles to 12.0 ton-miles (USDOT BTS 1998).

[5] A large air traffic hub is a community enplaning 1 percent or more of total enplaned passengers in all services and all operations. An air traffic hub may contain more than one airport.

Figure 1-2.
Largest Transit Markets: 1995

NOTE: Large transit markets are defined as having more than 200 million transit passenger-miles.

SOURCE: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, 1995.

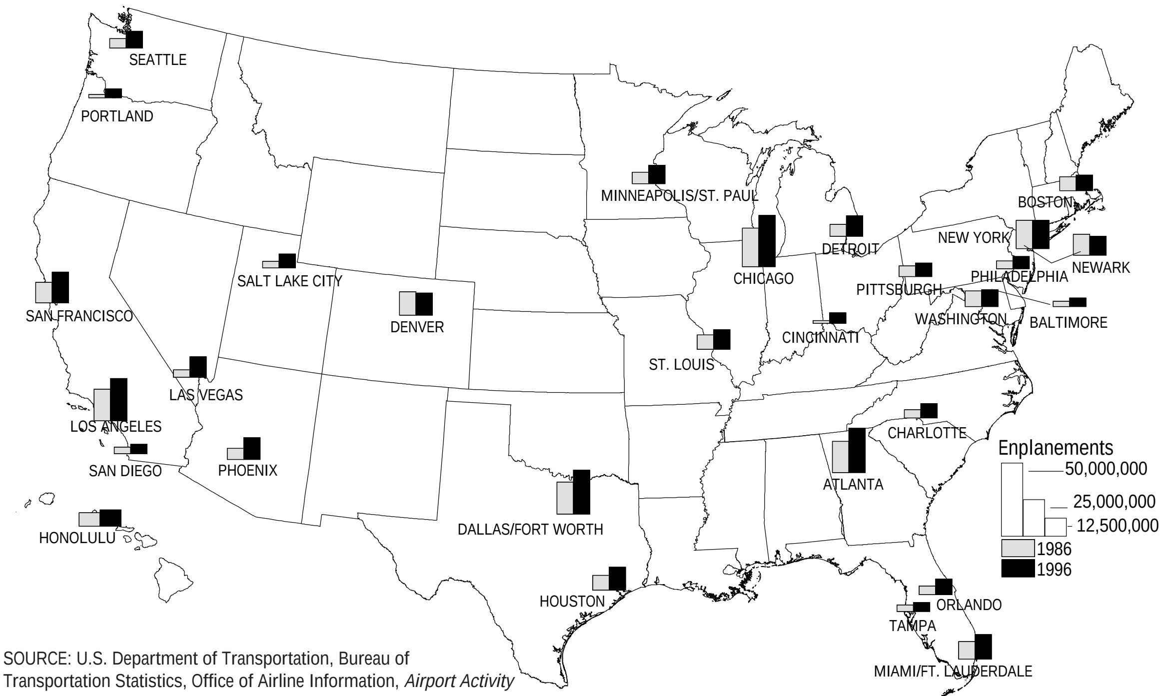
Railroads

The use of railroads to move freight continues its uninterrupted growth since 1986, while the extent of railroad track continues to decline. There were nine Class I freight railroads at the end of 1996, one fewer than in 1995 because of the merger of Southern Pacific and Union Pacific. There were another 543 regional and local railroads, 13 more than in 1995. Rail track continues to decline, while rail stock—locomotives and railcars—continues to increase. Miles of track owned by Class I railroads decreased about one-third, from 271,000 miles in 1980 to 177,000 in 1996. There were 19,300 locomotives in 1996, the most in service since 1988. Similarly, there were 1,241,000 freight cars in service in 1996, the most in service since 1987. Despite less track, revenue ton-miles reached 1.36 trillion in 1996, a 48 percent increase since 1980 (AAR 1997). The geography of freight rail tonnage can be seen in figure 1-4.

Capital expenditures on freight equipment and roadway and structures were $6.1 billion in 1996, much more than in the late 1980s and early 1990s (AAR 1997, 43). In 1990, for instance, capital expenditures were $3.6 billion (in current dollars). The number of employees, however, continues to fall. Year-end Class I, regional, and local freight rail employees totaled 205,000 in 1996, down from 236,000 in 1990. At the end of 1996, there were 182,000 Class I freight rail employees, down from 459,000 in 1980 (AAR 1996 and 1997, 3).

Amtrak operated 24,500 miles of track in 1996, but owned only 750 miles. In fiscal year (FY) 1996, Amtrak served 542 stations, 51 more stations than in FY 1986. (Stations are used for intercity service and may also be used for com-

Figure 1-3.
Enplanements at Major Hubs: 1986 and 1996



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, *Airport Activity Statistics of Certificated Air Carriers: Summary Tables, Twelve Months Ending December 31, 1996* (Washington, DC: 1997)

muter operations.) Amtrak had 299 locomotives in FY 1996, and 1,730 railcars. Capital expenditures in 1996 were $800 million, up from $617 million the previous year (unadjusted for inflation). Employment in 1996 was 23,300, up from 21,400 in 1980. There were about 20 million Amtrak passengers in FY 1996, down slightly from 21 million in FY 1980, although passenger-miles increased over this period from 4.5 billion to 5.1 billion miles. Moreover, Amtrak is now carrying many more commuter passengers, nearly 37 million riders in FY 1996, up from 10 million in FY 1987.

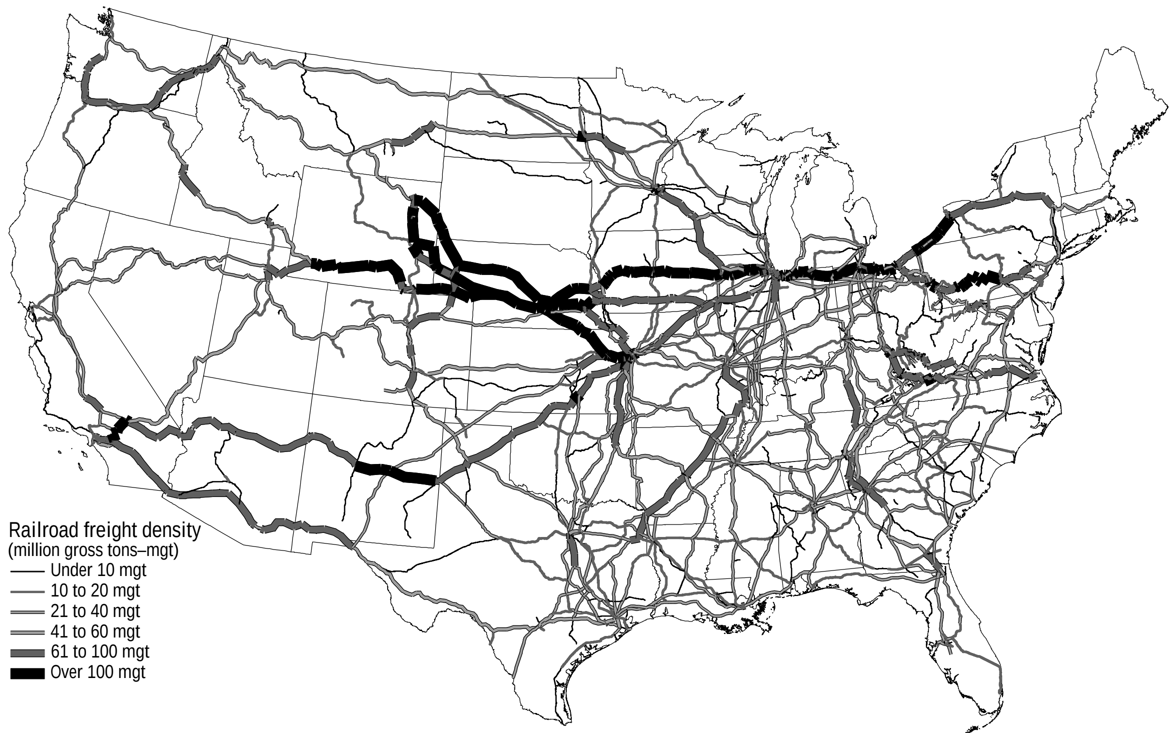
Pipelines

In 1995, oil pipeline mileage, including crude and product lines, was just over 200,000 miles, a decline from the 218,000 miles operated in 1980. Between 1980 and 1996, gas pipeline mileage grew to 1.269 million. All of the growth was in distribution mains mileage (952,000 miles in 1996). Gas transmission pipelines and field and gathering lines declined in length since 1980.

INTERNATIONAL TRANSPORTATION GATEWAYS

The movement of people and goods between the United States and other countries is a growing component of passenger and freight transportation. International passenger travel, excluding surface passage, grew from 56 million to 98 million inbound and outbound passengers between 1986 and 1996, a 75 percent increase. In 1996, 46 million visitors arrived in this country from abroad by air and 52 million U.S. residents left by air for a foreign country, up from 30 million

Figure 1-4.
Railroad Network Showing Volume of Freight: 1996



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

arrivals and 26 million departures in 1986 (USDOC ITA 1998). These numbers, however, do not include millions of people who traveled by land between the United States and Canada and between the United States and Mexico. Limitations in current data-collection programs make it very difficult to estimate the number of people who traveled across the U.S.-Mexican border and most likely seriously undercount travel across the U.S.-Canadian border. Some of these limitations stem from entry and exit rules promulgated by the North American Free Trade Agreement.

International goods movement also increased, more than doubling between 1986 and 1996 from $669 billion to $1,452 billion (in chained 1992 dollars) (USDOC BEA 1998). The growth in the number of international passengers and foreign goods trade requires infrastructure to serve as gateways. This section examines passenger and freight gateways linking North America (Canada and Mexico) and the rest of the world (overseas) for all modes of transportation.

Passenger Gateways

► North America

Canada and Mexico account for the majority of both short-term (day) and long-term (at least one night) passenger travel to and from the United States. In 1995, Canadians made more than 52.2 million trips[6] to the United States. Most (over 70 percent) of these trips

[6] These trips include day and overnight trips by all modes of transportation, and are obtained from customs declarations and travel forms required by Revenue Canada at land border crossings, international airports, and water ports. Comparable data are not available from U.S. government sources.

were same-day excursions. The border states of Washington, Michigan, and New York were the most popular U.S. destinations for Canadians, while Florida led the nonborder-state market. Americans made over 37 million trips to Canada in 1995. As with Canadian travel to the United States, the majority of these (65 percent) were same-day trips (Statistics Canada 1996). The Canadian provinces of Ontario and British Columbia were the leading destinations for Americans.

Canadians made the majority (two-thirds) of their overnight trips to the United States by car, accounting for nearly 10 million trips. Air was second with 22 percent or 3.8 million trips. Buses were used for 750,000 trips, 6 percent of the total (Statistics Canada 1996). One factor contributing to growth in air travel between the United States and Canada is the February 1995 Open Skies agreement.[7] Since the accord went into effect, over 70 new services were added allowing better links and increased capacity for business and leisure markets between the United States and Canada. In 1996, approximately 15 million passengers traveled on scheduled flights of U.S. and Canadian carriers. The busiest bi-directional flight routes were New York-Toronto, Chicago-Toronto, and Los Angeles-Vancouver (USDOT BTS OAI).

The border ports of Detroit and Buffalo were the busiest land gateways for travel by citizens of both countries. On an average day in 1996, approximately 64,000 passengers[8] and 23,000 personal vehicles entered the United States from Canada at the Detroit border (see table 1-4).

As with Canada, most of the travel between the United States and Mexico is in the form of short-term day trips, for business or shopping purposes. Unfortunately, there are no U.S. data on the proportions of short-term versus long-term trips between the United States and Mexico. Data from the U.S. Department of Commerce's Tourism Industries Office on long-term, overnight trips (primarily by air) suggest that approximately 8.5 million overnight visitors from Mexico entered the United States in 1996 (although this is almost certainly a large undercount) (see box 1-1). Due to reporting changes, comparisons cannot be made with data from previous years. Limited data are available on the travel of U.S. residents to Mexico. Estimates from the BTS American Travel Survey indicate

Table 1-4.
Passengers in Personal Vehicles Entering the United States: 1996
(By major North American border crossing)

	Annual passengers	Daily passengers
U.S.-Canada border		
Detroit, MI	23,510,000	64,400
Buffalo-Niagara Falls, NY	16,520,000	45,300
Blaine, WA	11,387,000	32,000
Port Huron, MI	5,392,000	14,800
Sault Ste. Marie, MN	5,325,000	14,600
U.S.-Mexico border		
San Ysidro, CA	42,541,000	129,000
El Paso, TX	41,483,000	114,000
Hidalgo, TX	19,221,000	53,000
Calexico, CA	18,296,000	50,000
Laredo, TX	16,932,000	46,000

NOTE: The number of passengers is based on those in passenger vehicles, and does not include pedestrians or passengers in buses or freight vehicles.

SOURCE: U.S. Customs Service, Mission Support Services, Office of Field Operations.

[7] The agreement allows, among other things: 1) airlines to serve any route between Canada and the United States, except that new U.S. airline service to Montreal, Toronto, and Vancouver is to be phased in; 2) new Canadian airline service from Canadian airports with customs pre-clearance facilities to Washington Reagan National Airport; 3) additional landing and takeoff slots for Canadian carriers at LaGuardia (New York) and O'Hare (Chicago) airports; 5) open code-sharing among Canadian and U.S. airlines.

[8] This number is based on those in passenger vehicles and does not include pedestrians or passengers in buses or freight vehicles.

Box 1-1.
NAFTA and Freight and Passenger Travel

The North American Free Trade Agreement (NAFTA) was signed in December 1993 and entered into force on January 1, 1994. NAFTA established deadlines for the harmonization of land transportation standards among Canada, Mexico, and the United States.

Notable progress has been made in the harmonization of commercial drivers' licenses through mutual recognition of existing bilateral mechanisms and driver medical standards. Several key areas, however, such as vehicle weight and dimension standards, remained unresolved at the beginning of 1998.

NAFTA also set a timetable for truck carrier access to the United States by Mexican carriers. The agreement provided for access to Mexican border states for Canadian and U.S. carriers and for Mexican carrier access to U.S. border states beginning in December 1995. This timeframe has not yet been met. Full liberalization of access for trucking in the United States and Mexico is still scheduled for January 1, 2000.

Most data on the travel of foreign nationals is collected from the Immigration and Naturalization Service (INS) I-94 Entry and Exit Form. One purpose of NAFTA was to facilitate temporary entry on a reciprocal basis between the United States and Canada and Mexico. Under NAFTA, Canadians can travel to the United States, for business or pleasure, without restrictions (i.e., without obtaining nonimmigrant visas) for a period of six months. Mexicans who frequently cross the border can apply for border crossing cards that can be used for admission to the United States for business or pleasure within 25 miles of the southern border for a period not to exceed 72 hours.

The Illegal Immigrant Responsibility Act of 1996 requires INS to develop and implement a system to document the entry and exit of all aliens by September 1998. This law, as currently written, will apply to all Canadians and Mexicans, and will require that they obtain a visa and formally register when leaving or entering the United States. Legislative proposals have been introduced in Congress to remove this requirement for land ports. INS has also notified Congress that it does not have the capacity to implement such a system at land ports by September 1998. INS plans to phase in the system at U.S. airports over several years.

that American residents made 9.6 million trips to Mexico in 1995 (this includes both day and overnight trips of over 100 miles one way).

Comprehensive data are likewise not available on the modal shares of overnight travel by Mexicans to the United States. Vehicle crossing data from the U.S. Customs Service, shows heavy activity at the southern land border ports. In 1996, the top land port on the southern border, San Ysidro (near San Diego), saw more passengers enter on a daily basis than did the busiest international air gateways. Approximately 129,000 passengers entered at San Ysidro on a daily basis in 1996 (see table 1-4).

Despite the limited data on U.S.-Mexican travel, the available sources reveal key trends. One of these is growth in air travel activity between the United States and Mexico. In 1996, scheduled air travel between the two countries increased 18 percent from the previous year, from 11 million passengers to approximately 13 million. The busiest city pairs for air travel were Los Angeles-Mexico City, Los Angeles-Guadalajara, and Miami-Cancun (USDOT BTS OAI).

► Overseas Gateways

Overseas travel (international travel excluding Canada and Mexico) to and from the United States is increasing. In 1996, the United States had approximately 22 million overseas arrivals and 20 million overseas departures (USDOC TIO 1996a and 1996b). After Canada and Mexico, the leading countries for international visitor arrivals to the United States were Japan, the United Kingdom, and Germany. Europe and the Caribbean led overseas destinations for outbound travel, while London and Tokyo led all other overseas cities for travel to and from the United States. In 1996, London was the origin and destination for approximately 12 million passengers traveling from or to the United States, while Frankfurt had 5 million. Several U.S. airports serve as critical gateways and connecting points for international air travel. The major passenger gateways for international air travel to and from the United States (not including North American travel) are New York, Miami, and Los Angeles. In 1996, approximately 62,000 international passengers entered or exited New York airports (Kennedy, La Guardia, and Newark) on an average day, while Miami served 39,000 and Los Angeles served 37,000 (UDOT BTS OAI).

International Freight Gateways

► North America

In 1996, nearly 30 percent by value of U.S. merchandise trade with the world was with Canada and Mexico (valued at $421 billion combined). In that year, Canada and Mexico were the first and third largest trading partners of the United States, respectively (Japan was second).[9]

Surface trade,[10] a key component of North American trade activity between the North American Free Trade Agreement (NAFTA) partners, accounts for 88 percent of all trade by value between the United States and Mexico (USDOC Census 1997, table 1313). Surface trade between the U.S. and Canada was $295 billion[11] in 1996, of which goods transported by trucks accounted for approximately 68 percent or $200 billion (USDOT BTS 1997a).

Detroit, Buffalo, and Port Huron were the leading U.S.-Canadian gateways for trade by all surface modes, and for trade by truck in particular (see figure 1-5). The port of Detroit alone accounted for 28 percent of all the surface trade between Canada and the United States. On an average day in 1996, 3,650 trucks crossed the border at the port of Detroit. Trade by rail remained relatively stable in 1996, at $56 billion or 19 percent of all surface trade. Detroit, Buffalo, and Port Huron are the leading U.S.-Canadian gateways for rail traffic, as well as for trucking. An average of 10 trains per day crossed each of those ports in 1996. Pipelines carried $13 billion, or 4 percent.

The primary commodities traded by surface modes between the United States and Canada in 1996 were in order of greatest value: motor vehicles and related parts; nuclear reactors, boilers and related machinery; electrical machinery and equipment; aircraft and aircraft parts; and mineral and fuel oils.

U.S.-Mexican surface trade was $115 billion in 1996 (USDOT BTS 1997a), about 40 percent as great as trade with Canada but up 19 percent from 1995. Trucks dominate U.S.-Mexican trade to an even greater extent than U.S.-Canadian trade, accounting for 80 percent in 1996, or $92 billion. The dominant gateway port on the southern border is Laredo, Texas (see figure 1-5). In terms of value, 34 percent of all U.S.-Mexican trade passed through Laredo. An average of 2,800 trucks and 9 trains crossed the border at Laredo each day in 1996. El Paso, Texas, and Otay Mesa/San Ysidro, California, followed Laredo with $23 billion and $11 billion in overall surface trade activity, respectively. Following Laredo, the top rail port was Eagle Pass, Texas, with an average of four train crossings per day, totaling $4 billion of rail trade in 1996.[12] The primary commodities traded by surface modes between the United States and Mexico include

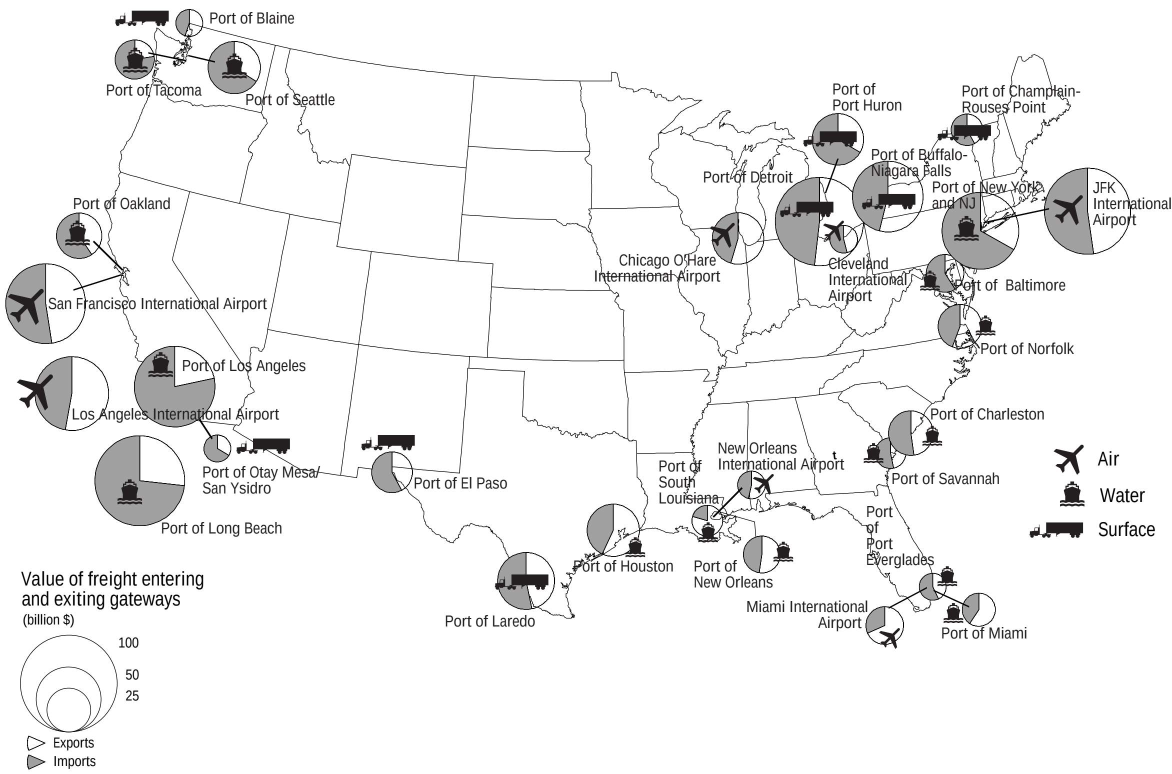
[9] Preliminary data for calendar year 1997 indicate that Mexico may surpass Japan as the second largest U.S. trading partner.

[10] Surface modes of transportation include truck, rail, pipeline, government mail, other, and foreign trade zones. *Other* includes flyaway aircraft (aircraft flown from the manufacturer to a customer, not carrying any freight), powerhouse (electricity), vessels moving under their own power, pedestrians carrying freight, unknown, and miscellaneous other.

[11] Includes transshipments. See footnote 15 for a definition of transshipments.

[12] The Kansas City Southern and Union Pacific Railroads in consortia won concession rights to recently privatized rail lines in northeast and northwest Mexico. Because of this, overall rail trade between the United States and Mexico at Laredo and Eagle Pass, Texas, may increase.

Figure 1-5.
Top Freight Gateways by Shipment Value: 1996



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

SOURCES: Air—U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division, special tabulation. Maritime and Great Lakes—U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division, *U.S. Waterborne Exports and General Imports: Annual 1996* (Washington, DC: July 1997). Surface—U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight Data, 1997.

electrical machinery, motor vehicles and parts, plastics, optical and medical equipment, and food and beverages.

U.S. air trade with Canada and Mexico was $23 billion ($19 billion with Canada and $4 billion with Mexico), or 6 percent of all U.S. air trade by value in 1996. In terms of weight, North American air traffic amounted to 350,000 tons, or 7 percent of total foreign air freight activity for 1996 (USDOC Census FTD 1997a). The dominant North American air freight routes that year were Miami-Mexico City, Los Angeles-Mexico City, and Dayton-Toronto.

Maritime trade between the United States and Canada or Mexico in 1996 was about $19 billion, with U.S.-Canada trade valued at $7 billion or 1.2 percent of all U.S. waterborne trade, and trade between the U.S. and Mexico valued at $12 billion or 2 percent (USDOC Census FTD 1997a). Trade between U.S. Great Lakes ports and Canada was nearly 35 million tons in 1995. In 1996, 36 million tons of cargo were moved on the U.S.-operated portion[13] of the St. Lawrence Seaway System (USDOT SLSDC 1997). (The St. Lawrence Seaway is a maritime gateway between the U.S. and Canada and other international markets.) The majority of these commodities were grain, iron ore, steel products, and coal. Demand for agricultural exports as well as the availability of alternative routes and modes for shippers are two factors that affect traffic levels on the Seaway.

► Overseas Gateways

Two-thirds of the value of freight traded is with countries other than Canada or Mexico, worth about $995 billion. Of this amount, 60 percent is moved by sea and 40 percent by air. Maritime trade, both imports and exports, represented $594 billion in 1996[14] (USDOC Census FTD 1997b). The nature of this maritime trade and the associated maritime gateways differ in a number of ways. Gulf ports lead other U.S. ports in foreign tons of all cargo shipments; agricultural, petroleum, and other bulk commodities form the majority of import and export shipments for many of these ports. The container ports on the west and east coasts are the most important gateways by value.

Long Beach and Los Angeles are the most important ports for containerized trade by weight, 20-foot equivalent units (TEUs), and by value. Containerized shipments account for the majority of foreign maritime trade for both of these ports. For example, in 1996, 92 percent of the value of all foreign trade at the port of Long Beach was containerized (2.4 million TEUs). Los Angeles handled 1.9 TEUs in 1996 (USDOC Census FTD 1997b). Other west coast ports such as Seattle (900,000 TEUs), Oakland (800,000 TEUs), and Tacoma (500,000 TEUs) also represent important containerized traffic gateways for shipments to and from leading Asian trade partners such as China, Japan, and South Korea. On the east coast, the ports of New York-New Jersey and Norfolk are the leading gateways for all types of cargo, including containers, 1.5 million and 700,000 TEUs, respectively. Charleston (800,000 TEUs), Miami (500,000 TEUs), and Savannah (450,000 TEUs) are high on the list of east coast container gateways (*Journal of Commerce* 1996).

Despite the comparatively low overall levels of maritime trade between the United States and Canada, the transshipment[15] of Canadian container traffic through U.S. ports (e.g., Tacoma, Seattle, New York-New Jersey) and the transshipment of U.S. container traffic through east coast Canadian ports (e.g., Montreal and Saint John) are notable. In 1995, transshipment of U.S. maritime cargo through Canadian ports accounted for approximately 4.3 percent of the value of total liner traffic,[16] or 5.8 million short tons (worth $20 billion) with a U.S. origin or destination (USDOT MARAD 1995). According to Canadian estimates, the 5.8 million short tons represent approximately 35 percent of total container movements through all Canadian ports. European countries were the main origins and destinations of U.S. container traffic transshipped through Canada. Transshipment of Canadian container traffic through the United States amounted to approximately 22 percent of total traffic with Canadian origins or destina-

[13] The U.S. St. Lawrence Seaway Development Corporation operates two of the Montreal-Lake Ontario locks of the Seaway.

[14] Does not include data for in-transit shipments—those shipments moving from one foreign country to another and transshipped (see footnote 15) via land, air, or maritime ports of the United States, Puerto Rico, or the Virgin Islands.

[15] As used in this chapter, transshipments are shipments entering or exiting the United States by way of Customs ports on the northern or southern borders, even when the actual origin or final destination of the goods is other than Canada or Mexico.

[16] A liner is a vessel offering scheduled common carrier service between specified ports on a regular basis.

tions in 1994, a decline from more than 25 percent in 1989. Approximately 20 percent of Canadian exports and 26 percent of imports were transshipped via the United States in 1994. Japan, South Korea, Hong Kong, Taiwan, and China account for the majority of Canadian container traffic routed through U.S. ports (Transport Canada 1997). Similar transshipment figures are not available for U.S.-Mexican trade.

Because American businesses increasingly seek quick and efficient delivery for their international transactions, air trade has grown rapidly. In 1996, 4.8 million tons of imports and exports worth $382 billion were shipped by air (USDOC Census 1997).[17] Air freight moves both by all-cargo carriers as well as via carriers that primarily transport passengers. New York's Kennedy International Airport was the leading gateway for international air shipments on scheduled air carriers. Japan was the top international origin and destination for U.S. air shipments in 1996, accounting for 16 percent of the value and 12 percent of the weight of all U.S. air trade.

TRANSPORTATION SYSTEM CONDITION AND PERFORMANCE

Highways

The condition and performance of the nation's highways can be measured in a number of ways. Changes by the Federal Highway Administration in the technique for measuring pavement roughness from the Present Serviceability Rating (PSR) to the International Roughness Index complicate long-term analysis of pavement condition. From 1994 through 1996, however, the condition of both urban and rural roads improved, although rural roads are in better shape than urban ones and have improved more over this short time period (see table 1-5). For example, in 1996, 55 percent of rural Interstates were in good or very good condition, up from 43 percent in 1994. This compares with an increase in the good and very good portion of urban Interstates from 33 percent to 38 percent over the same years. These improvements are consistent with earlier trends based on the PSR (USDOT FHWA various years).

The condition of bridges has also improved in recent years (see table 1-6). The percentage of structurally and functionally deficient bridges[18] dropped between 1990 and 1996, although functional deficiency did not change between 1993 and 1996. Despite these improvements, between 11 and 12 percent of both urban and rural bridges were structurally deficient in 1996, and a further 23 percent of urban bridges and 12 percent of rural bridges were functionally deficient (USDOT FHWA and FTA 1998).

Highway performance is measured by level of service (LOS), over a range from LOS A (defined as 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) or worse. LOS D equates to a volume-service flow (V/SF) ratio of 0.8, or 80 percent of capacity. The V/SF ratio measures the flow of traffic relative to a theoretical determination of capacity. The percentage of peak-hour mileage at V/SF greater than or equal to 0.8 on all urban principal arte-

[17] This amount underrepresents the complete air trade activity, as the U.S. Customs Service does not collect data on low-value air shipments (export shipments valued at less than $2,500 and import shipments valued at less than $1,250).

[18] Structurally deficient bridges are those that are restricted to light vehicles, require immediate rehabilitation to remain open, or are closed. Functionally deficient bridges have deck geometry, load carrying capacity, clearance, or approach roadway alignment that no longer meet criteria for the system of which the bridge is a part.

Table 1-5.
Pavement Condition on Highways: 1994 and 1996
(In percent)

	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
	1996	8.8	28.2	24.8	30.6	7.6	12,419
Other freeways and expressways	1994	5.3	12.7	58.1	20.9	2.9	7,618
	1996	3.4	8.8	55.1	26.0	6.7	8,403
Other principal arterials	1994	12.5	16.3	50.8	16.6	3.8	38,598
	1996	11.8	14.2	49.1	17.4	7.5	44,469
Rural							
Interstates	1994	6.5	26.5	23.9	33.2	9.9	31,502
	1996	3.9	19.4	21.8	38.4	16.4	31,298
Other principal arterials	1994	2.4	8.2	57.4	26.6	5.4	89,506
	1996	1.5	5.9	49.3	34.0	9.3	91,998
Minor arterials	1994	3.5	10.5	57.9	23.6	4.5	124,877
	1996	2.3	8.3	50.7	30.9	7.8	126,158

KEY: Poor = needs immediate improvement.
Mediocre = needs improvement in the near future to preserve usability.
Fair = will likely need improvement in the near future, but depends on traffic use.
Good = in 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. Percentages may differ from those in other published sources due to subsequent revision of data after publication of the cited source.

SOURCES: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: 1995, 1996, and 1997), table HM-64.

rial highways rose slightly between 1990 and 1995. More detail reveals, however, that urban Interstates and other arterials worsened, but urban “other” freeways and expressways improved somewhat (USDOT FHWA and FTA 1998). While the V/SF measures the severity of congestion, it does not indicate the duration of congestion. The Texas Transportation Institute (TTI) developed an indicator of the severity, duration, and cost of congestion, which assesses the delay in hours in 50 urban areas. TTI estimates that congestion nearly doubled, from 7.3 million daily person-hours in 1982 to 14.5 million in 1994. The delay experienced by each driver rose from 19 hours in 1982 to 34 hours in 1994. In addition, TTI estimates that in 1994 congestion cost $53 billion in the 50 cities analyzed (TTI 1997).

Transit

The Federal Transit Administration assesses the condition of transit vehicles using a rating scale from 5.0, meaning excellent condition, to 0.0,

Table 1-6.
Bridge Conditions: 1990–96

Type and condition	1990	1993	1996
Urban bridges	87,495	94,787	100,508
Structurally deficient	14.0%	12.8%	11.3%
Functionally deficient	25.7%	23.4%	23.4%
Rural bridges	254,603	254,978	245,856
Structurally deficient	16.0%	13.9%	11.9%
Functionally deficient	14.1%	11.8%	11.8%

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

Table 1-7.
Condition of Transit Vehicles: 1985 and 1995

Type of vehicle	1985	1995
Articulated buses	4.8	2.9
Full-size buses	4.0	3.8
Mid-size buses	4.6	4.3
Small buses	4.7	4.8
Vans	2.6	3.5
Locomotives	4.6	4.6
Rapid railcars	4.5	4.2
Unpowered commuter railcars	4.3	4.1
Powered commuter railcars	4.8	4.2
Light rail vehicles	4.0	4.5

Ratings: 0.0–1.99 = poor; 2.0–2.99 = substandard; 3.0–3.99 = adequate; 4.0–4.9 = good; 4.9–5.0 = excellent.

SOURCE: U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Condition and Performance: 1997 Status of the Nation's Surface Transportation System* (Washington, DC: 1998).

meaning poor condition.[19] Between 1985 and 1995, the average condition of most types of buses remained about the same (see table 1-7). The condition of full-size buses, the most predominant type of bus in service, worsened slightly, while vans improved. Most transit rail vehicles are in good condition and have changed only slightly over this period (USDOT FHWA and FTA 1998).

Air

Runway condition at airports in the National Plan of Integrated Airport Systems—airports that handle virtually all commercial passenger travel and much general aviation activity—improved from 1986 to 1997. Runways rated "good" increased from 61 percent in 1986 to 72 percent in 1997. Runways rated "poor" fell from 11 percent in 1986 to 5 percent in 1997 (USDOT BTS 1998).

Between 1995 and 1996, performance—based on on-time arrivals, involuntary boarding denials, and mishandled baggage—worsened. In 1996, 75 percent of flights arrived on-time, down from 79 percent in 1995. Nearly 83 percent of flights were on-time in 1991, the best performance between 1990 and 1996. In 1996, bad weather caused 75 percent of air carrier delay, airport congestion caused 18 percent, closed runways or taxiways contributed to 3 percent, problems with national airspace system equipment were responsible for 2 percent, and other factors at 2 percent. There was a 14 percent increase in passengers denied boarding between 1995 and 1996, constituting a rise from 1.84 to 1.99 denials per 1,000 passengers. Mishandled baggage per 1,000 passengers increased slightly between 1995 and 1996 from 5.2 to 5.3, but remained lower than the 6.7 recorded per 1,000 in 1990, the worst year during the 1990s (USDOT BTS 1998).

Rail

The average age of Amtrak locomotives increased from 13.9 years to 14.4 years between FY 1995 and FY 1996. On the other hand, the average age of railcars decreased from 21.8 years to 20.7 years with the delivery of 56 Superliners

[19] These ratings come from the Transit Economic Requirements Model, which uses nonlinear deterioration curves developed from transit asset condition and replacement records.

and 35 Viewliners. Early in 1998, Amtrak announced a $360 million capital investment program for new equipment, made possible under the Taxpayer Relief Act of 1997 (Amtrak 1998a). Late in 1999, Amtrak expects to begin high-speed rail service in the Northeast corridor (Washington, DC, to Boston), with a total of 18 new trainsets (Amtrak 1998b).

Since FY 1987, on-time performance of Amtrak trains has been between 70 and 80 percent. In FY 1996, on-time performance was 71 percent. Hours of delay, however, have fluctuated more wildly over this period, from a low of 12,000 in FY 1990 to a high of nearly 35,000 in FY 1994. In FY 1996, there were 24,000 hours of delay, with 46 percent of these hours due to freight train operation (maintenance of way, freight train interference, signal delays), and 21 percent resulting from Amtrak operations (equipment malfunctions, train servicing in stations, passenger-related delays). Other reasons such as weather caused the final 33 percent of delays. Delays due to freight train operations have generally worsened since the late 1980s. Delays due to Amtrak operations, however, have generally improved, mostly because of a reduction in the amount of time lost by equipment malfunctions (Amtrak 1997).

The physical condition of freight rail carriage continues to improve as new rail stock is introduced. In 1996, over 750 new locomotives and nearly 58,000 freight cars were introduced, reflecting a high level of investment. These new locomotives are more powerful now than in the past and new cars are larger capacity.

The performance of the industry continues to improve. Revenue ton-miles per employee-hour were 2,965 in 1996, up from 2,746 in 1995, and 863 in 1980. Freight revenue per ton-mile, a surrogate for freight rates, have continued to drop. In 1996 they were 2.352¢ per mile, a 55 percent decline since 1980 (in constant dollars) (AAR 1997, 6).

Pipelines

As pipelines age, the possibility of corrosion, which can reduce a pipeline's ability to support stress and higher pressures, increases. Preventive maintenance and replacement can, of course, offset the effects of aging, but incidents still occur.

Publicly available data on pipelines are limited. Attempts are being made to improve this situation (see chapter 3). These incidents are one of the few ways to assess condition. In the gas industry in 1996, there were 185 incidents, much less than in 1980 when there were 1,524 incidents. In the oil pipeline industry, there were 195 incidents in 1996 (USDOT BTS 1998).

SPECIAL FOCUS: THE DOMESTIC WATER TRANSPORTATION SYSTEM

The U.S. waterborne transportation system serves both international and domestic commerce. International cargo services are divided into three categories: liner (scheduled), nonliner (unscheduled dry cargo), and tanker. The domestic segment has three distinct parts: the shallow draft inland and intracoastal waterways, the Great Lakes-St. Lawrence Seaway system, and domestic offshore and coastal shipping in ocean-going vessels.

The U.S. port system provides the interface between water and land transportation and serves both the international and domestic segments. Traffic in the domestic trades is subject to U.S. cabotage laws and regulations under the Jones Act and the Passenger Services Act.[20] Completing the picture are passenger ferries and cruise ships serving both domestic and international travelers, recreational boating, the U.S. shipbuilding industry, and maritime labor. Be-

[20] These acts require waterborne cargo and passengers moving between U.S. locations to be carried aboard U.S. flag vessels built in U.S. shipyards and crewed by U.S. mariners.

cause marine transportation is such a broad topic, this special profile focuses on *domestic* water transportation. (See box 1-2 for an outline of the role of federal agencies in water transportation.)

There are approximately 12,000 miles of inland navigation channels in the United States, most providing channel depths of at least nine feet. About 11,000 miles of these channels account for nearly all of the significant commercial activity. Figure 1-6 shows the extent of this system. Its principal arteries are the Mississippi River and its tributaries, comprising about 7,000 miles of channels penetrating the Midwest as far north as Minneapolis and flowing into the Gulf of Mexico below New Orleans. Major rivers with commercial traffic in this system include the Ohio River (which itself has several important tributaries), the Missouri River, the Illinois Waterway, and the Arkansas River. At New Orleans, the Mississippi River ties into the Gulf Intracoastal Waterway, which is a sheltered shallow draft inland canal system extending 1,100 miles along the Gulf Coast from St. Marks, Florida to Brownsville, Texas. The Atlantic Intracoastal Waterway stretches 1,200 miles from Maine to Florida (with some gaps). On the west coast, the Columbia-Snake River system provides navigation for 465 miles to Lewiston, Idaho, and the Sacramento and San Joaquin Rivers connect interior points in California to the San Francisco Bay. Most of the traffic on the inland system consists of barges moving dry and liquid bulk cargo between inland waterway terminals and to and from ocean gateways.

The Great Lakes-St. Lawrence Seaway system provides a minimum 27-foot channel depth from the Atlantic Ocean to Duluth, Minnesota, a distance of 2,342 miles. This system primarily serves deep draft vessels, including so-called Lakers, which only operate on the Great Lakes, moving ore, coal, and other bulk commodities entirely within the Great Lakes, and oceangoing ships moving import-export cargo. There is also a small amount of shallow draft barge traffic moving short distances between the lakes and connecting inland rivers.

The domestic ocean navigation system comprises the noncontiguous routes between the U.S. mainland and Alaska, Hawaii, Puerto Rico, and other U.S. island territories, and coastal routes over the oceans and the Gulf of Mexico for movement of domestic bulk and liner cargo in U.S. flag vessels. Typical origin-destination pairings include New Orleans to Baltimore, Valdez, Alaska, to Los Angeles, and Houston to Philadelphia.

Water Transportation Infrastructure

Most of the inland waterway system is made navigable by a series of dams that form slack water pools, and navigation locks that allow vessels to move from one pool to the next. The U.S. Army Corps of Engineers own and/or currently operates and maintains 275 lock chambers at 230 sites. The largest inland waterway locks are 1,200 feet long and 110 feet wide, approximately the size of four football fields and larger than the Panama Canal locks (see box 1-3). Most busy traffic sites feature a main chamber of this size and a few have an auxiliary chamber 600 feet long and 110 feet wide. Significant open river segments without locks are the Mississippi River below St. Louis and the Missouri River, where navigation is maintained with river training structures (dikes, groins, and revetments). Nearly all of these navigation channels require periodic dredging to maintain a minimum depth of nine feet (Bronzini 1997).

The second major element of the water transportation system's infrastructure is the vast network of approximately 360 coastal and inland ports where cargo is transferred to and from vessels. These ports provide cargo services at 4,990

Box 1-2.
Selected Federal Agencies Involved in Water Transportation

Over two dozen agencies of the federal government are involved in water transportation. Highlighted below are the responsibilities of several agencies with direct responsibility for some aspect of commercial navigation.

Agency	Mission areas
Department of Transportation	
Maritime Administration	Assists U.S.-flag shipping and U.S. shipyards; develops cargo preference statutes; supports the development of U.S. ports, intermodal systems, domestic shipping; maintains cargo ships in the Ready Reserve Force and National Defense Reserve Fleet; trains merchant marine.
U.S. Coast Guard	Provides marine search and rescue, aids to navigation, marine inspection, mariner licensing, bridge clearances, ice operations, boating safety, maritime law enforcement, port safety and security, national defense operations, marine environmental protection, maritime differential global positioning system.
St. Lawrence Seaway Development Corporation	Develops, operates, and maintains the U.S.portion of the St. Lawrence Seaway.
Federal Highway Administration	Supports the development and maintenance of highway connectors to intermodal terminals. Also funds some aspects of the Alaskan Marine Highway, the Puget Sound ferries, and other ferry boat operations on the Federal-Aid Primary Highway System.
Federal Railroad Administration	Supports the development and maintenance of rail connectors to intermodal terminals.
Federal Transit Administration	Supports the development and maintenance of urban passenger ferry systems.
Department of Defense	
U.S. Army Corps of Engineers	Develops, operates, and maintains U.S. channels—coastal, intracoastal, Great Lakes, and inland; plans, constructs, operates, and maintains locks, dams, levees, breakwaters, and river training; disposes of dredged material; regulates wetlands dredge and fill activities; collects waterborne commerce, vessel, dredging, local, and port facilities data.
National Imagery and Mapping Agency	Produces nautical charts.
U.S. Transportation Command Military Sealift Command Military Traffic Management Command	Provides transportation for the Department of Defense. Provides ocean transportation. Manages ports, in support of national defense.
Department of Commerce	
National Oceanic and Atmospheric Administration	Produces nautical charts; provides information on ocean weather, tides, and currents.
Other agencies	
Environmental Protection Agency	Manages dredged material; regulates discharges into surface waters.
Federal Maritime Commission	Regulates liner competition.
U.S. Customs Service	Collects import duties.
Panama Canal Commission	Manages, operates, and maintains the Panama Canal.

Figure 1-6.
U.S. Inland Waterways

SOURCE: U.S. Army Corps of Engineers, Navigation Data Center.

terminal facilities. Table 1-8 shows the distribution of these facilities by geographic location and type of berth. About 38 percent of the coastal port terminals handle general cargo, whereas 85 percent of the inland waterway terminals handle dry or liquid bulk materials. Total capital expenditures at public coastal ports from 1991 to 1994 totaled $2.9 billion, and are projected to be another $4.6 billion from 1995 through 1999 (USDOT MARAD 1996).

The maritime equivalent of the highway system's signs and traffic control signals are the aids to navigation, primarily markers and buoys, that assist mariners in determining position and warn of dangers and obstructions. As of 1995, there were 49,900 federal aids and 49,700 private aids. In complex areas such as New York, Puget Sound, and Houston-Galveston, vessel traffic service systems are in operation. These systems use marine radar and telecommunications to provide real-time displays of navigation and traffic information to vessel pilots, assisting their operations in congested waters with a high degree of safety. Managing the aids to navigation system is one of the primary responsibilities of the U.S. Coast Guard.

Vessel Fleet

Table 1-9 shows the current makeup of the U.S.-flag fleet.[21] The fleet is overwhelmingly engaged in freight transportation. There are 967 commercial passenger vessels in the fleet—about 12 percent of the powered vessels and 2 percent of total ves-

[21] The Corps of Engineers, the Coast Guard, and the Maritime Administration all publish data on vessels, using somewhat different definitions and vessel categories. These agencies are beginning an effort to produce a composite table of vessel fleet information that will serve most data user needs.

Box 1-3.
The Panama Canal

Located strategically at the narrowest point between the Atlantic and Pacific Oceans, the Panama Canal has been an important artery in the world's sea trade since its opening in 1914. In fiscal year 1996 the canal served over 15,000 vessels carrying cargo of 198 million long tons,[1] and collected toll revenues exceeding $486 million. Two-thirds of the tonnage transiting the canal had either a U.S. origin or destination, making the United States the canal's biggest user.

The Panama Canal is approximately 50 miles long, and is a lock-type canal. A ship entering from the Atlantic Ocean at Cristobal Harbor sails at sea level for 7 miles to Gatun Locks. There it is lifted in three stages to the fresh waters of Gatun Lake, 85 feet above sea level. Transiting 23 miles through the lake, the ship reaches the north end of the Gaillard Cut, which is an 8-mile cut through the Continental Divide. When the ship exits the cut, it is lowered 31 feet through Pedro Miguel Locks to Miraflores Lake, travels 1 mile to Miraflores Locks, and is lowered 54 feet in two stages to the level of the Pacific Ocean. Further travel of 4 miles brings the ship to the Balboa port area, near Panama City.

The locks are all dual-lane facilities with chambers that are 110 feet wide and 1,000 feet long. This limits the maximum ship size to: beam, 106 feet; length, 950 feet; and draft, 39.5 feet. Over 90 percent of the world's merchant fleet fits within these so-called Panamax dimensions, and so may transit the canal. About one-third of the vessels that transit the canal are Panamax-class ships.

The capacity of the canal is approximately 38 ship transits per day, which is often exceeded by the number of arriving vessels. A project to widen the Gaillard Cut from its current minimum width of 500 feet to 630 feet, scheduled for completion in 2002, will increase this to about 43 ships per day (Panama Canal Commission 1997). The typical ship spends about 24 hours in canal waters, of which 8 to 10 hours are spent in transiting the canal proper. For each transit, approximately 52 million gallons of fresh water are used in locking operations and spilled to the oceans.

The Panama Canal Commission, created as the successor to the Panama Canal Company under the Panama Canal Treaty of 1977, is the agency of the U.S. Government that manages, operates, and maintains the canal. Under the treaty provisions, the Republic of Panama will assume full responsibility for the canal on December 31, 1999.

SOURCE: Panama Canal Commission, Office of Public Information, various releases.

[1] A long ton equals 2,240 pounds, or 1,018 kilograms (1.02 metric tons).

sels.[22] In addition to these vessels, there are an estimated 11.9 million registered—and perhaps as many unregistered—recreational boats in the United States, which place significant demands on navigation and safety services in some locations.

Table 1-10 shows some changes in the domestic fleet of towboats and barges since 1975. The number of towboats increased by 21 percent over the first decade and, in fact, increased an additional 5 percent from 1985 to 1990. The average towboat horsepower (hp) increased by 10 percent over this period, as newer boats added to the fleet tended to have higher installed power. This is borne out by the average age statistics. In 1995, the average towboat in the fleet was 26 years old, but 7 percent of the towboats exceeding 5,000 hp averaged 18 years of age (USACE 1996).

The domestic barge fleet followed a similar growth and decline pattern. Dry cargo barges and tank barges exhibited net increases of 34 percent and 20 percent, respectively, from 1975 to 1985, then declined by more than 6 percent through 1995. Average tonnage capacity of both types of barges increased by approximately 10 percent over the 20-year period. Dry barges were, on average, 18 years old in 1995, and tank barges averaged 22 years. Double-hull tank barges make up about 59 percent of the tank barge fleet and tend to be somewhat newer, with an average age of 19 years (USACE 1996).

[22] Some cargo vessels also carry a limited number of passengers.

Table 1-8.
U.S. Port Terminal Facilities by Type and Location: 1995

		Number of berths by type			
Location	Total	General cargo	Dry bulk	Liquid bulk	Other
Total berths	4,990	1,271	1,758	1,118	843
Coastal region					
Total	3,179	1,197	710	628	644
North Atlantic	756	264	96	184	212
South Atlantic	343	204	40	56	43
Gulf	790	270	169	184	167
South Pacific	405	211	50	72	72
North Pacific	378	153	79	75	71
Great Lakes	507	95	276	57	79
River system					
Total	1,811	74	1,048	490	199
Mississippi	1,756	65	1,016	483	192
Columbia/Snake	55	9	32	7	7

SOURCE: Adapted from U.S. Department of Transportation, Maritime Administration, *U.S. Public Ports Annual Report* (Washington, DC: 1996), tables 17, 18.

Table 1-9.
U.S.-Flag Vessels by ICST: As of December 31, 1996

ICST codes	Description	Number[P]
	Total vessels	41,006
	Total self-propelled	8,293
114, 120, 139,199	Tanker	161
229	Dry bulk carrier	72
310	Containership	75
321, 325, 329	Other specialised carrier	180
333, 334, 335	General cargo	386
351, 359	Passenger	967
422	Offshore support vessel	1,275
431, 432	Towboat/tugboat	5,177
	Total barges	32,713
141, 142, 143, 144, 149	Tank barge	3,938
341, 342, 343, 344, 349	Dry cargo barge	28,775

NOTE: Vessels operating or available for operation.

KEY: ICST = International Classification of Ships by Type; P = preliminary.

SOURCE: Adapted from U.S. Army Corps of Engineers, *Waterborne Transportation Lines of the United States, Calendar Year 1996* (New Orleans, LA: U.S. Army Engineer District, 1997).

Table 1-10.
U.S.-Flag Towboats and Barges: 1975–95

Type of vessel	1975	1985	1995
Towboats			
Number	4,100	4,954	5,127
Average horsepower	1,241	1,621	1,776
Dry cargo barges			
Number	21,876	29,287	27,342
Average capacity (tons)	1,167	1,319	1,462
Tank barges			
Number	3,534	4,252	3,985
Average capacity (tons)	2,321	2,550	2,803

SOURCE: U.S. Army Corps of Engineers, *Waterborne Transportation Lines of the United States, Calendar Year 1995; Volume 1--National Summaries* (New Orleans, LA: U.S. Army Engineer District, 1996), table 1.

There are 286 privately owned U.S. ships exceeding 1,000 gross tons, with a total cargo capacity of 13 million deadweight tons (DWT).[23] The oceangoing fleet includes 162 ships with unrestricted domestic trading privileges, or so-called Jones Act vessels, not all of which operate in domestic trade (USDOT MARAD 1997). U.S.-flag oceangoing vessels play a small role in carrying the nation's international commerce. Compared with fleets flagged to other countries, the United States ranks 26th in the number of ships and 11th in total DWT. These rankings vary considerably by vessel type. The United States ranks 13th in the number of tankers, 9th in tanker DWT, 8th in containerships, and 6th in containership DWT. Approximately 45 percent of the world fleet by deadweight capacity calls at U.S. ports (*U.S. Industry and Trade Outlook* 1998).

The age and vessel size of both the U.S. and world oceangoing fleets vary considerably by vessel type, but across all vessel types the newer ships tend to be larger and more fuel efficient, and have smaller crews. For example, approximately 85 percent of the U.S.-flag tanker DWT capacity was built prior to 1980. Over 90 million DWT accounting for 30 percent of tanker capacity, mostly in the form of large crude oil carriers, has entered the world fleet since 1989. In contrast, over 44 percent of the U.S. containership capacity, in TEUs, consists of 3,000 to 5,000 TEU ships built since 1980 (USDOT FHWA FTA MARAD 1995). As of November 1996, the world fleet included 36 containerships exceeding 4,500 TEUs, and another 45 post-Panamax "megaships" were on order. Together these 81 vessels will account for 7 percent of the world fleet's container-carrying capacity, and most analysts expect the trend toward larger intermodal ships to continue (*Containerisation International Yearbook* 1997).

[23] Deadweight tons are the lifting capacity of a ship expressed in long tons. The U.S.-flag fleet also includes 192 government-owned vessels with a total capacity of 3.6 million DWT.

Commercial Traffic

In 1996, the total waterborne commerce of the United States amounted to 2,284 million tons (USACE 1997). Foreign tonnage presently accounts for 52 percent of the total, and has grown at a compound rate exceeding 2 percent per year since 1990. By contrast, domestic waterborne commerce has changed little since 1990 at between 1.0 and 1.1 billion tons. Collectively, the domestic navigation system carried 27.3 percent of the ton-miles, 17.3 percent of the tons, and 3.9 percent of the value of goods moved in the United States in 1993 (USDOT BTS 1995).

Petroleum and petroleum products accounted for nearly 42 percent of all waterborne tonnage in 1996. Other major commodity groups, ranked by their tonnage, include crude materials (forest products, sand, gravel, stone, ores, and scrap), coal, farm products, chemicals, and primary manufactured goods and equipment (USACE 1997). In 1995, liner service accounted for approximately 75 percent of the value of U.S. international waterborne trade, and 76 percent of the containerized liner trade, up from 70 percent in 1994 (*U.S. Industry and Trade Outlook* 1998). Both the increasing use of marine intermodal containers and the increasing size of containerships have significant implications for the demands placed on U.S. ports and supporting inland transportation infrastructure.

System Development and Finance

The water transportation system is a mixed public-private enterprise. Significant elements of the infrastructure, including channels, locks, navigation aids, and at least portions of the nation's port facilities, are provided or administered by government and quasi-governmental agencies. Most vessels and operating equipment are privately owned and operated.

Since the canal building era of the early 1800s, the federal government, operating through the U.S. Army Corps of Engineers, has had the responsibility of canalizing the waterways, building additional or larger locks, providing other navigation structures, operating the locks and dams, and performing maintenance dredging of the navigation channels. Each waterway project is authorized by Congress usually in one of its biennial Water Resources Development Acts, and must thereafter receive annual appropriations for planning, design, and construction. The Corps' operations and maintenance budgets are also set by congressional appropriations.

Table 1-11 shows recent water transportation receipts and expenditures in the federal budget. The Harbor Maintenance Trust Fund has been by far the largest source of revenue, and its funds have been used to help defray the costs of channel dredging projects. Legal challenges to the collection of the harbor maintenance tax on U.S. exports and to the tax on imports will cause much of this revenue to disappear unless congressional action reconstitutes the fund. Panama Canal receipts are expected to cover all costs of operation and maintenance. The Inland Waterway Trust Fund currently generates roughly $100 million per year, and is used to pay 50 percent of the construction and rehabilitation costs of selected inland waterway projects.

A concern of inland waterway interests is the system's aging infrastructure. The big push to build new locks or to increase capacity at existing locks to keep up with the growth in waterway traffic was substantially over in the 1950s. Currently, nearly half of the 237 operating lock chambers in the system are over 50 years old, and most of these are deteriorating or functionally obsolete, and require major rehabilitation or replacement.

Table 1-11.
Federal Water Transportation Receipts and Outlays: Fiscal Year 1994
(Millions of current $)

Fund	Receipts
Total receipts	1,394
Harbor Maintenance Trust Fund	646
Panama Canal Receipts	548
Oil Spill Liability Trust Fund	103
Inland Waterway Trust Fund	97
Agency	**Outlays**
Total outlays	3,863
U.S. Army Corps of Engineers	1,559
U.S. Coast Guard	1,191
Panama Canal Commission	541
Maritime Administration	542
Federal Maritime Commission	18
St. Lawrence Seaway Development Corp.	12

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Receipts and Outlays in the Federal Budget: Fiscal Years 1977–94*, BTS97-E-01 (Washington, DC: 1997), tables 2-15, 2-16.

Table 1-12.
Traffic and Delay at Inland Waterway Navigation Locks: 1997

River	Lock chamber	Cargo (kilotons)	Tows	Barges	Average tow delay (hours)
Mississippi	27 main	66,418	6,076	64,103	1.6
	27 auxiliary	10,747	1,252	10,144	37.4
Mississippi	Melvin Price main	69,442	5,311	66,162	0.6
	Melvin Price auxiliary	1,407	986	2,253	0.1
Illinois	Lagrange	34,490	3,123	31,366	3.7
Ohio	Greenup main	69,122	6,228	73,002	1.0
	Greenup auxiliary	725	502	1,260	0.0
Ohio	Dashields main	22,707	3,886	30,387	1.2
	Dashields auxiliary	1,734	1,189	2,644	6.2

SOURCE: U.S. Army Corps of Engineers, *Lock Performance Monitoring System Summary; January–December 1996 and 1997* (Fort Belvoir, VA: Navigation Data Center, 1998).

System Performance

When looking at the performance of the inland waterway system, towing operations predominate. Most navigation locks operate around the clock and are quite busy, so tows often have to wait for their turn to lock through. Table 1-12 provides an extract from the extensive navigation lock performance database compiled by the Corps of Engineers. At the five locations shown, average waiting time per tow for the main chamber ranges from about one to four hours. Auxiliary chambers are usually smaller than the main chamber and are pressed into service when the main chamber is out of operation, so the delay results for these chambers tend to fluctuate widely, even for apparently low annual traffic levels.

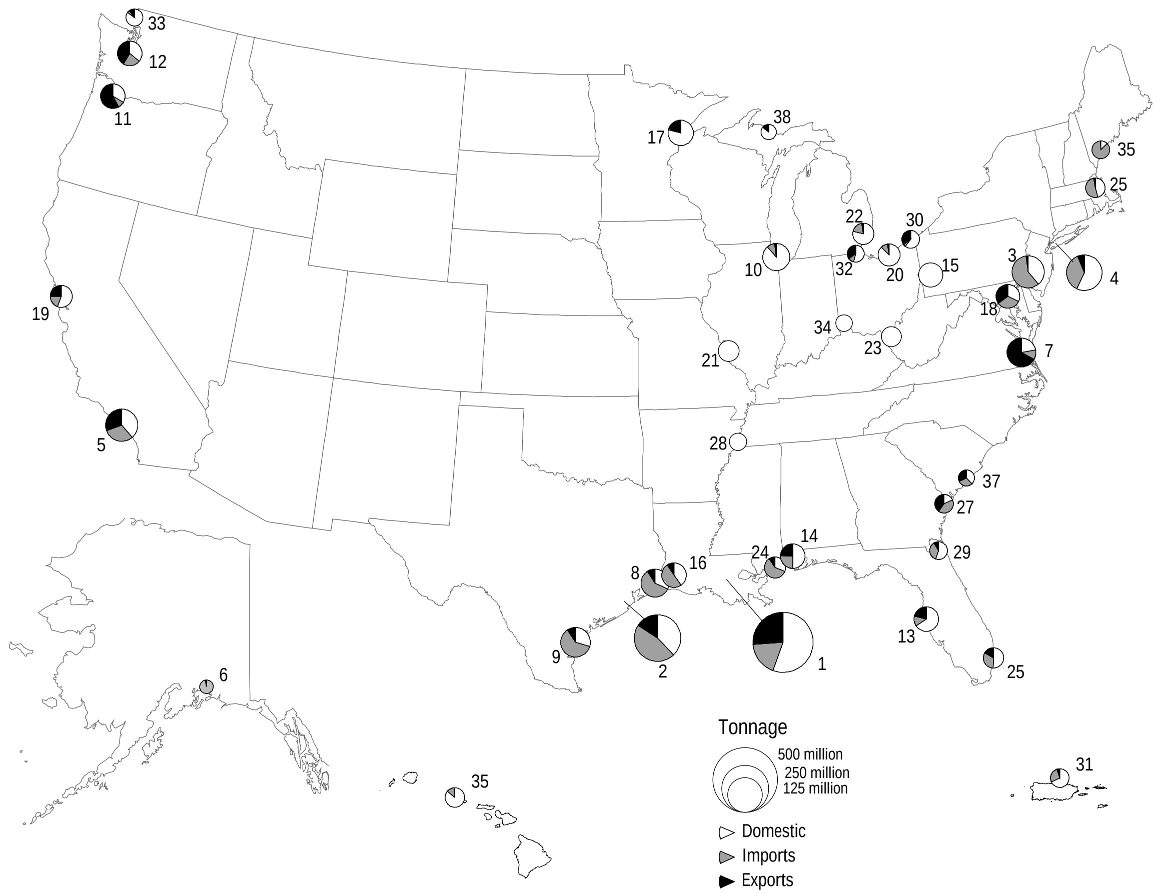
Lock processing and delay times typically account for 10 to 30 percent of a tow's trip time, so delays to existing traffic, coupled with projected long-term traffic growth, are sources of pressure to modernize or upgrade the system by building larger locks.

Port performance is often measured in terms of annual cargo throughput. There were 362 U.S. ports with commercial traffic in 1996, and 52 of these ports handled over 10 million tons of cargo, amounting to 90 percent of total waterborne commerce (see figure 1-7). An additional 97 ports had traffic totaling between 1 million and 10 million tons (USACE 1997). The 25 leading U.S. container ports handled over 19 million TEUs in 1995, accounting for 99 percent of all containers moved through U.S. ports in international trade (*Containerisation International Yearbook* 1997). Ship turnaround time at ports is a widely used measure of service quality, but no public agency collects or reports such data.[24]

Port efficiency is also affected by the rail and highway connections affording access to the terminals. The most recent comprehensive look at port landside access, published in 1993, indicated that at least half of all ports and two-thirds of container ports face growing traffic congestion on the truck routes that serve their terminals. Conflicts between container trains crossing surface streets at grade and urban highway traffic is another significant concern (TRB 1993).

[24] This measure is not based on a clearly defined standard, but on a series of independent events and commercial decisions.

Figure 1-7.
Tonnage Handled by Major Ports: 1996



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-New Jersey
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
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
    Two Harbors, MN
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 1996, 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.

Current Issues

A major issue currently facing the U.S. maritime industry is how to cope with the explosive growth of international trade and the trend toward ever larger ships. This is particularly acute at container ports. Ship operators wish to discharge and take on several thousand containers as quickly as possible, which places considerable strain on port and landside transportation facilities. Larger ships also require ports to invest significant amounts of capital in larger container cranes and in expanded land areas to marshal containers for loading.

On the inland waterways, renewal and selected expansion of aging lock and dam facilities is a key issue. With relatively flat but steady growth in traffic in most areas, and with increasing pressure on the federal budget, it is a challenge to find the proper mix of expenditures on system maintenance, rehabilitation, and new construction. There are also environmental protection constraints on disposal of dredged material and other infrastructure project elements.[25] Conflicts between maritime transportation and other uses of water resources and waterside land affect the future development of both inland and coastal facilities.

TRANSPORTATION EVENTS

Several notable events shaped transportation news in 1997. These include severe flooding in the Upper Midwest, labor strikes against the Bay Area Rapid Transit (BART) system and the United Parcel Service (UPS), and freight rail service disruptions. The flooding, in particular, had far-reaching impacts that continue to be felt today. This section focuses primarily on the transportation-related impacts of each of these events, which ranged from minor inconveniences to major disruptions in service to infrastructure and equipment damage. Some affected freight transportation, while others impacted passengers only.

Flooding

Record-breaking snow in the winter of 1996–97, followed by massive spring snowmelts, ice jams, and heavy rains, produced severe flooding in North Dakota, Minnesota, and South Dakota. The Red River of the North, which borders North Dakota and Minnesota and flows northward to Manitoba, Canada, flooded farmland up and down the Red River Valley, forcing people to evacuate their homes. In some areas, houses, businesses, and livestock were destroyed, and lives were lost. The floods claimed the lives of seven people in North Dakota and four in Minnesota, while livestock losses exceeded 123,000 (FEMA 1997h; FEMA 1997f).

Near Grand Forks, North Dakota, where flood waters rose to 26.2 feet above flood stage on April 23, numerous transportation problems ensued. Most bridges were either under water or closed from Grand Forks north to the Canadian border, and Interstate-29 (I-29), the main artery from Fargo to Grand Forks, was closed at many locations. Because of the high water, all transit and intercity bus operations were suspended, and transit vehicles were diverted for evacuation purposes. By the end of the month, I-29 between Fargo and Grand Forks and bridges south of Grand Forks were reopened (FEMA 1997f; FEMA 1997e).

The flooding also disrupted commercial rail and barge operations in Iowa, Minnesota, and North Dakota. Among the railroads affected were Burlington Northern Santa Fe (BNSF), Canadian Pacific, Red River Valley and Western, and Union Pacific. BNSF closed its main line between Chicago and Minneapolis and another line

[25] See chapter 4 in this report and in *Transportation Statistics Annual Report 1997* for detailed information (USDOT BTS 1997b, 103–105).

between Grand Forks and Fargo (Somasundarum 1997), but was back in service in early May.

In South Dakota, on April 10, 1997, 29 roads were closed or damaged, and rail service was disrupted due to snow drifts, high water, or eroded track beds. (Water continued to hamper traffic on several state and U.S. routes through mid-June). (FEMA 1997b and 1997c) On the same day, nearly 50 U.S. or state highways were closed in Minnesota. Because of the closings, state officials had to divert traffic at numerous locations to help ease the situation. Several bridges were either closed or monitored by state transportation officials throughout the flooding period (FEMA 1997a). Mississippi River flooding in Minnesota prompted the U.S. Army Corps of Engineers to close nine locks and dams from St. Anthony Falls, Minnesota, to Trempaleau, Wisconsin (FEMA 1997g).

The U.S. Department of Transportation helped in flood recovery efforts. Using emergency relief highway funds, the Federal Highway Administration funded the removal of debris and the repair of damaged federal-aid highways and bridges. The flood's impact on the region's bridges has spurred interest among state and federal government officials in building a new bridge between Grand Forks and East Grand Forks that would be high enough to clear a 500-year flood level. The Research and Special Programs Administration, Office of Pipeline Safety monitored the flood's impact on pipeline facilities. Although no significant pipeline failures due to the flooding were reported, precautions were taken to isolate pipeline segments in flood-impacted areas. Also, U.S. Coast Guard (USCG) helicopters, boats, and personnel were used in search and rescue operations. USCG assisted 838 people stranded by rising waters. In addition, it provided 3 floating pumps and 800 feet of hose for fighting flood-related fires in downtown Grand Forks (FEMA 1997d).

Bay Area Rapid Transit Strike

On September 7, 1997, striking train operators and mechanics brought California's BART heavy-rail system to a standstill. The 8-day strike was the only major transit work stoppage of the year. It caused monumental traffic jams on bridges and highways, and forced BART riders to seek alternative methods of getting to work. Some took the bus, others drove, and still others telecommuted. Other impacts of the strike included a downturn in sales for businesses located near BART's 39 stations and parking shortages.

The 93-mile BART system carries approximately 275,000 passengers on weekdays and about 65,000 on weekends (USDOT FTA 1997). Other transit companies in the Bay Area, including bus and ferry lines, partially filled the gap created by the strike, but many passengers were left stranded. Local newspapers criticized the area's transit systems for being unprepared for the strike. For example, no contingency plans were in place for one company to loan equipment and personnel to another. AC Transit, the largest bus system in the Bay area, provided no additional buses, and its drivers had to pass stops because there was no room for additional passengers. Still, AC Transit reported ridership increases of 20,000 during the strike (Fagan et al 1997, A1).

During the strike, many commutes took from two to four times longer than normal. For example, a pre-strike 30 to 45 minute commute from Berkeley to San Francisco on BART ballooned to more than 2 hours (Lee et al 1997, A1; Nolte 1997, A19). Normal delays of 25 to 30 minutes at the Eastshore Freeway toll plaza increased to between 1 to 1½ hours.

The biggest problem, however, was not the increase in the number of vehicles on bridges but the timing—too many peak period users trying to drive at the same time. Morning and evening rush periods started one hour earlier than normal (4:30 a.m. and 3:00 p.m.) during the strike. To help ease traffic, the San Francisco Government limited the hours of roadwork, increased the number of officers directing traffic, strengthened ticketing of parking and carpool violators, and set up casual loading zones downtown for carpooling.

Some commuters got to work by an informal system of carpools that were organized in the parking lots of fast food restaurants and at regular transit stops. This informal system worked well in the morning but less well in the evening, because there was no central location for catching a ride home. (Informal carpooling has been going on in the Bay Area since the early 1970s, when the first carpool lanes were set up on Bay Area bridges and highways.) (Chiang 1997, A15) The use of carpool lanes continued to increase after the strike. The number of vehicles using carpool lanes rose from about 6,800 prior to the strike to 9,100 in October 1997 (Cabanatuan 1997a, A17).

Telecommuting was another option for some workers during the strike. Several companies gave telecommuting a try and others expanded their existing programs. For example, Pacific Gas and Electric (PG&E), Pacific Bell, Chevron, and the Bank of America encouraged telecommuting during the strike. PG&E also converted its San Ramon training center into a 36-computer telework center for East Bay residents who were required to attend meetings in San Francisco (Cabanatuan 1997b, A15).

Strikers returned to work on September 15. It appears that BART has retained its ridership. On September 17, ridership was only slightly less than normal—257,000 passengers. AC Transit also retained many of the passengers who used its buses during the strike. Peak afternoon commutes on AC Transit average between 13,000 to 13,500 passengers a day, up from 9,500 prior to the strike (Abramson 1998). The opening of Interstate 80 carpool lanes and a $1 surcharge added to bridge tolls boosted the transit company's ridership. Likewise, the Oakland-Alameda ferry service reported serving 300 additional passengers a day since the strike (Hendrix 1997, A1).

United Parcel Service Strike

A 1997 International Brotherhood of Teamsters strike against UPS was the first nationwide strike in the company's 90-year history. It started on August 4, 1997, when ground services employees walked off the job, demanding better compensation, and lasted two weeks. (UPS pilots did not strike; they belong to another union.)

Founded in 1907, the Atlanta-based company is the nation's largest private package delivery company. It handles about 3.1 billion parcels and documents annually, or 12 million packages daily. In 1996, UPS generated $22.4 billion in revenues, and lost $600 million due to the strike (UPS 1998). In comparison, Federal Express Corporation (FedEx) handles nearly 3 million packages daily (Fedex 1998).

The movement of small packages and parcels is a major freight activity in the United States. The 1993 Commodity Flow Survey reported that U.S. manufacturing, mining, and wholesale businesses relied on parcel, postal, or courier services to transport goods valued at over $560 billion. Package and parcel deliveries are usually intermodal in nature. UPS, for example, uses its fleet of trucks and planes and relies on the rail system to move parcels. Burlington Northern Santa Fe and Conrail are two major carriers of UPS shipments. BNSF carries about 1,200 UPS loads on an average weekday, and more than 300,000 annually, while Conrail moves more than 200,000 annually. According to one source, UPS accounts for about 10 percent of all intermodal revenues for the rail industry and about 2 percent of total revenues (*Traffic World* 1997b, 26).

At the beginning of the strike, UPS delivered less than 10 percent of its normal daily capacity, using nonunion managers and workers. As the strike continued and some union workers returned to work, UPS hubs reported service levels near 35 percent of capacity (Distributors React 1997).

The strike affected various sectors of the economy and industries disproportionately. Small businesses, especially retailers who ship specialty items, were hit particularly hard. Bridal salons and wholesalers, for example, were swamped with phone calls from nervous brides worried about whether their gowns would be delivered on time. Moreover, they were unable to track packages that were in transit. One of the most serious problems to occur during the strike was the loss of several hundred units of blood products because they did not reach their destinations on time and spoiled. As a result, America's Blood Center, which provides almost half of the nation's blood supply, had to resort to shipping on commercial airlines in passenger cabins, because cargo areas are not climate controlled (Swoboda 1997, B1).

The strike also caused a 3.2 percent drop in total freight railroad trailer traffic, despite increases in intermodal shipments by FedEx and the U.S. Postal Service. According to the Association of American Railroads, the railroad industry lost $11.5 million a week on average because of the strike. Not surprising, BNSF was the hardest hit, posting a 11.3 percent decrease in trailer traffic for the week of August 9 (Field 1997).

The strike exposed shippers to UPS alternatives, including differences in services and rates, and afforded other parcel delivery businesses an opportunity to demonstrate their ability to respond to customers demands in a timely fashion and at competitive prices. FedEx, for example, recorded a 40 percent rise in business during the strike, with shipment volume rising to 4 million packages daily, compared with 2.8 million reported at the same time the previous year (Schulz 1997, 10). FedEx also reported that it retained about 15 percent of UPS business after the strike and increased its first-quarter fiscal 1998 revenues by $150 million (*Traffic World* 1997a, 9). The U.S. Postal Service recorded a profit of more than $1 billion in 1997, attributable, in part, to increased volume during the UPS strike (Service 1997). Air cargo carriers, including Airborne Freight and Emery Worldwide benefited from the strike as well. Both companies posted nearly 18 percent increases in shipments in 1997 (Schulz 1997). In addition, the 15-day UPS strike help boost third-quarter fiscal 1997 profits of regional less than truckload (LTL) companies, including USFreightways and American Freightways (*Traffic World* 1997c, 19).

Rail Service Disruption

In the summer and fall of 1997, a variety of rail service problems became evident on the Union Pacific Railroad (UP), including line congestion, crew and equipment shortages, computer tracking difficulties, safety concerns, and missed deliveries. Problems began during the summer in the Houston area, and then spread throughout the 36,000-mile rail system, which represents one-quarter of Class I mileage. Shippers claimed these problems stemmed from the September 1996 merger of UP and Southern Pacific (SP) Railroads, which created the largest railroad in North America.

UP operates in the western two-thirds of the country, serving 23 states, Canada, and Mexico, and links major West Coast and Gulf Coast ports. Because of the large geographic extent of the rail system, service disruptions included clogged California ports, idled mining equipment in Colorado, grain harvests stored in the Midwest, and stalled supply deliveries to petrochemical plants on the Gulf Coast. By one estimate, these disruptions cost the nation $2 billion from July 1997 through January 1998, with $1.1 billion in lost production and higher transport costs reported in Texas, the most hard-hit state (Weinstein and Clower 1998, 4, 5, 10). These rail problems proved to be the most long-term, widespread, and expensive of any transportation disruptions that took place in 1997.

A review by the Federal Railroad Administration (FRA) reported widespread safety deficiencies in training, dispatching, and employee fatigue. A September 1997 inspection found that 56 percent of the UP locomotives were defective and some maintenance workers were inexperienced in repairing defects. FRA noted that dispatchers were fatigued due to heavy workloads and stress. Nine rail worker fatalities were reported in 1997, double the number of the previous year; five of these occurred during collisions involving UP-SP trains. At the end of 1997, the collisions were being investigated by the National Transportation Safety Board (USDOT OASPA 1997b). In early November, FRA conducted a followup inspection to determine whether safety commitments made by the railroad were being implemented (USDOT OASPA 1997a). According to UP, decided improvements in safety occurred in 1997.[26] The Administration's final report in February 1998 concluded that ". . . employee involvement in safety is being strengthened at every level of the organization" (USDOT FRA 1998).

In response to shipper complaints, the Surface Transportation Board (STB) held a hearing on October 27, 1997, focusing primarily on rail service problems. More than 60 witnesses testified about the difficulties of moving and locating shipments as well as traffic congestion (STB 1997d). In particular, Kansas and Nebraska legislators appealed to STB to grant priority status to their states' export grain shipments.

Coal shipments were also affected by rail service traffic problems. Shipments from the Cyprus Amax Minerals mine near Steamboat Springs, Colorado, to CFE (a Mexican utility) were cut by two-thirds (Raabe 1997). In addition, rail delays from the ARCO Coal Company's West Elk Mine in Colorado were severe enough to idle mining equipment, because the facility ran out of storage space for coal awaiting shipment (Aven 1997).

Moreover, Dow Chemical Company reported that financial damages from delays at its Freeport, Texas, plant totaled in the millions of dollars. General Motors reported shipment delays for cars and trucks, most acutely at its plants in Oklahoma City and Oshawa, Ontario, Canada (Quaid 1997).

STB imposed an emergency service order on October 31, 1997, aimed at relieving congestion. It included ordering the opening of UP track to the Texas Mexican Railroad to ease service problems (STB 1997a). STB also ordered UP to begin a series of Weekly Service Recovery Reports on changes in service quality in 12 categories (STB 1997b).

STB held a second hearing on December 3, 1997, to determine progress, and extended its emergency order to March 15, 1998. The Board also found that rail service to agricultural shippers by both UP and BNSF was inadequate. According to the Department of Agriculture, in late November, nearly 94 million bushels of grain were still awaiting shipment, the majority being in states served by UP-SP. STB then directed UP and BNSF to meet with agricultural representatives and submit plans establishing priorities for grain shipping. In addition, the Board extended permission to the Texas Mexican Railroad to continue handling traffic in the Houston area over UP track (STB 1997c).

[26] See Davis (1998). For comparisons with earlier dates, see also Safety Numbers (n.d.)

UP went to unusual lengths to resolve difficulties, including an agreement to share its track ownership and train dispatching with BNSF. The disruptions and efforts to restore service on this significant portion of the railroad network continue well into 1998.

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chapter two

Transportation and the Economy

Transportation exists in every phase and facet of life today. It is responsible for the high degree of mobility enjoyed by Americans and the nearly unrestrained flow of goods among the many cities and towns of the United States. It connects the country geographically, enables regional specialization, and links spatially separated activities into an economic system. Because of this, transportation plays a vital role in the American economy.

This chapter focuses on the economic performance of the U.S. transportation system. First, it discusses measures of transportation's importance to the economy, including its economic magnitude relative to other societal functions and its scale as an industrial activity. Then, it discusses the importance of transportation to American households through analysis of consumer expenditures on transportation and their trends over time. The chapter also examines government revenues from, and expenditures on, transportation and reviews employment and labor productivity in transportation industries.

MEASURING TRANSPORTATION'S ECONOMIC IMPORTANCE

The economic importance of transportation to society can be measured from a consumption or production perspective. From the consumption perspective, it is measured by the amount of money society spends for transportation purposes. In the national accounts,[1] which are used to estimate aggregate economic activity, consumer and government expenditures (including investment) for transportation, plus the value of transportation investments (e.g., trucks and other vehicles purchased by businesses), are called transportation-related final demand.

From the production perspective, it is measured by the value generated by transportation services in moving people and goods on the transportation system. These services include both for-hire and in-house transportation.

Transportation-Related Final Demand in GDP

Transportation-related final demand is a net measure of one sector of the economy, while Gross Domestic Product (GDP)[2] is a net measure of all sectors of the economy. As presented in the national accounts, the two measures are internally consistent. Both measure the production, and not the consumption, of the economy, since they include products that are exported and thus not consumed domestically, and exclude those that are imported and thus consumed here. Also, they are measures of net economic output, not gross output, because intermediate output or business operation expenditures, such as motor fuels, tires, and accounting services, are excluded from both.

In current dollars, transportation-related final demand totaled about $847 billion in 1996, or about 11 percent of GDP (see table 2-1). Personal consumption is the primary component of transportation-related final demand, accounting for 71 percent of the total. Gross private domestic investment and government transportation-related purchases were 16.5 percent and 17.3 percent, respectively.

International trade in transportation-related goods and services consistently ran a deficit from 1992 to 1996, primarily as a result of lackluster automobile and parts trading. In 1996, this deficit was $42.3 billion, slightly lower than the previous year (see table 2-2). In contrast, civilian aircraft and parts trade ran a surplus, with exports about three times imports. Without this surplus, the transportation-related trade deficit would have been even larger (USDOC BEA 1997). With international trade, what an economy produces and what it consumes may differ significantly, because some portion of domestic demand is supplied by imports and some portion of a country's products are exported. The difference between the two is the net international trade of transportation-related goods and services, which in 1996 was negative (i.e., more imports than exports). Because the United States imported more transportation-related goods and services than it exported, the sum of the shares of personal consumption, gross private domestic investment, and government purchases in transportation-related final demand was greater than $847 billion in 1996.

In the national accounts, a country's domestic final demand, that is, the sum of personal con-

[1] The national accounts are a set of macroeconomic accounts, balance sheets, and tables based on a set of internationally agreed upon concepts, definitions, classifications and accounting rules. They provide an accounting framework within which economic data can be compiled and presented in a format designed for economic analysis.

[2] 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.

Table 2-1.
Summary Table: Final Demand and Gross Domestic Demand for Transportation-Related Goods and Services in the U.S. Economy: 1992–96

Current dollars (in billions)	1992	1993	1994	1995	1996
Gross Domestic Product (GDP)	6,244.4	6,558.1	6,947.0	7,265.4	7,636.0
Transportation-related final demand[1]	669.4	709.1	760.2	798.7	846.6
Transportation-related final demand in GDP	10.7%	10.8%	10.9%	11.0%	11.1%
Gross Domestic Demand (GDD)	6,273.9	6,618.8	7,037.9	7,351.4	7,730.8
Transportation-related domestic demand[2]	684.9	734.9	798.7	841.5	888.9
Transportation-related domestic demand in GDD	10.9%	11.1%	11.3%	11.4%	11.5%
Chained 1992 dollars[3] (in billions)	**1992**	**1993**	**1994**	**1995**	**1996**
Gross Domestic Product	6,244.4	6,389.6	6,610.7	6,742.1	6,928.4
Transportation-related final demand[1]	669.4	690.8	723.2	739.9	763.0
Transportation-related final demand in GDP	10.7%	10.8%	10.9%	11.0%	11.0%
Gross Domestic Demand	6,274.0	6,458.0	6,712.7	6,837.5	7,037.7
Transportation-related domestic demand[2]	684.9	716.8	759.5	778.6	801.6
Transportation-related domestic demand in GDD	10.9%	11.1%	11.3%	11.4%	11.4%

[1] Demand for goods and services produced in the United States, regardless of where they are consumed. The measure counts exported goods and services, but does not include imports.
[2] Demand for goods and services consumed in the United States, regardless of where they are produced. The measure counts imported goods and services, but does not include exports.
[3] The Bureau of Economic Analysis derives chained dollars by using the Fisher Ideal Quantity Index to calculate changes between adjacent years. Annual changes are then chained (multiplied) together to form a time series.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, calculated from data in U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business,* 1997, various issues.

sumption, gross private domestic investment, and government purchases, is called Gross Domestic Demand (GDD), to distinguish it from final demand for the products of the economy. GDD includes imports, but excludes exports, thus counting only what is consumed, purchased, or invested in the United States. In 1996, U.S. transportation-related GDD was about $889 billion.

This demand can be directly compared with total U.S. GDD to measure the importance of transportation in U.S. domestic demand. From 1992 to 1996, the share of transportation-related domestic demand in U.S. GDD increased from 10.9 percent to 11.5 percent. During the same period, the share of transportation-related final demand in GDP increased from 10.7 percent to 11.1 percent. A larger portion of U.S. domestic demand for transportation was supplied by foreign production in 1996 than in 1992 (USDOC BEA 1997). Figure 2-1 presents the components of U.S. domestic demand for transportation in 1996.

► Comparison with Other Functions

The 11.1 percent share of transportation-related final demand in GDP, as well as the 11.5 percent share of transportation domestic demand in GDD, provide measures of the role that transportation plays in the economy. The relative importance of transportation in an economy can also be seen by comparing it with the five major societal functions for which goods and

Table 2-2a.
Transportation-Related Components of U.S. GDP and GDD: 1992–96
(In billions of current $)

	1992	1993	1994	1995	1996
Transportation-related final demand[1]	669.4	709.1	760.2	798.7	846.6
Transportation-related domestic demand[2]	684.9	734.9	798.7	841.5	888.9
Personal consumption of transportation	471.6	504.0	542.2	572.3	602.3
Motor vehicles and parts	206.9	226.2	246.6	254.8	261.3
Gasoline and oil	106.6	107.6	109.4	114.4	122.6
Transportation services	158.1	170.2	186.2	203.1	218.4
Gross private domestic investment	89.9	104.0	122.9	130.1	140.1
Transportation structures	3.7	4.1	4.3	4.4	5.6
Transportation equipment	86.2	99.9	118.6	125.7	134.5
Net exports of transportation-related goods and services	–15.5	–25.8	–38.5	–42.8	–42.3
Exports (+)	125.0	124.9	131.3	134.4	143.6
Civilian aircraft, engines, and parts	37.7	32.7	31.5	26.1	30.8
Automotive vehicles, engines, and parts	47.0	52.5	57.8	61.8	65.0
Passenger fares	16.6	16.6	17.1	19.1	20.6
Other transportation	23.7	23.1	24.9	27.4	27.2
Imports (–)	140.5	150.7	169.8	177.2	185.9
Civilian aircraft, engines, and parts	12.6	11.3	11.3	10.7	12.7
Automotive vehicles, engines, and parts	91.8	102.4	118.3	123.8	128.9
Passenger fares	10.6	11.3	12.9	14.4	15.8
Other transportation	25.5	25.7	27.3	28.3	28.5
Government transportation-related purchases	123.4	126.9	133.6	139.1	146.5
Federal purchases	16.8	17.6	18.8	17.9	18.7
State and local purchases	95.3	99.8	106.5	112.4	118.8
Defense-related purchases	11.3	9.5	8.2	8.8	9.0

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

KEY: GDP = Gross Domestic Product; GDD = Gross Domestic Demand.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, calculated from data in U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, 1997, various issues.

services are produced: housing, health care, food, transportation, education, and "other," which includes all other functions. Table 2-3 shows the value and share in GDP of each of these functions.

Ranked according to their shares in GDP, housing was the largest component of U.S final demand in 1996, health care was second, food was third, and transportation was fourth. This ranking has not changed since 1991, although there have been some slight changes in relative shares over the period.

Transportation Satellite Accounts

The role of transportation services in the U.S. economy has long been underrepresented in national economic data used by government and private sector decisionmakers. One reason is

Table 2-2b.
Transportation-Related Components of U.S. GDP and GDD: 1992–96
(In billions of chained[1] 1992 $)

	1992	1993	1994	1995	1996
Transportation-related final demand[2]	669.4	690.8	723.2	739.9	763.0
Transportation-related domestic demand[3]	684.9	716.8	759.5	778.6	801.6
Personal consumption of transportation	471.6	490.7	515.0	527.8	540.0
Motor vehicles and parts	206.9	218.9	230.0	229.5	231.3
Gasoline and oil	106.6	108.7	109.8	113.1	114.1
Transportation services	158.1	163.1	175.2	185.2	194.6
Gross private domestic investment	89.9	102.2	117.1	122.8	129.8
Transportation structures	3.7	3.9	3.9	3.9	4.8
Transportation equipment	86.2	98.3	113.2	118.9	125.0
Net exports of transportation-related goods and services	–15.5	–26.0	–36.3	–38.7	–38.6
Exports (+)	125.0	122.9	127.4	127.8	133.9
Civilian aircraft, engines, and parts	37.7	31.7	29.7	23.8	27.0
Automotive vehicles, engines, and parts	47.0	52.1	56.7	60.0	62.4
Passenger fares	16.6	16.4	16.4	17.4	18.7
Other transportation	23.7	22.7	24.6	26.6	25.8
Imports (–)	140.5	148.9	163.7	166.5	172.5
Civilian aircraft, engines, and parts	12.6	10.9	10.6	9.8	11.2
Automotive vehicles, engines, and parts	91.8	100.9	112.9	114.8	118.8
Passenger fares	10.6	11.5	13.0	13.9	14.9
Other transportation	25.5	25.6	27.2	28.0	27.6
Government transportation-related purchases	123.4	123.9	127.4	128.0	131.8
Federal purchases	16.8	16.9	17.9	16.1	16.4
State and local purchases	95.3	97.5	101.5	103.6	106.5
Defense-related purchases	11.3	9.5	8.0	8.3	8.8

[1] The Bureau of Economic Analysis derives chained dollars by using the Fisher Ideal Quantity Index to calculate changes between adjacent years. Annual changes are then chained (multiplied) together to form a time series.
[2] Demand for goods and services produced in the United States, regardless of where they are consumed. The measure counts exported goods and services, but does not include imports.
[3] Demand for goods and services consumed in the United States, regardless of where they are produced. The measure counts imported goods and services, but does not include exports.

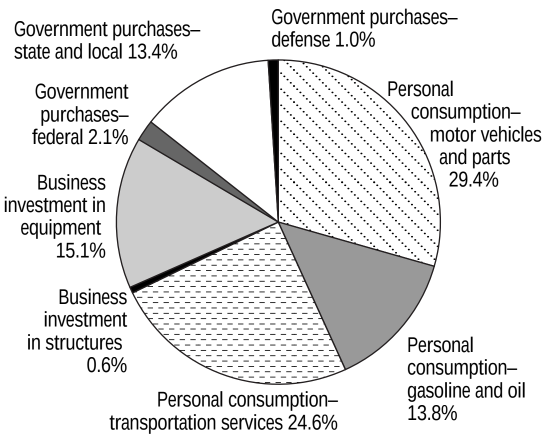
KEY: GDP = Gross Domestic Product; GDD = Gross Domestic Demand.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, calculated from data in U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, 1997, various issues.

that, until now, national measures of transportation services only counted the value of for-hire transportation, ignoring the sizable contribution of in-house transportation services by nontransportation firms. For example, grocery companies often use their own truck fleets to move goods from their warehouses to their retail outlets. Because the in-house contribution was missing in the national data, the true value of transportation services in the economy was unknown, and, therefore, most estimates of the economic benefits to industry from transportation investments have been too low.

A new accounting tool, called the Transportation Satellite Accounts (TSA), now provides a way to measure both in-house and

Figure 2-1.
Components of Transportation-Related Domestic Demand: 1996



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, calculated from data in U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business,* 1996–97, various issues.

for-hire transportation services. The TSA, developed jointly by the Bureau of Transportation Statistics (BTS) of the U.S. Department of Transportation and the Bureau of Economic Analysis of the U.S. Department of Commerce, is statistically and conceptually consistent with the national accounts used to calculate GDP. These accounts are based on the five-year Economic Census; 1992 is the most recent year for which complete data are available

The TSA indicated that transportation services contributed about $313 billion, or 5 percent of the value generated by the U.S. economy in 1992. This is roughly comparable to the value-added by the wholesale/retail trade industry or the health industry, and more than the individual shares of the agriculture, mining, and computer industries.

The value-added by in-house transportation services was about $121 billion compared with about $192 billion contributed by for-hire transportation (figure 2-2). The value-added contributed by in-house transportation alone was about the same as education ($120 billion), and more than either the agriculture, mining, or computer industries ($86 billion, $75 billion, and $89 billion, respectively). The method used to calculate the value-added by in-house transportation services has not been applied to most other industries. For example, the value-added when companies use their own staff and facilities to provide in-house educational services to their employees is not included in the education figure cited above.

It is important to note that the TSA measures for-hire and in-house transportation services from the supply side, and is comprised only of services that move people and goods on the transportation system. It should not be confused with the measures of transportation-related final demand described earlier in this chapter.

The importance of including in-house transportation is most notable in trucking, which accounts for 65 percent of the total value-added

Table 2-3.
Gross Domestic Product by Major Societal Function: 1992 and 1996

Societal function	1992	1996
Total (billions of current $)	6,244.4	7,636.0
Housing	1,468.7	1,864.3
Health	880.2	1,101.7
Food	803.1	928.6
Transportation	669.4	846.6
Education	427.9	523.5
Other	1,995.0	2,371.3
Percent	100.0	100.0
Housing	23.5	24.4
Health	14.1	14.4
Food	12.9	12.2
Transportation	10.7	11.1
Education	6.9	6.9
Other	31.9	31.1

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, calculated from data in U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, 1996–97, various issues.

by transportation services. As shown in table 2-4, more than half of trucking contributions were in-house. The next largest contributors to the value-added of transportation services were air transportation and railroads.

Adding in-house transportation changes the view of which industries are most dependent on transportation services. Agriculture, construction, and wholesale/retail trade are the most transportation-intensive sectors, counting both in-house and for-hire services. Although manufacturing is the most intensive user of for-hire transportation services, and also consumes the most transportation services in absolute terms, it ranks below some sectors in overall transportation intensity because other industries rely more heavily on in-house services. Table 2-5 presents transportation services costs for the nine non-transportation sectors of the economy. Each sector is an aggregate of many related industries. On average, agriculture and services industries use about twice as much in-house transportation as they use for-hire transportation services. The ratio of in-house to for-hire transportation was about 3 to 1 in construction, and roughly 5 to 1 in wholesale/retail trade industries.

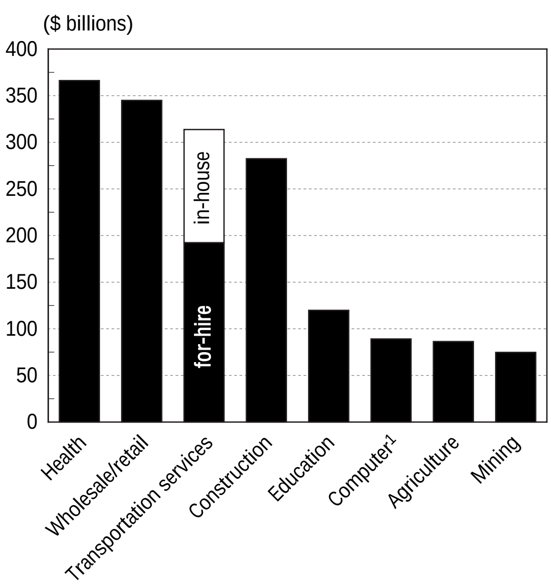
Table 2-4.
Transportation Services Value-Added by Mode: 1992

Mode	Value-added ($ billions)	Percent
Total transportation services, adjusted[1]	313.2	
Total transportation services, unadjusted	313.9	100.0
Railroad and ground passenger transportation	34.4	11.0
Water	12.8	4.1
Air	42.2	13.4
Pipeline and other transportation services	19.6	6.3
For-hire trucking and warehousing	83.4	26.6
In-house trucking	120.2	38.3
In-house bus	1.3	0.4

[1] Adjustment is a reduction of $0.7 billion for selected state and local government subsidies to passenger transit.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, April 1998.

Figure 2-2.
Value-Added by Selected Industry Sectors: 1992



[1] The computer industry consists of computer and office equipment manufacturing and computer and data processing services.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, April 1998.

Figure 2-3 shows total transportation services costs embodied in a dollar of goods or services purchased by consumers and other end-users in 1992. For example, transportation services costs embodied in construction and agricultural products are larger than that in manufactured products on a per dollar basis.

The TSA documents the critical importance of transportation to specific industries, as well as how changes in industrial output influence transportation demand. For instance, transportation services costs have a greater effect on agricultur-

Table 2-5.
Transportation Services Costs to Establishments in Nontransportation Industries

Industry	In-house services ($ millions)	For-hire services ($ millions)	Total transportation costs ($ millions)	Industry output ($ millions)	Transportation cost per $ output
Total	164,743	151,835	316,578	9,519,471	0.033
Agriculture, forestry, fisheries	13,177	5,720	18,897	237,662	0.080
Mining	3,870	2,810	6,680	156,717	0.043
Construction	38,950	13,286	52,235	679,330	0.077
Manufacturing	21,806	80,248	102,054	2,951,303	0.035
Communication and utilities	1,187	8,803	9,990	520,688	0.019
Wholesale and retail trade	42,819	8,963	51,783	1,091,489	0.047
Services[1]	42,035	21,482	63,517	2,227,550	0.029
Finance, insurance, real estate	899	10,523	11,422	1,654,732	0.007

[1] In the national accounts, these are: hotels and lodging; personal and repair services; computer and data processing services; legal, engineering, and accounting services; business and professional services; advertising; automotive repair services; amusements; health services; education; and social services.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, April 1998.

al product prices and markets than on manufacturing or mining products. A $1 increase in the demand for agricultural products will require 14.2¢ of transportation services, compared with 9.1¢ in the case of manufacturing and about 8¢ for mining.

Transportation will continue to play a key role in the economy, even as the economy shifts from a manufacturing focus to a focus on services. The services sector, as defined in the national accounts, is the largest and fastest growing sector in the U.S. economy. According to the national accounts, demand for for-hire transportation generated from services sector growth between 1992 and 1996 was about $6 billion. TSA data show that the services sector would have used an additional $12 billion of in-house transportation.

These findings suggest that transportation may have a greater influence on the competitiveness of U.S. products in international markets than previously thought, and the economic benefits of transportation infrastructure investments are larger than estimates based on for-hire transportation data alone. Because of the addition of in-house services, transportation comprises a larger share of the total costs of the products and services of many industries than previously estimated in the national accounts. Therefore, improvements in transportation efficiency would have a larger influence on the prices of many products, particularly agricultural products, and their competitiveness in international markets.

The TSA also shows that the economic benefit of investing in transportation infrastructure is larger than shown by estimates based solely on for-hire transportation statistics. To illustrate this point, consider the wholesale/retail trade as a hypothetical example. Assume that investments in transportation infrastructure increase the speed, reliability, and flexibility of transportation, resulting in a 10 percent decrease in the cost of transportation services. If only for-hire data are used to calculate transportation's share of production costs, the 10 percent reduction would translate into a 0.08 percent decrease in wholesale/retail trade production costs, or a 0.08 percent increase in its productivity. In reality, wholesale/retail trade would benefit more from a 10 percent fall in transportation costs. Its production costs would decline by 0.47 percent, and its productivity would increase by 0.48 percent, six times more than estimated using for-hire transportation statistics only.

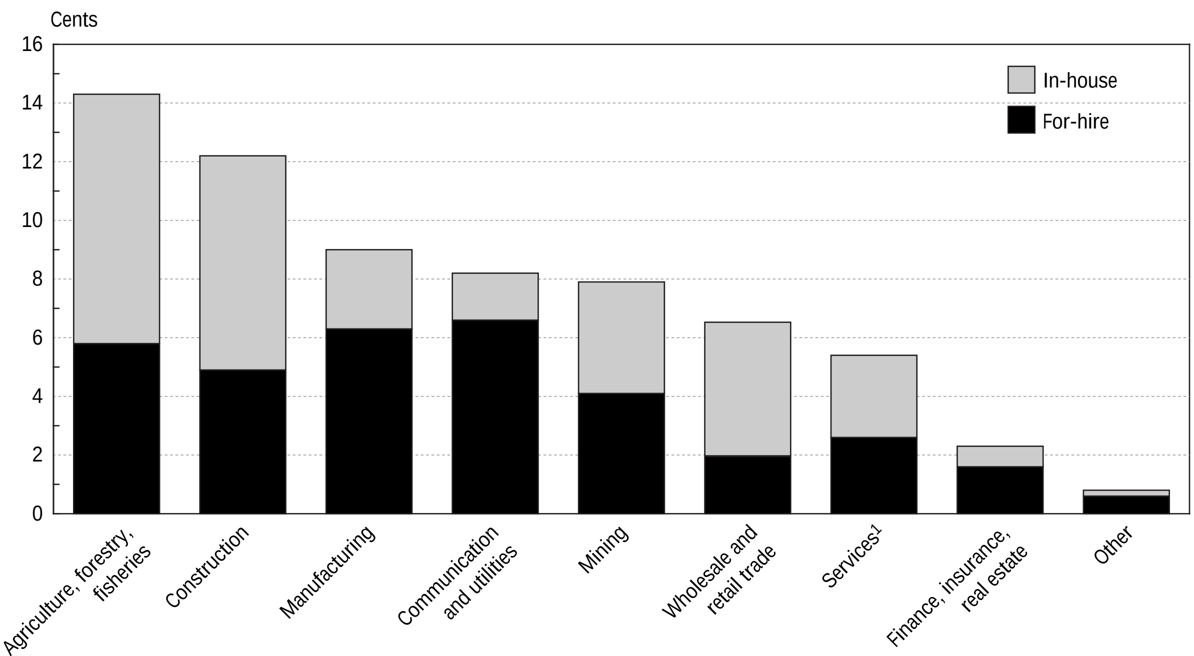
Although the TSA demonstrates that transportation services command a much larger role in the economy than previously understood, the expanded picture is still incomplete. Some in-house transportation services, such as the use of corporate aircraft, have not yet been measured. Also, the TSA does not fully reflect the economic role of personal transportation in getting people to work or school, in bringing goods home from retail outlets, and in supporting social and recreational activities.

CONSUMER EXPENDITURES FOR TRANSPORTATION[3]

In 1995, the average American household spent about $6,000 on transportation, accounting for 18.6 percent of total expenditures (see table 2-6). This appears to be a slight decrease from the previous year, the first year since 1991 that expenditures had not increased compared with the previous year. This also marks the first time that American households, on average, spent more on purchasing used cars and trucks than on new ones. Another trend in American household transportation expenditures is the substantial

[3] In this section, BTS has not checked explicit or implicit comparisons for statistical significance.

Figure 2-3.
Total Transportation Services Costs Embodied in a Dollar of Goods and Services Purchased by Consumers and Other End-Users: 1992



[1] In the national accounts, these are: hotels and lodgings; personal and repair services; computer and data processing services; business and professional services; legal, engineering, and accounting services; advertising; automotive repair services; amusements; health services; education; and social services.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, April 1988.

increase in spending on leased vehicles. In 1991, for example, American households, on average, spent $63 on leased vehicles, which accounted for 1.2 percent of total transportation expenditures. In 1995, this expenditure was $198, more than triple the amount spent in 1991.

Regional Differences

Household transportation expenditures vary from region to region in both the amount of money spent and the component shares of the expenditures. Historically, because of differences in geographic conditions, population density, land-use patterns, industry mix, and household income, households in the West, on average, spent more on transportation than households in the Midwest, South, and Northeast. Among the four regions, the Northeast, on average, spent the least on transportation. In 1984, for example, the average household transportation expenditures were nearly $4,000 in the Northeast, and about $4,800 in the West. In terms of growth rate, since 1984 household transportation expenditures in the Midwest and South increased faster than in the West and the Northeast. In 1995, the average household transportation expenditures in the Midwest reached almost $6,400, the highest among the four regions. (USDOL BLS 1995 and 1996).

Proportionally, households in the South and Midwest spent more money on the purchase of vehicles and related finance charges, while households in the Northeast and West spent more on vehicle insurance and purchased transportation services. In 1995, the share of expenditures on purchasing vehicles and related finance charges in household annual transportation expenditures was just over 50 percent in the South and Midwest, but only 43 percent in the Northeast and the West. The share of vehicle insurance in household transportation expenditures was about the same in all regions. Purchased transportation services accounted for a larger portion of household transportation expenditures in the Northeast (9 percent) and the West (7 percent) than in the Midwest (5 percent) and the South (5 percent) (USDOL BLS 1996).

Table 2-6.
Household Transportation Expenditures: 1995

Type of expenditure	1995
Average annual household transportation expenditures (in current $)	$6,016
	Percentage of components
Vehicle purchases	43.9
Cars and trucks, new	19.8
Cars and trucks, used	23.5
Other vehicles	0.6
Gasoline and motor oil	16.7
Other vehicle expenses	33.5
Finance charges	4.3
Maintenance and repairs	10.9
Insurance	11.8
Vehicle rental, lease, license, and other charges	6.5
Purchased transportation service	5.9

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

Rural and Urban Households

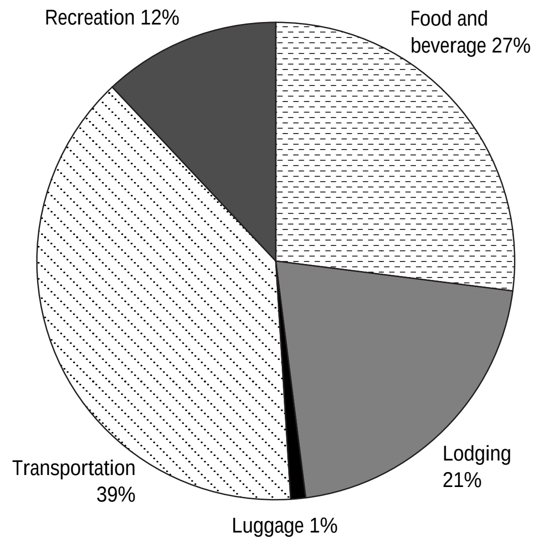
Data on the relative amount of transportation expenditures by rural and urban households suggest considerable fluctuation over time. In the 1984 to 1991 period, annual expenditures of rural households, on average, were always 15 to 20 percent lower than those of urban households. Transportation expenditures of rural households, however, were higher than those of urban households from 1992 to 1995. The most recent data show, however, that the gap between rural and urban spending narrowed to less than 1 percent between 1994 and 1995 (USDOL BLS 1995 and 1996). It is too early to tell whether this change is a temporary aberration or a fundamental shift.

Two important differences between rural and urban household transportation expenditures remained in 1995. One was that the share of transportation spending of total household expenditures, on average, was higher in rural households. The other was that spending on vehicles continued to account for a larger proportion of total transportation expenditures among rural households (22 percent for rural and 18 percent for urban). Since the automobile is the only mode of day-to-day transportation for most rural households, it is not surprising that a larger share of their transportation expenditures is on vehicles. In 1995, vehicle purchases and related finance charges, on average, accounted for 55 percent of rural household transportation expenditures, but only 47 percent for urban households. Rural households on average spent almost $1,200, or 20 percent of their transportation expenditures, on gasoline and motor oil in 1995, compared with an average of about $1,000 for urban household spending, or 16 percent (USDOL BLS 1996).

Expenditures on Out-of-Town Trips[4]

When Americans travel out-of-town, they spend the largest portion of household travel expenditures on transportation—over $400 or 39 percent (USDOL BLS 1996). In terms of total annual household expenditures, households spent about $1,000 on out-of-town trips.[5] Figure 2-4 shows the 5 major components of household expenditures on out-of-town trips (USDOL BLS 1996).

Figure 2-4.
Household Expenditures on Out-of-Town Trips by Category: 1995



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, calculated based on data from U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, 1995.

As for specific items making up household transportation spending on out-of-town trips, air transportation expenditures accounted for the lion's share, followed by gasoline and motor oil. In 1995, these two subcategories together accounted for about three-quarters of the total (54 percent for air transportation and 20 percent for gas and motor oil), followed by expenditures on vehicle rental (7 percent), boat fare (6.5 percent), intercity train transportation (4.4 percent), intercity bus transportation (3.4 percent), and taxis and local transit (3.2 percent). Tolls and parking fees were about 2 percent of the total (USDOL BLS 1996).

Between 1984 and 1995, annual household expenditures on vehicle rental, intercity train transportation, and taxis and local transit on trips increased by 12.5 percent, 11 percent, and 7.6 percent, respectively. During this period, household expenditures on air transportation increased more slowly, at a rate of 2.1 percent

[4] The following section does not include employee-reimbursed business travel.

[5] This refers to goods and services that are purchased and consumed for travel out-of-town. These expenditures may be incurred before or during the trip, e.g., airline tickets are purchased before a trip, but the services are consumed during the trip. Sunk costs on durable goods that are used for out-of-town trips, such as expenditures on an owned vacation home, cars, trailers, motorized campers, and other recreation vehicles, are excluded.

per year, while expenditures on gasoline for out-of-town trips actually decreased at a rate of 2 percent annually. Because air transportation and gasoline expenditures accounted for large shares of the total, they carried more weight in the calculation of the annual growth rate of household transportation expenditures on out-of-town trips, which was 2.4 percent (USDOL BLS 1996).

Gasoline and motor oil was the only subcategory for which household expenditures decreased between 1984 and 1995. This decrease reflected an improvement in vehicle fuel efficiencies and lower fuel prices (USDOT BTS 1997a).

GOVERNMENT TRANSPORTATION REVENUES AND EXPENDITURES

In fiscal year (FY) 1994, governments at the federal, state, and local levels spent $124.5 billion on the nation's transportation system, accounting for 1.8 percent of U.S. GDP (USDOT BTS 1997b). Government spending on transportation is partially financed by revenues generated from government transportation-related user charges, taxes, or fees and earmarked for transportation expenses. By this definition, funds generated from transportation-related sources but not used for transportation purposes are not considered transportation revenues (e.g., motor fuel taxes designated for deficit reduction). Also, funds not generated from transportation-related sources, even though earmarked for transportation purposes, are not included in transportation revenues (e.g., general tax revenue used to defray transportation infrastructure costs). In comparison, government transportation expenditures are defined much more inclusively as the final actual costs to all levels of governments for providing transportation infrastructure, equipment, and operating services covered by government transportation programs, regardless of what funds are used to defray the costs. Because of this difference in definitions, annual government transportation revenues are usually smaller than government transportation expenditures.

The following discussion presents 1994 data, the most recently available for all levels of government, and shows annual growth rates for one year (1993 to 1994) and 10 years (1984 to 1994).

Revenues

In FY 1994, government transportation revenues totaled $86 billion (current dollars), covering 69 percent of government transportation expenditures in the same year (see table 2-7). The federal government collected about 30 percent of these revenues, while states collected 50 percent, and local governments the rest. From a modal perspective, highways generated 71 percent of transportation revenues in FY 1994. Air transportation ranked second, contributing 15 percent of the total, while transit and water transportation contributed 10 percent and 4 percent, respectively. Pipelines provided less than one-half percent of the total (USDOT BTS 1997b).

Government transportation revenues in FY 1994 were only about 1 percent higher than in FY 1993, primarily because revenues collected by the federal government fell by 6.4 percent between those two years. Between FY 1984 and FY 1994, government transportation revenues grew much more—6.2 percent annually on average. State government transportation revenues grew at a slower pace—3.5 percent between 1993 and 1994, about half its average annual growth rate between FY 1984 and FY 1994. Only local government transportation revenues maintained their growth trend between 1993 and 1994 (USDOT BTS 1997b).

By mode, government transportation revenues collected from water transportation decreased 3.6 percent between FY 1993 and FY 1994. Revenues from highways increased by only one-half percent, less than one-tenth of its average annual growth rate between 1984 and 1994. Air and transit are the two modes whose contributions to government transportation revenues increased substantially (3.1 percent and 4.5 percent, respectively) between 1993 and 1994. Compared with previous growth trends, however, the increases were relatively small. Percentage-wise, government transportation revenues from pipelines posted a large increase (26.7 percent) between 1993 and 1994, but in absolute terms, the increase was small as pipelines contributed only $19 million to government transportation revenues in 1994 (USDOT BTS 1997b).

Expenditures

Government expenditures on transportation increased steadily between 1984 and 1994, with an above average increase between FY 1993 and FY 1994. Federal, state, and local governments together spent $124.5 billion (current dollars) on the nation's transportation system in FY 1994 (see table 2-8). Of this total, state governments spent 40 percent and local governments, 48 percent. In contrast with the small increase in transportation revenues, expenditures in 1994 were up 7.3 percent over that in 1993. This increase was appreciably higher than its 6.1 percent average annual growth rate during the 1984 to 1994 period. In particular, local government transportation expenditures grew 9.7 percent between FY 1993 and FY 1994, a significant increase in light of local governments' already large share of total government transportation expenditures. The growth rate of the federal government's direct transportation expenditures was 9.0 percent between FY 1993 and FY 1994. State government transportation expenditures increased the least among all levels of government, only 4.1 percent between FY 1993 and FY 1994—much lower than its 6.2 percent average for the 1984 to 1994 period (USDOT BTS 1997b).

Table 2-7.
Government Transportation Revenues: Fiscal Year 1994

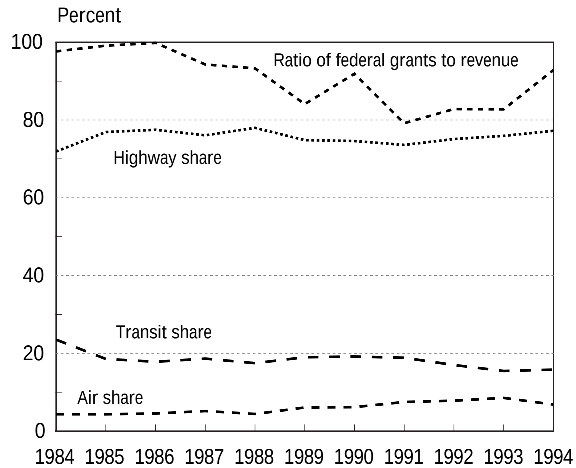
	Revenues after transfers (millions of current $)	Share in total (percent)	Annual growth rate (percent)	
			1993–94	1984–94
Total	85,978	100.00	1.1	6.2
By level of government				
Federal	25,552	29.70	–6.4	4.6
State	42,861	49.90	3.5	6.7
Local	17,565	20.40	7.8	7.9
By mode				
Highway	60,724	70.60	0.5	5.8
Air	13,101	15.20	3.1	8.5
Transit	8,947	10.40	4.5	5.7
Water	3,179	3.70	–3.6	7.7
Pipeline	19	0.02	26.7	U
Unallocated	7	0.01	–30.0	U

U = data for 1984 are not available.

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

For the 1984 to 1994 period, the federal government collected more in transportation revenues than it spent directly on transportation. A large portion of federal transportation revenues was transferred to state and local governments as transportation grants, which were then counted in the transportation expenditures of state and local governments. In FY 1994, federal transportation grants totaled $23.7 billion, equivalent to 93 percent of the federal government's transportation revenues in the same year. The lion's share of federal grants was spent on highway-related programs. Specifically, 77 percent of federal transportation grants went to highways in FY 1994 (see figure 2-5). Transit was the second largest recipient of federal transportation grants, accounting for 15.8 percent in FY 1994. Air transportation was next, receiving 6.8 percent of the total, followed by rail and pipelines with only 0.12 percent and 0.03 percent, respectively, in FY 1994.

Figure 2-5.
Federal Transportation Grants and Modal Shares: 1984–94



NOTE: Rail and pipeline are not included as their share is too small to show. Waterborne transportation is not included, because it does not receive a federal grant.

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

Table 2-8.
Government Transportation Expenditures After Transfers: Fiscal Year 1994

	Expenditures (millions of current $)	Share in total (percent)	Annual growth rate (percent) 1993–94	Annual growth rate (percent) 1984–94
Total	124,471	100.0	7.3	6.1
By level of government				
Federal	15,342	12.3	9.0	4.0
State	49,738	40.0	4.1	6.2
Local	59,392	47.7	9.7	6.6
By mode				
Highway	74,531	59.9	6.8	6.2
Air	17,940	14.4	3.2	9.3
Transit	24,242	19.5	11.8	6.0
Water	6,491	5.2	7.9	4.2
Rail	844	0.7	3.5	–10.4
Pipeline	36	0.0	5.7	15.0
Unallocated	387	0.3	16.2	10.9

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

Highway grants as a share of total federal transportation grants fluctuated over the 1984 to 1994 period. This share increased from FY 1984 to FY 1988, decreased to a low point (73.6 percent) in FY 1991, then increased again between FY 1991 and FY 1994. Transit's share decreased from 19 percent in FY 1991 to 15.8 percent in FY 1994. The share of air transportation in federal transportation grants increased steadily from FY 1984 (4.3 percent) to FY 1993 (8.5 percent), but dipped in FY 1994 (USDOT BTS 1997b).

Transit led all modes in the growth of total government transportation expenditures between FY 1993 and FY 1994, increasing by 11.8 percent. This increase bumped transit's share in total government transportation expenditures from 18.7 percent in FY 1993 to 19.5 percent in FY 1994. Water transportation was another mode for which government expenditures increased faster between FY 1993 and FY 1994 than total government transportation expenditures. As a result, its share in total government transportation expenditures increased slightly to 5.2 percent in FY 1994 (USDOT BTS 1997b).

Although highway expenditures have consistently accounted for a dominant share of government transportation expenditures, they have grown more slowly than other modes in recent years. Between FY 1993 and FY 1994, highway expenditures increased 6.8 percent, a slightly lower rate of increase than that of total government transportation expenditures. Although the share of highway expenditures in the total consequently decreased only 0.2 percent, FY 1994 was the first year since 1984 in which the share of highway expenditures in total government transportation expenditures was lower than 60 percent (USDOT BTS 1997b).

Government air transportation expenditures showed the least growth among the modes from FY 1993 to FY 1994. At 3.2 percent, this was less than half the rate of increase of total government expenditures in that period. Yet, before FY 1994, air transportation had been one of the fastest growing modes in terms of government expenditures, with an average annual growth rate of 9.3 percent. FY 1994 was the first year since 1984 in which the growth rate of government expenditures on air transportation was lower than 7 percent. The slower than average growth dropped the share of air transportation in total government transportation expenditures from 15 percent in FY 1993 to 14.4 percent in FY 1994. Over the 10-year period, rail was the only mode that reported a significant decrease in its growth rate. Between FY 1993 and FY 1994, government expenditures on rail transportation increased 3.5 percent (USDOT BTS 1997b).

► Investment

In the United States, government expenditures on transportation have become more concentrated on investment, particularly infrastructure investment.[6]

Total government investment in transportation was $54.9 billion (current dollars) in FY 1994. About 84 percent, or $45.9 billion (current dollars), of this total was spent on infrastructure (see table 2-9). The remaining portion was used to purchase transportation equipment, such as motor vehicles, airplanes, and traffic control systems. When viewed by mode, highway accounted for the largest share of government investment in infrastructure (more than 88 percent), followed by air (82 percent), and transit (70 percent) in FY 1994 (USDOC Census 1997). Private investments in transportation infrastructure predominated in railroads and pipelines.

[6] Investment is defined here as expenditures on fixed assets. Transportation investments are expenditures on fixed transportation assets, such as highways, railroads, ports and airports, transportation equipment, and traffic signal and control systems.

Table 2-9.
Government Investment in Transportation Infrastructure: Fiscal Year 1994

	Infrastructure investment (millions of current $)	Shares (percent)	Share in total transportation fixed investment (percent)	Annual growth rate (percent) 1993–94	1984–94
Total	45,860	100.0	83.5	10.6	7.4
Highways	35,013	76.3	88.2	8.5	7.0
Air transportation (airports)	4,972	10.8	81.8	6.0	11.5
Transit	4,820	10.5	69.2	37.9	9.1
Water transportation and terminals	937	2.0	47.4	3.2	–0.01
Parking facilities	118	0.3	70.7	–4.0	U

U = data for 1984 are not available.

SOURCES: U.S. Department of Commerce, Bureau of the Census, *Government Finances 1983-84* (Washington, DC: 1984); U.S. Department of Commerce, Bureau of the Census, Government Finances 1993–94, working files, 1997.

In 1994, more than three-quarters of infrastructure investment went to new highway construction and major improvements to or replacement of existing highways. Airport construction ranked second on the government transportation infrastructure spending list, accounting for 11 percent of the total. Government spending on transit construction was slightly lower than on airport construction, but still accounted for more than 10 percent of the total. The remainder was shared by water transportation and terminals (2 percent) and parking facilities (less than 1 percent).

From 1984 to 1994, government investment in transportation doubled, with an annual growth rate of 7.1 percent. Government investment in transportation infrastructure increased even faster, with an annual growth rate of 7.4 percent between 1984 and 1994. Air transportation was the mode in which government infrastructure investment grew most in the 10-year period, tripling in amount over that time. During this time, average annual growth rate of government investment in airports and related facilities was 11.5 percent (USDOC Census 1984 and 1997). Government investment in transit infrastructure also increased faster than average: 9.1 percent annually between 1984 and 1994. Government investment in water transportation facilities showed a general decline during this period, particularly when inflation is taken into account. A 38 percent increase in government investment in the nation's transit systems between 1993 and 1994, boosted transportation infrastructure's growth rate to 10.6 percent, significantly higher than its average in the 1984 to 1994 period (USDOC Census 1997).

TRANSPORTATION EMPLOYMENT

Transportation contributes to the economy by providing jobs and generating income. The number of transportation-related jobs can be calculated by industry and by occupation. Employment in the transportation industry covers all workers hired by for-hire transportation industries, including some nontransportation jobs, such as personnel managers and accountants. Employment in transportation occupations includes only transportation jobs regardless of industry. For example, truck drivers working in the retail industry would be counted. It is important to note that employment numbers for transportation occupations differ from those for the transportation industry, though there is substantial overlap between the two, with transportation occupations accounting for a large portion of transportation industry employment.

The Bureau of Labor Statistics (BLS), reported that in 1996 the for-hire transportation industry employed about 4 million people and employment in transportation occupations reached nearly 4.5 million, accounting for 3.2 percent and 3.5 percent, respectively, of total U.S. employment. Between 1986 and 1996, total U.S. employment increased from 108 million to 127 million, with an average annual growth rate of 1.6 percent. In comparison, for-hire transportation industry employment grew much faster, averaging 2.8 percent annually. The faster growth rate boosted the for-hire transportation industry's share of total employment from 2.8 percent in 1986 to 3.2 percent in 1996. Employment in transportation occupations, however, grew at about the same rate as total U.S. employment. The difference between industry and occupation growth rates implies that in recent years transportation occupations have become more concentrated in the for-hire transportation industry, or the share of nontransportation jobs in the for-hire transportation industry has increased (USDOL BLS 1984–97 and 1998a).

Within the for-hire transportation industry, air transportation employment has grown the most rapidly. Its average annual growth rate between 1986 and 1996 was 7.2 percent, two and one-half times the average of transportation as a whole (see table 2-10). Consequently, air transportation's share in total for-hire transportation industry employment increased from 16 percent in 1986 to 28 percent in 1996. The other two fast growing for-hire transportation industries were transit and transportation services.[7] Their average annual growth rates in the 1986 to 1996 period were 4.4 percent and 3.9 percent and their shares in the employment of the overall for-hire transportation industry increased from 9 percent to 11 percent and to 10 percent, respectively. Trucking and warehousing employment grew more slowly, and its share in

[7] Earlier in this chapter, transportation services included carriers, in-house transportation providers, and supporting activities, such as travel agents and freight forwarders. In this section, services refer to the more restrictive definition in table 2-10.

Table 2-10.
Employment in the For-Hire Transportation Industry: 1996

	Employment (in thousands)	Shares (percent)	Annual growth rate (percent)	
			1995–96	1986–96
Total	4,038.0	100.0	3.4	2.8
Trucking and warehousing	1,640.9	40.6	3.4	1.7
Air	1,122.1	27.8	5.0	7.2
Local and intercity passenger transit	439.2	10.9	4.8	4.4
Transportation services[1]	417.3	10.3	4.0	3.9
Rail	231.1	5.7	–3.1	–3.5
Water	173.1	4.3	–0.8	–0.1
Pipeline, except natural gas	14.5	0.4	–4.0	–2.2

[1] Includes establishments furnishing services incidental to transportation, such as forwarding and packing services, and arrangements for passenger and freight transportation.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "Employees on Nonfarm Payrolls by Industry," available at www.bls.gov/webapps/legacy/cesbtab1.htm, cited on 5 February 1998.

total for-hire transportation industry employment decreased from 45 percent to 41 percent. During the same period, railroad, water, and pipeline employment decreased. Among the three, railroad transportation declined the most, averaging a decrease of 3.5 percent annually. Not surprising, railroad's share in total for-hire transportation industry employment dropped from 11 percent in 1986 to less than 6 percent in 1996 (USDOL BLS 1998a).

The modal structure of employment in transportation occupations differs from that of the transportation industry. Motor vehicle operators, which include truck, bus, and taxi drivers, accounted for 90 percent of transportation jobs in 1996 (see table 2-11). Air, rail, and water transportation jobs—such as airplane pilots, navigators, attendants, and air traffic controllers; railroad conductors, locomotive operators, and railroad brake, signal, and switch operators; and ship captains, sailors, and marine engineers—together accounted for less than 10 percent of the total transportation jobs. A comparison of tables 2-10 and 2-11 shows that employment numbers for air, rail, and water transportation occupations were much smaller than the total number employed in each corresponding industry. In contrast, the number of motor vehicle operators is more than double that of the trucking and warehousing industry, a reflection of the fact that motor vehicle (or highway) transportation is extensively diffused throughout the economy. The for-hire trucking industry accounts for a smaller share of the total number of motor vehicle operators than do industries whose primary economic activities are not transportation (USDOL BLS 1984–97).

Over the 1986 to 1996 period, changes in the employment numbers in transportation occupations were similar to that of for-hire transportation industries. The number employed in air transportation occupations grew most rapidly, while the number in rail occupations decreased. Between 1995 and 1996, the number employed in transportation occupations grew 3.3 percent, much faster than its 1.7 percent average annual rate during the 1986 to 1996 period. In particular, employment in rail transportation occupations reversed its 10-year declining trend with an 11.5 percent increase between 1995 and 1996 (USDOL BLS 1984–97).

Table 2-11.
Employment in Transportation Occupations: 1996

	Employment (in thousands)	Shares (percent)	Annual growth rate (percent)	
			1995–96	1986–96
Total	4,451	100.0	3.3	1.7
Motor vehicle operators	4,024	90.4	3.2	1.8
Air transportation occupations	241	5.4	1.3	2.7
Rail transportation occupations	116	2.6	11.5	–2.1
Water transportation occupations	70	1.6	6.1	1.6

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "Employment and Earnings," table 11 of the Annual Average Tables, January issues 1984–97.

LABOR PRODUCTIVITY AND CONSUMER PRICE INDEX

Labor Productivity

Among transportation industries, rail has been the leader in labor productivity growth (measured in output per hour worked), increasing 4.3 percent between 1992 and 1993 (the latest year for which data are available). Rail also outperformed the manufacturing sector between 1982 and 1993; rail labor productivity grew 150 percent, while manufacturing labor productivity increased 35 percent (see figure 2-6) (USDOL BLS 1998b and 1998c).

In comparison, labor productivity growth in air transportation and petroleum pipelines was slower and less steady. For example, between 1982 and 1986, both air transportation and petroleum pipeline labor productivity grew 21 percent, faster than that of the manufacturing sector. Air transportation labor productivity continued to grow, while petroleum pipeline labor productivity decreased between 1986 and 1987. Because of the decreases in output caused by a slowdown in the U.S. economy from 1988 to 1991, air and pipeline productivity decreased 7 percent and 6 percent, respectively. After 1991, labor productivity of both industries rose again. Between 1982 and 1995, both air and pipeline labor productivity grew 40 percent, which was slightly lower than that of the manufacturing sector (43 percent), but much higher than that of the overall economy (18 percent) (USDOL BLS 1998b and 1998c).

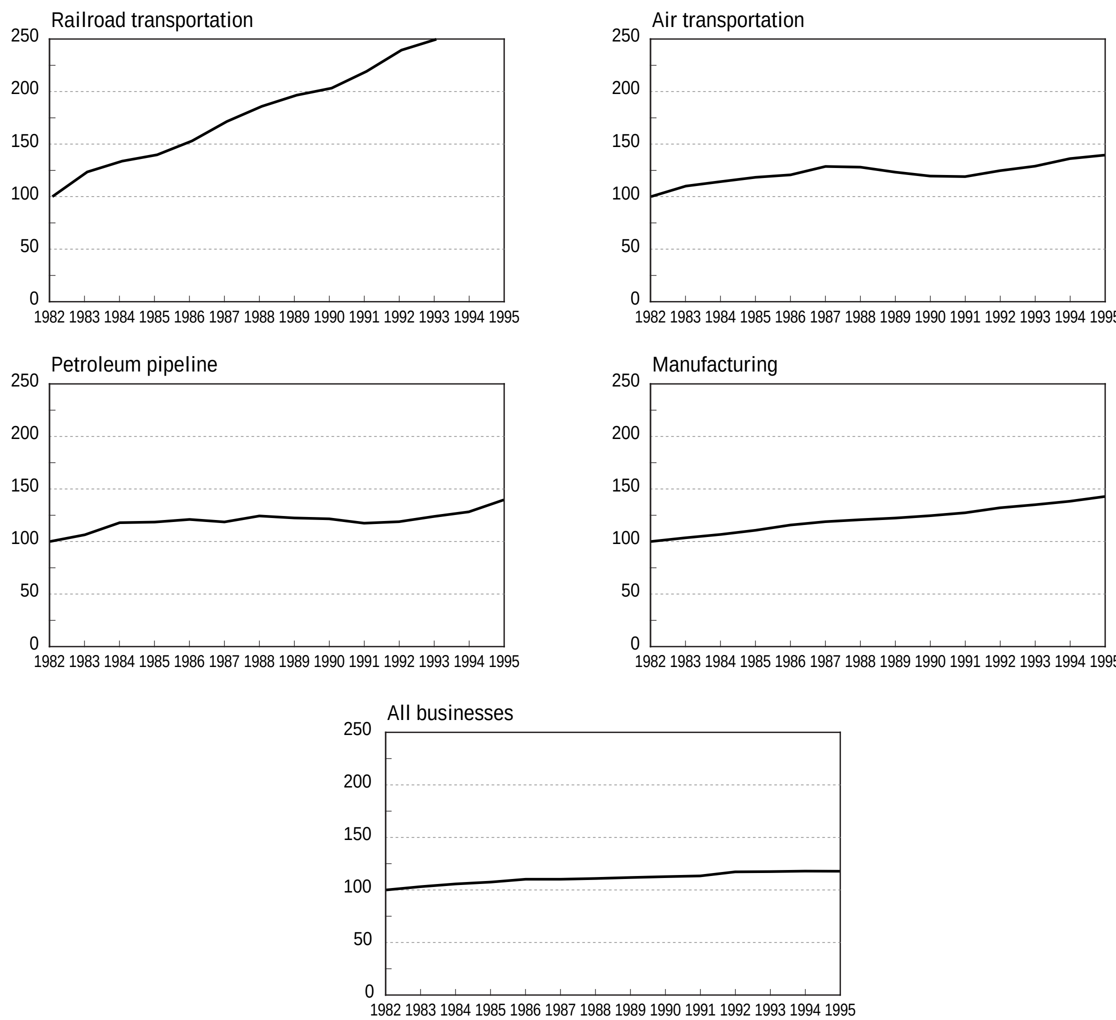
Transportation Statistics Annual Reports 1995 and *1997* discussed changes in trucking and bus labor productivity up to 1989. Post-1989 labor productivity data for these two industries and water transportation are not available from BLS.

Consumer Price Index

An increase in productivity often translates into lower prices for products and services, or a slower rate of increase in prices than otherwise would be expected due to general inflation. Figure 2-7 presents consumer price indexes for major categories of goods and services for the 1982 to 1997 period. The average consumer price for transportation carriers and supporting service providers was 43 percent higher in 1996 than was reported for the 1982 to 1984 base period. In comparison, the average price of all consumer goods and services was 57 percent higher in 1996 than in the base period. Although the average price of transportation increased, it cost 25 percent less in 1996 relative to the base period if the price of other goods and services are taken into consideration (USDOL BLS 1998d).

Between 1982 and 1985, the average price of transportation services increased at about the same rate as the average price of all consumer goods and services. From 1986 to 1994, the increase in the average price of transportation services was the lowest among the five major categories of consumer goods and services. After 1994, the increase in the average price of transportation services had risen to that of the apparel category, but was still considerably lower than that of food and housing.

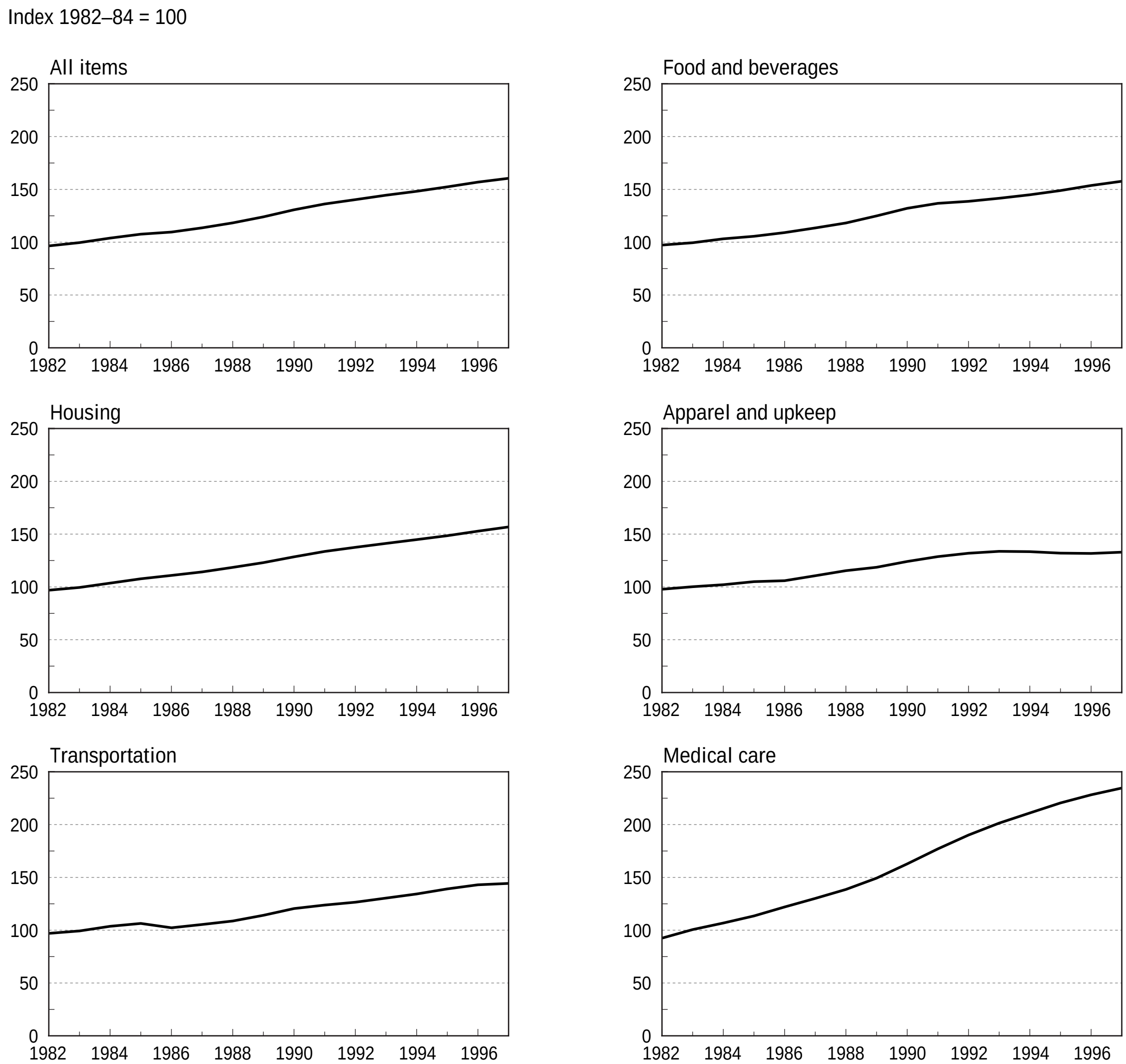
Figure 2-6.
Labor Productivity Indices: 1982–95
Index: 1982 = 100



NOTE: The latest data for railroad transportation are for 1993. For air transportation, labor productivity index is based on output per employee.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "Major Sector Productivity and Cost Index" and "Industry Productivity Index," available at http://stats.bls.gov/top20.html, cited as of February 1998.

Figure 2-7.
Consumer Price Indices for Major Categories of Goods and Services: 1982–97
(All urban consumers)



NOTE: Three years (1982–84) are used as a reference period for the price index. The average expenditure over three years is more stable than that of one year, and hence may be a better base for trend analysis.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, “Consumer Price Index–All Urban Consumers,” available at http://stats.bls.gov.top20.html, cited as of February 1998.

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Transportation Safety

In 1996, 44,505 people in the United States lost their lives in crashes and incidents involving transportation vehicles, vessels, aircraft, and pipelines. Transportation fatalities account for slightly under half of all U.S. accidental deaths.

Despite the enormous toll, much progress has been made in improving transportation safety over the last three decades. Indeed, the number of fatalities for most modes in 1996 was much lower than in 1970, even though travel has doubled (see table 3-1). Yet, there is little reason for complacency, and, as is discussed subsequently in the modal profiles section of this chapter, safety indicators for some modes have shown little improvement in the last several years.

Fatalities and injuries occur in all modes, but crashes involving motor vehicles[1] account for almost 95 percent of all transportation fatalities and most injuries. Motor vehicle and firearm fatalities were the two leading causes of injury deaths in the United States in 1996, accounting for 29 and 24 percent of all injury deaths,[2] respectively (USDHHS 1997). Societal economic losses from motor vehicle crashes are huge, estimated by the National Highway Traffic Safety Administration (NHTSA) to exceed $150 billion annually (Blincoe 1996).

[1] Includes crashes involving pedestrians and pedalcyclists struck by motor vehicles, occupants of cars, trucks, and buses, and motorcycle riders.

[2] Injury deaths (i.e., those deaths that are not due to a disease or medical procedure) include unintentional injury, suicide, homocide, legal intervention, and injury from war operations.

Table 3-1.
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-borne[8]	Recre-ational boating	Gas and hazardous liquid pipeline
Fatalities: 1960–96										
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	[R]956	43,825	454	N	131	1,116	[R]33
1990	39	7	50	[R]765	44,599	599	339	85	865	9
1991	50	77	[R]70	[R]794	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	63	[R]730	40,716	611	320	[R]69	784	22
1995	168	9	52	[R]734	41,817	567	274	46	829	21
1996	380	14	63	631	41,907	551	264	50	709	20
Injuries: 1985–96										
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]3,149,000	17,284	52,668	[R]160	3,559	112
1994	35	6	32	452	[R]3,265,000	14,850	58,193	[R]179	4,084	[R]1,971
1995	25	25	14	395	[R]3,465,000	12,546	57,196	145	4,141	64
1996	77	2	20	359	3,511,000	10,948	55,288	129	4,442	85
Accidents: 1985–96										
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	58,077	3,613	6,411	[R]378
1991	26	22	87	[R]2,175	6,117,000	2,658	46,418	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]2,038	[R]6,106,000	2,611	30,559	[R]3,425	6,335	447
1994	[R]23	10	[R]85	[R]1,995	[R]6,496,000	2,504	29,972	[R]3,972	6,906	[R]465
1995	[R]36	[R]11	[R]75	[R]2,055	[R]6,699,000	2,459	25,683	[R]4,196	8,019	349
1996	38	12	89	1,905	6,842,000	2,443	21,412	3,799	8,026	380

[1] Large carriers operating under 14 CFR 121, all scheduled and nonscheduled service.
[2] All scheduled service operating under 14 CFR 135.
[3] Nonscheduled service operating under 14 CFR 135.
[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 bus, 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/Incidents include only collisions and derailments/vehicles going off the road.
[8] Vessel casualties only.

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

SOURCE: Various sources, as compiled and reported in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at http://www.bts.gov/ntda/nts.

Our increasingly mobile society exposes all age groups to the risks of crashes, as passengers, as drivers, and as pedestrians. Motor vehicle crashes are the leading cause of death for people between 6 and 27 years of age (USDOT NHTSA 1998).

To illustrate the loss that motor vehicle crashes impose on society, a metric called years of potential life lost (YPLL) before age 75 can be applied.[3] Table 3-2 shows that over the last 15 years the country has seen a drop of 32 percent in YPLL from motor vehicle crashes, almost twice the decrease in YPLL for all causes of death. The YPLL estimates, however, fail to account for people over the age of 75, a fast growing segment of the population.

People are living longer and driving for more years than ever before. There were 16.5 million licensed drivers in 1995 who were age 70 or older, about a 47 percent increase from 1985 (USDOT NHTSA 1997). Older drivers and their special needs will continue to be a factor in traffic and vehicle planning decisions as the baby boom cohort ages. Injuries to elderly passengers and elderly pedestrians involved in transportation crashes and incidents are more likely to prove fatal or to have lasting health impacts than the same injuries would for younger adults.

People are also exposed to transportation risks at work. Transportation-related incidents in transportation occupations and industries account for some of the highest rates of occupational fatalities and injuries in the economy. In 1996, 6,112 workers died from occupational injuries: about 36 percent died in motor vehicle or aircraft crashes, or in accidents involving railroads or water vessels. Among those killed were 785 truck drivers, 100 airplane pilots and navigators, and 65 taxicab drivers and chauffeurs. Workers in the transportation and public utilities industries experience fatality rates (deaths per 100,000 employees) far higher than those in the economy as a whole—13.1 versus 4.8. Fatality rates, however, are higher in the mining and agri-

[3] This measure of premature mortality was developed by the National Center for Health Statistics. Since 1996, YPLL has been calculated for persons under 75 years of age; before 1996, 65 years of age was the ceiling used. Average life expectancy in the United States is over 75 years.

Table 3-2.
Years of Potential Life Lost Before Age 75 for Selected Causes of Death
(Per 100,000 population under 75 years of age)

	1980		1990		1995		Percentage change
	Years	Percent	Years	Percent	Years	Percent	1980–95
Total population (thousands)	226,546	100.0	248,718	100.0	262,890	100.0	16.0
Under 75 years of age (thousands)	216,577	95.6	235,684	94.8	248,089	94.4	
Cause of death							
All causes of death	9,814	100.0	8,793	100.0	8,128	100.0	–17.2
Motor vehicle crashes	1,011	10.3	789	9.0	688	8.5	–31.9
Other unintentional injuries	678	6.9	474	5.4	468	5.8	–31.0
Suicide	403	4.1	406	4.6	406	5.0	0.7
Homicide and legal intervention	461	4.7	466	5.3	436	5.4	–5.3
Other causes	7,262	74.0	6,658	75.7	6,131	75.4	–15.6

SOURCE: U.S. Department of Health and Human Services, National Center for Health Statistics, Centers for Disease Control, *Health, United States, 1996–97* (Hyattsville, MD: 1997), tables 1 and 32.

cultural industries, at over 20 deaths per 100,000 workers in 1996 (USDOL OSHA 1997).

Ensuring the safe passage of people, goods, and vehicles that carry them is the highest priority of the U.S. Department of Transportation (DOT) (USDOT 1997). Keeping track of safety trends is essential for monitoring progress toward achieving this goal, and good data are required for this purpose.

This chapter summarizes recent safety statistics, discusses trends, and evaluates data adequacy in light of current modal issues. Particular attention is paid to the need for better measures of exposure to risk of death, injury, or property damage by users of the transportation system. The chapter also discusses causes of transportation crashes and incidents (with special attention given to the weather), and features a discussion of transportation safety and the elderly.

A PERSPECTIVE ON RECENT CRASHES

The numbers of fatalities and injuries tallied in the national statistics are so large that the human toll that lies behind these statistics is difficult to grasp. In some ways, the reality behind these figures is understood more keenly by focusing on particular crashes or accidents, each with its own set of circumstances. In many cases, investigation of particular incidents reveals a broader problem needing the attention of safety officials and organizations.

Table 3-3 lists examples of the U.S. transportation crashes and accidents that occurred from mid-summer 1996 through the end of 1997. These incidents reflect one or more of the following circumstances: a large number of fatalities relative to transportation incidents for the mode concerned; substantial property or environmental damage; extensive public attention; or a highly visible safety issue, such as school bus safety or safety concerns about pipelines in densely populated areas. The incidents in the table are not intended to be representative of incidents in these modes and do not reflect the frequency of accidents in these modes.

Although 19 of 20 transportation fatalities take place on highways, most fatal highway crashes involve one or two deaths and seldom attract national or international attention. An exception (not listed in table 3-3 because it occurred in France) was the death of Princess Diana, her friend, Dodi Al Fayed, and their driver in a high-speed crash in August 1997. Although still under investigation, the crash focused worldwide attention on the tragic impacts of motor vehicle crashes and increased awareness of safety issues. Tests showed the driver to be legally intoxicated by French standards. Also, the only survivor of the crash was wearing a safety belt.

The relatively small share of motor vehicle crashes that involve multiple fatalities also can focus public attention on safety issues. One example occurred on July 29, 1997, in Michigan. Eleven people, including nine children, died when a pickup truck ran a stop sign and was rammed by a dump truck; the children were riding in the rear of the pickup truck. Another example that received national attention occurred in June 1997. Four pedestrians were killed and three injured when they were struck by an urban transit bus at a “park and ride” facility in Missouri. The National Transportation Safety Board (NTSB) found that the driver, a trainee, misapplied the accelerator of the bus. A contributing factor was inadequate separation between the roadway of the transit facility and its pedestrian platform (NTSB 1998a).

These high profile crashes are dramatic illustrations of a more general fact about motor vehicle safety. Most motor vehicle crashes are in some sense preventable, and human factors contribute to a high proportion of crashes. Choices made by drivers and occupants affect their expo-

Table 3-3.
Selected Transportation Crashes and Incidents: September 1996–December 1997

Date	Mode	Location	Incident	Consequence
9/4/96	Highway	Washington, DC	Bus with elderly tourists collided with sport utility vehicle on Interstate highway	1 death, 32 injuries
9/5/96	Water	Cape Ann, MA	Collision between fishing vessel and tank barge	3 deaths, tank barge capsized
9/6/96	Air	Newburgh, NY	Cargo/courier jet in-flight fire	Plane destroyed, minor injuries
9/27/96	Water	Portland, ME	Liberian tank vessel rammed the Million Dollar Bridge, with oil spill	Substantial damage to ship and bridge, 170,000 gallons of oil spilled into waterway
11/19/96	Air	Quincy, IL	Commuter plane collided on runway with private plane	14 deaths, both planes destroyed
11/21/96	Pipeline	San Juan, PR	Leak and explosion of gas line in residential and shopping district	33 deaths, 69 injuries, damage to buildings and cars in adjacent area
11/23/96	Rail	Secaucus, NJ	Derailment of an Amtrak train, which sideswiped another Amtrak train on adjacent track	43 injuries, more than $3.6 million in damages, 12 cars derailed
12/7/96	Water	Marina del Rey, CA	Fire on pleasure craft near dock	62 passengers jumped into water
12/14/96	Water	New Orleans, LA	Ramming of wharf and adjacent mall, hotel, and parking garage by Liberian bulk carrier	4 serious injuries, 58 minor injuries, $20 million in damages
12/22/96	Air	Narrows, VA	Courier jet crashed in post-maintenance flight test	6 deaths, plane destroyed
1/9/97	Air	Monroe, MI	Commuter plane crashed on landing approach and burned	29 deaths, plane destroyed
1/12/97	Rail	Kelso, CA	Derailment of freight train	$4.4 million in damages, 3 locomotives and 68 cars derailed
1/13/97	Highway (Transit)	Cambridge, MA	Transit bus plunged through ice into Charles River	1 death
2/12/97	Highway	Slinger, WI	Double tractor-trailer crossed median and back with multiple collisions	8 deaths, 4 injuries
4/10/97	Highway	Monticello, MN	School bus hit by gravel truck	4 deaths
6/11/97	Transit	Normandy, MI	Transit bus struck 7 pedestrians at park and ride facility	4 pedestrians deaths, 3 injuries

(continued on following page)

Table 3-3.
Selected Transportation Crashes and Incidents: September 1996–December 1997 *(continued)*

Date	Mode	Location	Incident	Consequence
7/2/97	Rail	Rossville, KS	Collision and fire on 2 freight trains carrying hazardous materials	1 death, 1 injury, evacuation of 1,000 nearby residents
7/29/97	Highway	Concord, MI	Pickup truck ran a stop sign; hit by dump truck at intersection	11 deaths, including 9 children riding in the back of the pickup truck
7/29/97	Highway	Petersburg, VA	Charter bus carrying children plunged into Virginia River	1 death, 10 injuries
7/31/97	Air	Newark, NJ	Courier jet bounced on landing and burned	Plane destroyed
8/6/97	Air	Guam	Foreign air carrier jet crashed while trying to land	226 deaths, plane destroyed
8/7/97	Air	Miami, FL	Cargo jet crashes near Miami airport	5 deaths, plane destroyed
8/9/97	Water	Gloucester, MA	Fire on, and subsequent sinking of, whale-watching boat	143 passengers rescued by Coast Guard
8/18/97	Highway	Baltimore, MD	Gasoline tanker truck overturned on beltway, with explosion	1 death, 2,800 gallons of gasoline exploded, Interstate highway closed for several hours
11/17/97	Highway	Mendota, CA	Van carrying 12 people collided with semi-trailer while trying to pass in fog	11 deaths, van destroyed
12/11/97	Highway	Sacramento, CA	Fog on Interstate highway caused multiple crashes and fires involving 36 vehicles	5 deaths, 26 injuries
12/14/97	Multi-modal	Littleton, CO	Medical helicopter snagged in power lines after picking up auto crash victims	4 deaths in helicopter, 1 death in car crash, 15,000 lose electrical power
12/28/97	Air	Pacific Ocean	Jet airliner hits severe turbulence at 31,000 feet	1 death, 102 injuries

NOTE: A September starting date was selected to provide continuity with a similar table in *Transportation Statistics Annual Report 1997.*

sure to risk. For example, the risks of highway travel are quite different for a passenger wearing a safety belt in a car driven by a careful driver at a safe speed than the risks of travel for an unbelted passenger in a car driven at high speed by an aggressive driver.

Although commercial aviation accounts for only a small share of transportation fatalities, the crash of a large passenger jet usually prompts a great deal of public and media attention. The crashes of ValuJet 592 on May 11, 1996, and TWA 800 on July 17, 1996, with 110 and 230 fatalities, respectively, were in the daily news for many weeks. Another major air disaster, this one involving a foreign carrier, took place in Guam (a self-governing U.S. territory) in August 1997, when 226 people died. Two other crashes involving foreign carriers focused attention on the safety of air operations in other countries. In November 1996, airplanes from Saudi Arabia and Kazakstan collided, killing at least 349 people in history's deadliest midair crash. In December 1997, an Indonesian crash in dense haze arising from forest fires claimed 97 lives. These and other crashes outside the United States have contributed to a growing concern for the safety of U.S. citizens traveling abroad. According to the American Travel Survey, Americans took nearly 27 million roundtrips by air to destinations outside the United States in 1995 (USDOT BTS 1997).

Despite the great attention focused on commercial airline crashes, general aviation crashes involving private planes operated by individuals and businesses claim far more lives each year on average. Like motor vehicle crashes, general aviation crashes seldom receive much national media attention. An exception in 1997 was the crash that claimed the life of entertainer John Denver, who was piloting his own experimental aircraft. As is discussed in the modal profile section, good exposure measures for general aviation are lacking.

Exposure to transportation risk is not limited to people on the move. Bystanders, people on nearby property, or even nearby communities can be exposed to risks—albeit remote—as is suggested by several of the incidents in table 3-3. Since 1990, there have been, on average, nearly 300 accidents each year related to the transportation of hazardous materials (excluding pipelines).

Hazardous materials incidents, such as the overturning of a gasoline tanker truck on the Baltimore, Maryland, beltway in August 1997, and the collision of freight trains carrying hazardous materials near Rossville, Kansas, in July 1997, can require closing of highways and evacuation of nearby residents as a precaution.

People in a commercial district of San Juan, Puerto Rico, were the victims of a deadly pipeline accident that occurred in November 1996, and resulted in 33 deaths and 80 injuries. The NTSB investigation of the disaster found that leaking propane from a cracked pipe, damaged several years earlier from excavation, fueled the explosion (NTSB 1997). Excavation damage is a perennial pipeline safety problem.

In another incident, a Mississippi River bulk carrier rammed a wharf adjoining a waterfront mall in New Orleans in December 1996, causing substantial property damage and four serious injuries. The vessel temporarily lost propulsion power, a failure NTSB ascribed to inadequate management and oversight of maintenance of the vessel's powerplant. This accident highlights the risks of siting commercial development in locations vulnerable to vessel mishaps. According to NTSB, inadequate efforts had been made to assess, manage, or mitigate these risks (NTSB 1998b).

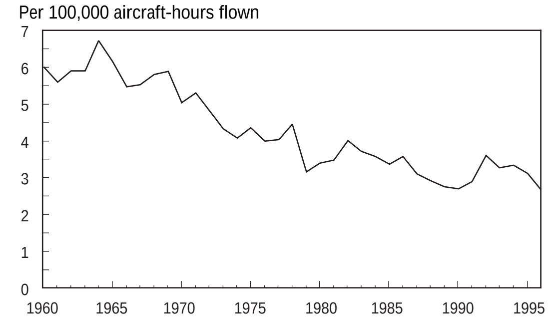
MODAL PROFILES

Figure 3-1 shows fatality rates by specified unit of exposure for selected transportation modes. (Rates are calculated using occupant fatalities where data permit.) The long-term improvement in occupant safety is evident here as in table 3-1 (which showed change in absolute number of fatalities). As is discussed subsequently, good exposure measures by which to analyze some modes, such as recreational boating, are not available. The number of boating fatalities has trended downward, however, while activity levels are likely to have increased. Hence, improvement in boating fatality rates is also likely.

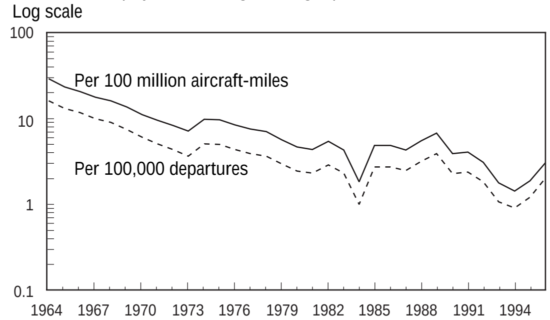
Table 3-4 shows the distribution of transportation fatalities in 1996. Over 77 percent of the fatalities were occupants of cars, light trucks (including sport utility vehicles), or motorcyclists. Another 14 percent were pedestrians or bicyclists struck by motor vehicles. Recreational boating and general aviation (including private business planes and private-use planes) together

Figure 3-1.
Fatality Rates for Selected Modes

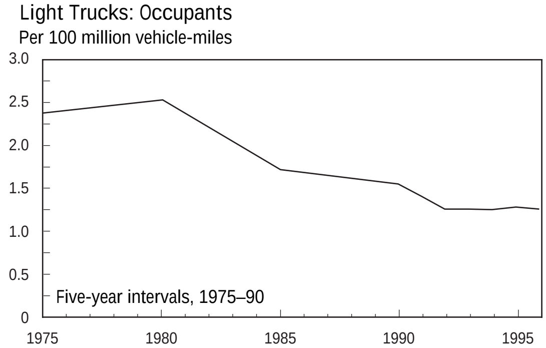
General Aviation (noncommercial)



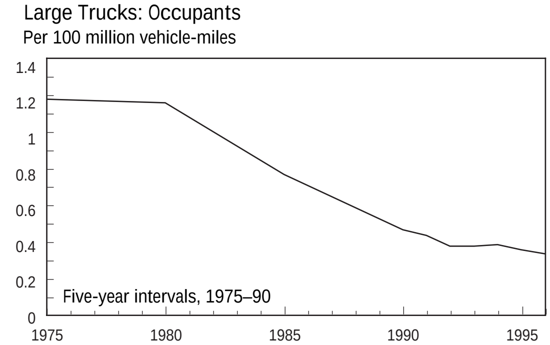
Air Carriers (5-year moving averages)



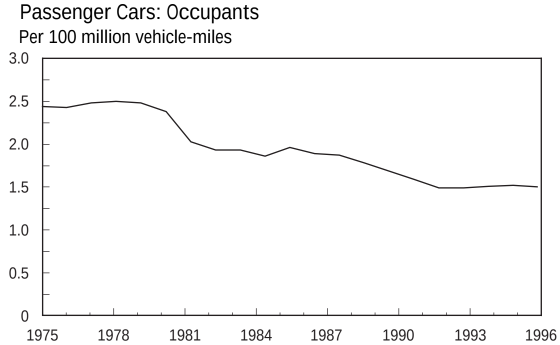
Light Trucks: Occupants



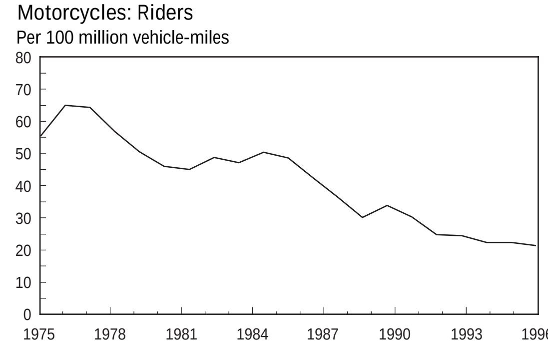
Large Trucks: Occupants



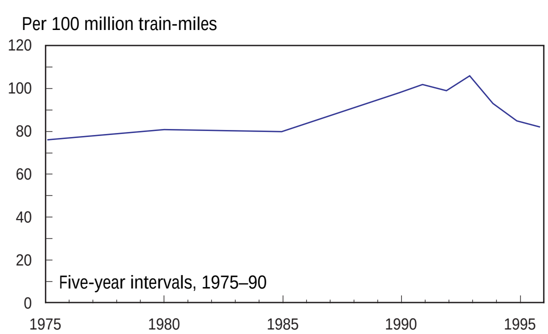
Passenger Cars: Occupants



Motorcycles: Riders



Railroad: Passengers, Employees, Contractors and Other Nontrespassers, and Trespassers (excludes grade-crossing fatalities)



SOURCES: General aviation—For 1960–74, data include air taxi. Data from U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook* (Washington, DC: 1960–74). For 1975– 96: National Transportation Safety Board, *Annual Review of Aircraft Accident Data, General Aviation* (Washington, DC: Annual volumes). For all other modes: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at http://www.bts.gov/ntda/nts.

Table 3-4.
Distribution of Transportation Fatalities: 1996

Category[1]	1996	Percent
Total	44,505	100.0
Passenger car occupants	22,416	50.4
Light-truck occupants	9,901	22.2
Pedestrians struck by motor vehicles	5,412	12.2
Motorcyclists	2,160	4.9
Pedalcyclists struck by motor vehicle	761	1.7
Recreational boating	709	1.6
General aviation	631	1.4
Large-truck occupants	621	1.4
Railroad[2] (excluding grade crossings)	551	1.2
Other and unknown motor vehicle occupants	460	1.0
Air carriers	380	0.9
Other nonoccupants struck by motor vehicles[3]	153	0.3
Heavy rail transit (subway)	74	0.2
Grade crossings, not involving motor vehicles[4]	73	0.2
Air taxi	63	0.1
Waterborne transportation	50	0.1
Bus occupants (school, intercity, and transit)	21	< 0.1
Transit buses, fatalities not related to accidents[5]	19	< 0.1
Commuter air	14	< 0.1
Gas distribution pipelines	14	< 0.1
Demand response transit fatalities not related to accidents[5]	8	< 0.1
Light rail transit	6	< 0.1
Hazardous liquid pipelines	5	< 0.1
Undetermined motor vehicle occupants	2	< 0.1
Gas transmission pipelines	1	< 0.1
Other counts, redundant with above[6]		
Grade crossings, with motor vehicles	415	
Transit buses, accident-related fatalities	82	
Commuter rail	72	
Passengers on railroad trains	12	
Demand response, accident-related fatalities	3	

[1] Unless otherwise specified, includes fatalities outside the vehicle.
[2] Includes fatalities outside trains.
[3] Includes all nonoccupant fatalities, except pedalcyclists and pedestrians.
[4] Grade-crossing fatalities involving motor vehicles are included in counts for motor vehicles.
[5] Fatalities not related to accidents for transit buses and demand response transit are not included under highway submodes.
[6] Fatalities at grade crossings with motor vehicles are included under relevant motor vehicle modes. Commuter rail fatalities are counted under railroad. For transit bus and demand response transit accidents, occupant fatalities are counted under "bus" and nonoccupant fatalities are counted under "pedestrians," "pedalcyclists," or other motor vehicle categories.

SOURCES: Various sources, as compiled and reported in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at http://www.bts.gov/ntda/nts.

accounted for 3 percent of the fatalities—more than all commercial passenger modes and freight trains combined. Occupants of large trucks accounted for 1.4 percent of all transportation fatalities, although large trucks were involved in crashes that resulted in 11.5 percent of the fatalities in the table.

The following modal profiles focus on selected safety concerns that have implications for the collection and analysis of data.

Motor Vehicles

The nation's highways are much safer now than 30 years ago, even though vehicle-miles have doubled. Both the absolute number of motor vehicle fatalities and the rates have declined. If the fatality rates in the late 1960s—more than 5 fatalities per 100 million vehicle-miles—had persisted, more than twice as many people would have died on the road in 1996 than actually were killed. (This estimate factors in the decrease in occupancy rates of motor vehicles since the late 1960s.)

The improvements, however, leveled off in the 1990s. In 1992, there were 39,250 motor vehicle fatalities, the fewest deaths since 1962. Subsequently, the numbers of deaths have started to rise. Because travel has increased, the fatality rate has stayed flat at 1.7 fatalities per 100 million vehicle-miles.

Numerous factors interact to affect highway safety: roadside safety features, demographics, vehicle size, onboard equipment, use of occupant protection devices, driver and pedestrian distractions and fatigue, alcohol and drug use, and vehicle speed, to cite just a few. The beneficial effects of programs to discourage alcohol abuse and encourage use of occupant protection devices, technological advances such as antilock braking systems and traction control, and advances in trauma intervention are apparent. Yet, only about two-thirds of Americans use safety belts, despite evidence that their use saves lives and reduces injury severity in crashes. (See box 3-1 for a discussion of alcohol and drug involvement in crashes.) New approaches, in addition to maintaining those already working well, will also be essential if there is to be improvement in fatality, injury, and crash rates.

► Safety Effects of Speed Limit Changes

In December 1995, Congress repealed the last federal provisions for a 55 miles per hour (mph) speed limit. The 55 mph limit, put in place nationwide in 1974, was adjusted in 1987 to allow states to raise rural Interstate limits to 65 mph. The 1995 repeal granted states sole authority to set speed limits on all roads within state boundaries. As of August 1997, only Connecticut, the District of Columbia, Hawaii, and New Jersey had elected not to raise speed limits on at least some part of their Interstate highways. The upper speed limit, types of roads and vehicles eligible, and other circumstances vary greatly among states. Montana, for example, has no specified upper limit for daytime speed on rural Interstates. Ten states have set lower speed limits for trucks than for passenger vehicles on their rural Interstate highway segments.

Many analytical efforts have tried to assess the crash impacts of speed limit increases in a particular state for a certain period; however, the conclusions of these studies differ. A 1997 study found an association between higher speed limits and occupant fatalities (Farmer et al 1997). The study compared data for the 12 states that increased their speed limits to 70 mph or higher on Interstate highways with data from 18 states that either did not raise limits, or raised limits on less than 10 percent of urban mileage. The states with 70 mph and higher limits experienced a 12 percent or higher increase in occupant fatalities. A smaller increase was found on other types of roads.

A report to Congress, released in 1998, detailed the findings of a jointly sponsored

Box 3-1.

Alcohol and Drug Involvement in Transportation Crashes and Incidents

Alcohol and drug involvement are factors in transportation crashes and incidents, and account for a high number of fatalities each year. Reporting agencies use a variety of definitions and procedures to determine alcohol and drug involvement, making comparable cross-modal tallies difficult. Testing drivers or operators involved in crashes for alcohol is common. For motor vehicle drivers, most states use a blood alcohol concentration of 0.10 grams per deciliter as the legal definition of intoxication, although 13 states have set the limit at 0.08. Also, 38 states have a lower limit for young drivers. The police use field sobriety tests and breathalyzers routinely at the site of a motor vehicle crash. In the case of transit employees, a saliva testing device is used to test for alcohol. Testing for drug involvement in transportation crashes is more difficult than alcohol testing, since urine samples must generally be obtained.[1] Even then, only some drugs can be verified conclusively.

In 1996, alcohol was a factor in crashes involving motor vehicles that claimed 17,126 lives or 41 percent of all highway fatalities that year. Alcohol involvement tallies include drivers and nonmotorists, mostly pedestrians, in fatal crashes. In 1982, at the beginning of a renewed, national effort to eliminate alcohol as a crash contributor, 25,165 fatalities, constituting 57 percent of all highway fatalities, occurred in crashes involving alcohol.

The proportion of drivers in fatal crashes varies widely by vehicle type. For instance, drivers of large trucks involved in fatal crashes had a 1.4 percent intoxication rate in 1996, while drivers of light trucks, passenger cars, and motorcycles involved in fatal crashes had 22, 19, and 30 percent intoxication rates, respectively. Alcohol is often coupled with excessive speed. In 1996, 42 percent of intoxicated drivers involved in fatal crashes were speeding (USDOT NHTSA 1997a, 2). There is, however, no single profile of an alcohol-impaired driver.

Alcohol usage is a factor in pedestrian safety as well. In 1996, of the pedestrians killed in traffic accidents who were 14 years of age or older, 36 percent were intoxicated (USDOT NHTSA 1997b, 38).

The National Transportation Safety Board investigates aviation accidents where drugs or alcohol are suspected. In 1995, 22 fatalities occurred in general aviation accidents where the agency determined that alcohol or unapproved drugs were involved. No data were compiled for commercial air carriers. U.S. Coast Guard (USCG) investigations showed that 29 alcohol-related deaths and 6 drug-related deaths occurred for waterborne commerce in 1995. Of the 846 recreational boating fatalities in 1995, USCG records show 149 fatalities associated with alcohol use, and 17 with drug use (USDOT BTS 1997).

REFERENCES

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS). 1997. *Transportation Statistics Annual Report 1997*. Washington, DC.

U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA). 1997a. *Speeding: Traffic Safety Facts 1996*. Washington, DC.

_____. 1997b. *Traffic Safety Facts 1996*, DOT HS 808 649. Washington, DC. December.

[1] The National Highway Traffic Safety Administration encourages police to do more urine collection when there is suspicion of drug involvement, particularly when alcohol has been ruled out by field sobriety or breathalyzer tests. Some field tests exist for drugs, but their results are not considered to be conclusive.

NHTSA/Federal Highway Administration (FHWA) analysis of Interstate highway fatalities and economic costs associated with repeal of the national 55 mph limit (USDOT NHTSA FHWA 1998). The study is based on data from the first year of fatal crash experience, 1996, which for most states is only a partial year with the higher limits. It is estimated that fatalities on Interstates were about 9 percent higher in 32 states that increased speed limits than would have been expected given historical trends. The study noted, however, that it was not known how various traffic safety factors may have contributed to the increase; more data would be needed to conduct this analysis. No change in the expected pattern of fatalities was evident on

Interstates in states that did not raise speed limits. The study did not attempt to assess the potential benefits of the repeal—such as travel time—stating that data would need to be collected for a more protracted period. The study also included a summary of material from 10 states that conducted their own studies.

There are several factors that complicate analyses of the effects of raised speed limits. Many drivers tend to exceed posted speed limits. It is possible that for certain segments of highway on which there was a change in speed limits, actual driving speeds may show little change. Conversely, on other highway segments, actual speeds may increase by more than the increase in speed limits. The degree of enforcement of the limit, before and after the repeals, could also affect the consequences of the repeals, so could the enforcement of drunk driving laws, as alcohol use is correlated with drivers exceeding posted limits.

▶ Injury and Exposure Data Needs

Analysis of motor vehicle safety is impeded by the lack of meaningful risk exposure measures for specific conditions faced or induced by drivers. In addition, the number and severity of injuries is inadequately reported in national estimates.

A great deal of diverse data are needed to analyze how various conditions and countermeasures affect the number of highway crashes, and how some crashes might be prevented. Examples include: description of the attributes of crashes, such as vehicle types, persons involved, and crash circumstances; and exposure measures, such as the amount of driving by subsets of the population or by specific time period (e.g., by age or time of day). Even with the best data, it is always difficult to separate out the effects of policy and intervention measures from other factors that affect driving risk.

By dividing the number of crashes by an appropriate exposure measure, meaningful and policy-relevant rates can sometimes be developed. Practical limitations on data collection and conceptual difficulties limit the number of reliable rates.

Data with multiple attributes have been collected for years for motor vehicle-related fatalities. Samples of injury and/or property damage crashes have also been collected over a number of years, but not with the same reporting consistency. The need for better information about crashes involving injuries is clear, and several states are now participating in an effort to improve reporting of injury data (see box 3-2). This effort, called the Crash Outcome Data Evaluation System, is supported in part by NHTSA.

Where specific exposure measures are lacking, indirect methods (such as proxies) are sometimes employed. For example, if the exposure of drivers of a certain age group is sought, and data on miles driven by age group of driver are unavailable, data on the proportion of licensed drivers by age group can be used as a proxy. More sophisticated indirect methods have sometimes been used to measure the effects of interventions like safety belt laws, minimum drinking age laws, and speed limit changes, because no exposure or proxy exists. Clearly, however, more detailed benchmark exposure data would be useful for safety analysis.

The location of crashes is another fundamental data need that is inadequately addressed in current databases. Location information could facilitate development of exposure measures that account for the influence of highway design elements and the level of traffic on the number and severity of crashes.

Safety analysis would also benefit from more detailed data on fatal crashes and injury or

Box 3-2.
Motor Vehicle Crash Data

The Fatality Analysis Reporting System (FARS), begun in 1975 and maintained by the National Highway Traffic Safety Administration (NHTSA), lists every crash involving a motor vehicle on a public road[1] in which at least 1 person died within 30 days of the crash. Over 100 attributes for each crash are collected and are classified as one of four levels: crash, vehicle, person, or driver. The 23 years of FARS data make it possible to compare and interrelate attributes from these levels over time.

National estimates of injuries and nonfatal crashes are subject to many more uncertainties than fatality counts. The General Estimates System (GES), the major database on injuries, contains a sample of police accident reports (PARs) for motor vehicle crashes. In contrast to FARS, sampling errors occur because the GES includes only some PARs from state databases. Other errors arise for many reasons. For example, police at the site of a crash often have too little information and knowledge to estimate injury severity. Also, many crashes are not reported to the police. While unreported crashes generally involve only minor injuries and property damage, cumulatively they represent many injuries and sizable property damage. The General Accounting Office and others have cautioned against using PAR data for certain types of safety analyses. Because only PAR data are used, perhaps as many as half of all motor vehicle crashes not involving a fatality are not included in the GES database. Thus, estimates for accidents, injuries, and property damage are underreported.

Recently, several states, with NHTSA support, have begun developing the Crash Outcome Data Evaluation System (CODES) to provide more comprehensive and consistent information about injuries from highway crashes. For example, at least 14 states are seeking to link highway crash reporting and medical data systems. This could result in much more complete reporting about the number of injuries, their severity, and their economic costs as reflected in hospital and rehabilitation costs.

The states are also working with the federal government to develop more detailed information about truck and bus crashes. In addition to the FARS and GES, truck crash data can be found in the Motor Carrier Management Information System (MCMIS) database[2] and the Trucks Involved in Fatal Crashes file (detailed information on fatal truck crashes). The databases have different crash reporting thresholds, and for this and other reasons, the numbers of crashes reported are not always in agreement. The MCMIS statistics suffer from incomplete reporting by states. The Office of Motor Carriers receives reports on only about 61 percent of trucks involved in crashes that would be reportable under criteria recommended by the National Governors' Association.[3] The GES bus file is based on a very small sample.

REFERENCE

Venturi, C., National Highway Traffic Safety Administration, U.S. Department of Transportation. 1998. Personal communication.

[1] A public road, or trafficway, is defined as any road, street, or highway open to the public as a matter of right or custom for moving persons or property from one place to another. Fatalities that do not occur on public roads are estimated to be less than 2 percent of the annual traffic fatalities (Venturi 1998).

[2] The MCMIS is maintained by the Federal Highway Administration Office of Motor Carriers (OMC). States report crashes to OMC through the Safetynet computer reporting system. MCMIS includes data elements recommended by the National Governors' Association (NGA) and covers trucks and buses involved in crashes that meet NGA thresholds (truck with 2 or more axles and 6 more tires, or a bus with 16 or more seats, including the driver's).

[3] NGA thresholds also require at least one fatality, one injury where a person is taken to a medical facility for immediate attention, or one vehicle towed from the scene due to disabling damage.

property damage crashes involving large trucks and buses. The 1991 Intermodal Surface Transportation Efficiency Act emphasized motor carrier safety by mandating that the 48 contiguous states participate in the Safetynet program and report crashes involving large trucks and buses to the FHWA Office of Motor Carriers.[4] Several truck crash databases exist, but not all states report crashes meeting reporting thresholds (as is discussed in box 3-2).

[4] Large trucks are defined as vehicles with a gross vehicle weight of 10,000 pounds or more. Buses (e.g., school buses, transit buses, and motorcoaches) are defined as vehicles with more than 15 seats, including the driver's.

Aviation

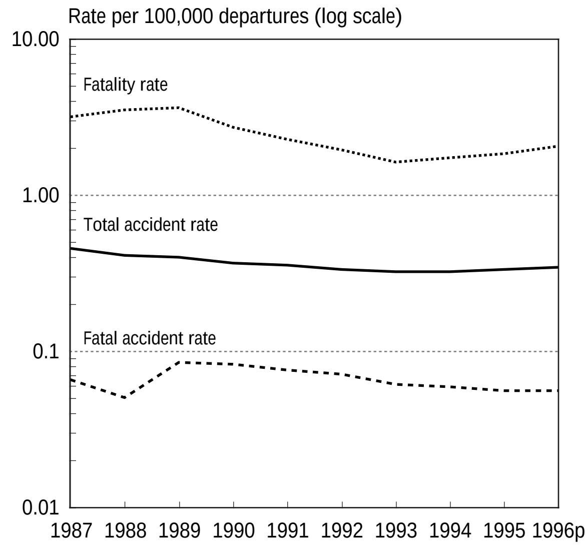
While crashes of the magnitude of TWA Flight 800 contribute to the perception on the part of some that air travel is becoming less safe than it once was, the long-term trend depicted in figure 3-1 shows that travel today on U.S. airlines is much safer than it was in the 1960s.

The most robust improvement occurred in the 1960s and 1970s. Over the last 10 years, the fatality rate, fatal crash rate, and total crash rate have remained relatively stable, as seen in figure 3-2, which expresses these rates as a moving average to reveal the trend that underlies year-to-year variations.

Concern about the long-term implications of continued growth in air travel without corresponding improvements in air safety was expressed by two recent blue-ribbon commissions on aviation safety and security. The final report by the Commission on Aviation Safety and Security was submitted to President Clinton in 1997 (USEOP 1997). The Commission recommended establishment of a national goal by government and industry of reducing the rate of fatal accidents in U.S. commercial aviation by a factor of five within a decade. The Commission further recommended that safety research be conducted to support the goal. Another group, the National Civil Aviation Review Commission, reported to Congress and the President in December 1997, urging concerted government and industry actions to improve aviation's safety and security (NCARC 1997).

The historical data show that the majority of aviation accidents occur during takeoff or landing, and a minority occur during the cruise phase of the flight. The cruise portion of the flight, however, constitutes the largest part of the total flying distance and the total flight time. Hence, of the different exposure measures—aircraft-miles, aircraft-hours flown, and number of operations (sometimes called landings and takeoffs)—the last is the best. Data on the first two exposure measures are available separately for all aircraft modes. As for the last and most preferable measure, data on the number of operations are available for major and commuter air carriers, but the number of landings for air taxi and general aviation are combined in the available data sets. Thus, data users must choose to either combine air taxi and general aviation in their analyses (which is not desirable, as the two submodes have quite different operating profiles), or rely on less useful exposure measures, that is, aircraft-miles flown or aircraft-hours operated.

Figure 3-2.
Fatality, Fatal Accident, and Total Accident Rates for Major Air Carriers: 1987–96
(10-year moving average)



KEY: p = preliminary.

NOTE: Data are for air carriers operating under 14 CFR 121, scheduled and nonscheduled service.

SOURCES:
Fatalities, accidents and fatal accidents data:
1978–81: National Transportation Safety Board, *Annual Review of Aircraft Accident Data* (Washington, DC: Annual issues).
1982–96: _____. NTSB Press Release SB 97-03, 1997.
Departures data:
Compiled by the Federal Aviation Administration, combining data from Forms 41, 298C, and 291, for Large Certificated Air Carriers, Small Certificated Air Carriers, and Express operations, respectively.

Highway-Railroad Crossing Collisions

About half of all rail-related fatalities result from collisions between trains and motor vehicles at railroad crossings. In 1996, 4,257 train-motor vehicle collisions occurred, killing 488 people and injuring another 1,610 (USDOT BTS 1998). In 1997, there were 453 grade-crossing fatalities. Figure 3-3 shows the location of all but 60 of these fatalities. More than one fatality occurred at some locations.

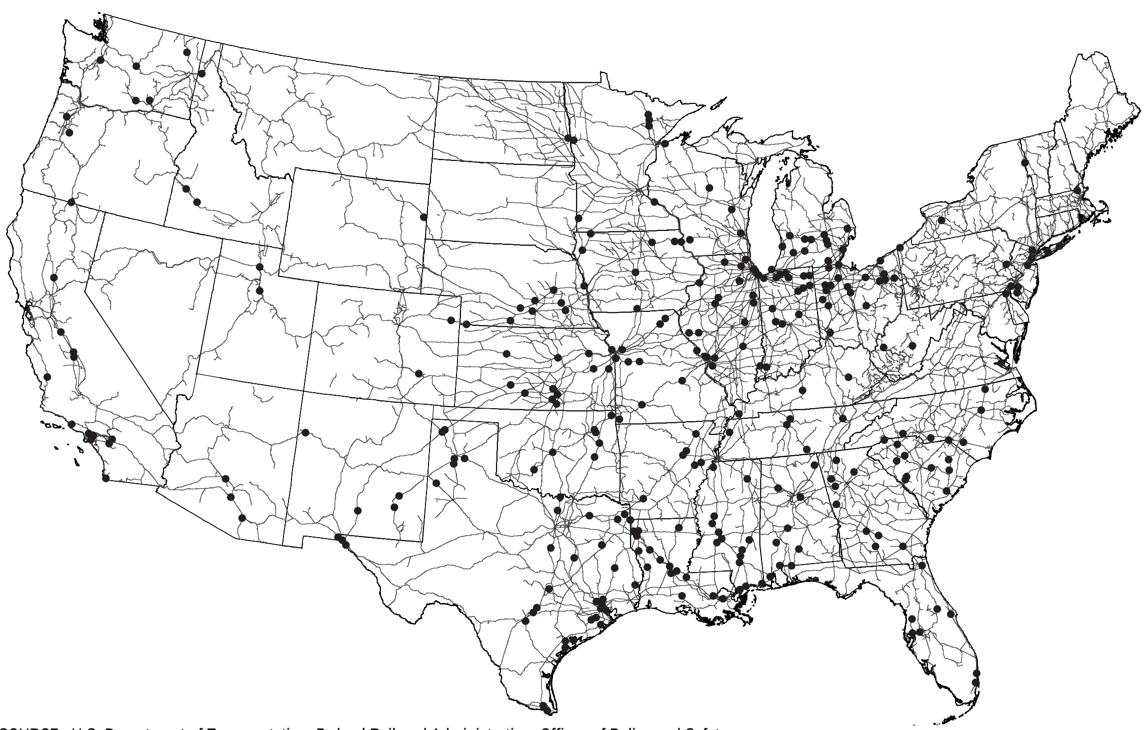
A variety of measures make many public and private grade crossings safer. In 1996, for example, 40,000 underpasses or overpasses separated trains from motor vehicles and other traffic. The vast majority of crossings, however, are at grade, and thus less safe. These include 162,000 public and 103,000 private at-grade crossings. Automatic gates have been installed on about 19 percent of public at-grade crossings, and another 18 percent have flashing lights. These and other active devices are considered more effective than passive devices such as crossbuck signs, which remain the most common form of warning. Most private crossings have no signs or signals (USDOT FRA 1997).

Public education and law enforcement also promote safety, because drivers who ignore warning indicators are a major cause of grade-crossing collisions. Under its Rail-Highway Crossing Safety Action Plan, DOT aims to reduce railroad crossing accidents and fatalities by 50 percent between 1994 and 2004.

Railroad Safety

Railroad mergers and acquisitions have led to concerns about safety. The freight rail industry has

Figure 3-3.
Grade-Crossing Fatality Locations: 1997



SOURCE: U.S. Department of Transportation, Federal Railroad Administration, Offices of Policy and Safety.

increased the tonnage it carries, while reducing the size of its workforce. In addition, more hazardous materials are being transported over rail.

Existing data make it laborious to separate fatalities and injuries in train accidents from fatalities and injuries that take place on railroad premises but do not involve moving trains. This complicates efforts to construct exposure rates for train travel. The Federal Railroad Administration includes in its fatality counts employees and other people who are not occupants on a moving train, including workers in railyards performing mechanical or electrical work, trespassers on the right-of-way, and contractors making deliveries on the premises. While including trespasser fatalities and injuries in railroad counts is similar in some respects to including pedestrian fatalities and injuries in highway counts, many more people die outside trains in railroad incidents than on them. Unless one looks very closely at the statistics, the effect is to make rail travel look less safe for passengers than it is.

Care needs to be taken to avoid double counting when analyzing railroad safety data, as commuter rail is included in both rail and transit totals. Also, data for crashes involving motor vehicles at rail-highway grade crossings may be counted in both the highway and rail totals. All double counting has been eliminated in the totals in table 3-4.

Transit

Of all modes, transit is the most eclectic. Transit vehicles operate on highways (buses), on railroad tracks or other fixed guideways (e.g., heavy and light rail, commuter rail, and cable car), and on the water (ferry boats). Transit operations often share all or part of the right-of-way with other modes. For example, buses travel primarily on city streets, although some systems operate routes using bus-only lanes. Commuter rail shares track with intercity passenger and freight rail. Surface light rail generally operates on an exclusive right-of-way, but with frequent grade crossings with motor vehicle and pedestrian traffic.

Because transit shares right-of-way with other modes, fatality, injury, and incident counts can be redundant with other modal counts. Thus, transit bus fatalities in the Safety Management Information Statistics (SAMIS) Report include not only those for transit bus occupants, but also pedestrian, pedalcyclist, and other vehicle occupant fatalities in incidents involving transit buses (USDOT FTA annual). In addition, the Fatality Analysis Reporting System (FARS) shows occupant fatalities for all buses, including transit. The SAMIS transit bus fatality count for 1996 (82) (table 3-4), might seem inconsistent with the FARS count for all buses (21). For the reasons explained above, however, there is no contradiction; the 82 transit bus fatalities from SAMIS are all counted in FARS, but spread over bus, passenger car, light truck, pedestrians, pedalcyclists, and so on. Hence, the transit bus fatalities from SAMIS *should not count* toward total fatalities for all modes. Similarly, commuter rail fatalities are included in the count for rail.

Another feature of the systemwide approach for collection of transit safety data is that all fatalities, injuries, and incidents on transit property, including those not caused by transit vehicle operations, (e.g., injuries on escalators and in parking lots) are counted. In this respect, the data problems discussed under railroad safety are similar to those in transit safety analyses.

Finally, those transit agencies receiving Urbanized Area (UA) Formula Funds are required to report transit data to the National Transit Database (NTD). This includes almost all government-owned transit agencies, as well as the vast majority of services provided under contract by private companies. Transit agencies not receiving UA Formula Funds are not included (e.g., agencies exclusively providing paratransit services that do not receive UA funds). This means that national totals of fatalities, injuries, and incidents for transit are slightly understated in the NTD. The degree of understatement can be estimated from data published by the American Public Transit Association, which estimates that nationwide transit passenger-miles in 1995 were 39,815 million (APTA 1996), as compared with the 37,970 million reported in the NTD. Thus, in 1995, the NTD covered 95 percent of transit service nationwide as measured in passenger-miles. Since the numerators (i.e., adverse outcome counts) and the denominators (i.e., exposure measures) for rate variables are both slightly understated, it is likely that the rates are even less in error than the totals.

Recreational Boating

Recreational boating differs from most other modes in two ways: almost all usage of this mode is discretionary, and the purpose of trips is primarily to spend time on the water, not to get from one point to another. It shares these characteristics with recreational walking and bicycling, which, however, do not comprise all walking and bicycling trips. Recreational flying and touring on a motorcycle or in an automobile also share these characteristics, but very often combine recreational objectives with destination-oriented travel.

The recreational purpose of most boating makes it hard to quantify risk exposure. Miles of travel are hard to estimate. Many boats do not have equipment to record travel distance. Moreover, this measure is not very meaningful, since traveling to a predetermined destination is seldom the purpose of a recreational boating trip. The number of trips is also not a good exposure measure, as a trip of longer distance or duration involves greater exposure to risk than a short-distance, short-duration trip. The longer the trip, the more likely the boaters are to be exposed to hazards such as submerged rocks or bad weather. Duration of trips (in boat-hours) may be the best measure of exposure. It reflects exposure to common hazards (e.g., human errors, weather, and equipment failure) and also expresses activity time on the water. Trip duration data are hard to collect, however.

At present, the U.S. Coast Guard (USCG) uses the number of registered boats (11.9 million in 1996) as an exposure measure. All boats, however, are not registered and all registered boats may not be in active use. Moreover, among boats in active use, some are used very infrequently, some are used seasonally, and some are used throughout the year.

The counts of fatalities, injuries, accidents, and property damage, especially the last three, are subject to underreporting. For example, all boating accidents involving a fatality, an injury requiring treatment beyond first aid, a missing person, complete loss of the vessel, or damage to the vessel or other property of $500 or greater are required to be reported to the Coast Guard (33 CFR 173). The requirement is hard to enforce, and the number of reported accidents—about 8,000 in 1996—excludes the many unreported accidents. While the great majority of fatalities and missing persons are reported promptly, that is not necessarily the case with injuries, nonfatal accidents, and property damage.

Commercial Waterborne Transportation

Currently, the Coast Guard collects extensive data on incidents, fatalities, injuries, property damage, and pollution, but there are no equivalent exposure data. One of the major problems with selecting an appropriate exposure measure is that the nature of the risk is very different for a vessel on coastal waters, on the deep sea, or on inland waterways. In the vicinity of ports, traffic volumes are high, leading to the risk of collisions between vessels, especially in passing and over-taking situations. Also, in these waters, proximity to the land and land-based facilities greatly increases the risk of groundings and collisions with bridges.

For deep sea navigation, most of these hazards are negligible, or, in some cases such as collisions with bridges, nonexistent. Other kinds of hazards, such as vessels capsizing from waves and winds, or crew being swept overboard, are important for both deep sea and coastal navigation. Therefore, the risk profile for oceangoing vessels approaching ports is very different from their risk profile during most of their operation. That is why many vessels are required to use local pilots during the final approach from a sea buoy to a port.

For inland waterway navigation, however, the near-port hazards described above are present in all phases of operation. Because of shoaling, grounding is a major risk on inland waterways, especially the Mississippi River, and sharp turns and complex maneuvers are risky for large vessels and for tows with multiple barges.

Great Lakes shipping presents a range of exposure situations. A vessel sailing from a Lake Superior port to a Lake Michigan port encounters the equivalent of deep sea exposure in Lake Superior, Lake Huron, and Lake Michigan, and near-port type exposure in the passages between the lakes. Ice can also be a problem during the winter.

Several different safety rate data sets would be needed to characterize safety regimes as diverse as those described above. For example, further research would be needed to determine the feasibility of constructing vessel-miles data. The Census Bureau collects vessel movement data that includes port entrances and clearances, but is restricted to vessels engaged in foreign trade. It should in theory be possible to combine vessel inventory data with vessel logs to construct all required exposure data, but that would entail a costly data-collection program and a major analytical effort. A simpler approach might be to require installation of data recorders onboard oceangoing vessels. A further complication in evaluating exposure arises for commercial fishing, which is included in the safety statistics for waterborne transportation.

Hazardous Gas and Liquid Pipelines

Gas and hazardous liquid pipelines account for a large portion of the domestic movement of petroleum, natural gas, and similar products. Pipeline networks span 1.46 million miles in the United States. Currently, pipeline information in publicly available geographic databases is limited. The Office of Pipeline Safety (OPS) within DOT's Research and Special Programs Programs Administration collects data on incidents, fatalities, and injuries caused each year by pipeline activities. In addition, OPS serves as the lead federal agency on the joint Government-Industry Pipeline Mapping Team, aimed at developing and maintaining a national digital database on pipelines.

As noted in *Transportation Statistics Annual Report 1997*, there is a lack of good exposure data to gauge the risk of pipelines and their products. Specific exposure is an important determinant of risk. Excavation activities or pipeline ruptures around populated areas and buildings, such as the deadly explosion in San Juan mentioned earlier, are of particular concern to safety officials. Even in relatively unpopulated regions, pipelines present exposure risks, such as areas susceptible to seismic activity, mud slides, or flood washouts. The only national measure of exposure now available is miles of pipeline. Dividing fatalities by miles of pipeline, however, averages out all specific risk factors, which are important in pipeline safety analysis. It would be equivalent to dividing road fatalities by miles of trafficway, a decidedly crude measure of exposure.

Accident data needs to be collected and reported in sufficient detail to show the cause and related factors that would either decrease or increase the likelihood of occurrence (NTSB 1996). Because of regulatory arrangements, pipeline operators do not have to notify OPS of all pipeline hits during excavations, but only ones that meet certain criteria. Data on these unreported incidents could be extremely valuable as an aid in determining potential risk from particular types of exposure.[5]

CAUSES OF CRASHES AND ACCIDENTS

Good data can improve understanding of the causes of transportation crashes and accidents. This understanding, in turn can then lead to more focused prevention strategies and priority setting. Assigning causes for accidents is not an easy task; typically, transportation accidents are a complex sequence of events, with more than one cause. In addition, it is important to distinguish between causation and association. The presence of a condition at the time and place of an accident does not necessarily mean that the condition caused the accident. Finally, cause data must be mode-specific. Because the modes differ, causes of accidents and thus effective prevention strategies will differ.

In this section, the causes of transportation accidents are assigned to five broad categories, which are then used to discuss accident causation by mode. The categories are:

- *Human factors.* These include errors of judgment, violations of traffic laws, and errors in operation of vehicles or equipment. Errors by operators of traffic control equipment (e.g., air traffic controllers and railroad signal operators) are included.
- *Equipment failure.* These include failure of some part of the vehicle that leads to loss of control, fire or an explosion, overturning, or loss of power. Often, equipment failures can be traced back to a human error, such as in design, quality control, maintenance, repairs, and inspection. Because they do not involve a human error on the part of an operator or traffic controller, they are not counted in the human factors category.
- *Weather conditions.* The safety of all modes is affected by weather conditions. Atmospheric and water conditions can cause loss of control or overturning of a vehicle, or loss of visibility resulting in a crash. The conditions that pose the biggest risk vary by mode. Weather is analyzed separately here, rather than being grouped with factors in the physical environment listed under "other causes" below. Weather as a cause is of special interest because current technologies make it feasible to provide short-term, small-scale weather forecasts that can greatly enhance safety across modes through prevention methods. The potential to use this information in personal transportation vehicles, such as cars and boats, is growing (see box 3-3).
- *Infrastructure failure.* This category includes structural defects in trafficways (e.g., highways or railroad tracks), as well as in terminal facilities (e.g., runways and piers), that cause or influence accidents. Infrastructure failure as a cause is significant for certain modes (e.g., rail) and negligible for others (e.g., waterborne).
- *Other causes.* In addition, there are, for all modes, other causes that cannot be classified into the above four categories. These include, for instance, factors in the physical environment (other than weather) that affect trans-

[5] NTSB has expressed concern about the ability of OPS to collect and analyze accident data for petroleum pipelines, to identify accident trends, and to evaluate operator performance (NTSB 1996).

Box 3-3.
Highway Safety Applications of Advanced Weather Information Technologies

Weather information techniques and technologies are advancing quickly, and include observation technologies such as NEXRAD doppler radar, the Geostationary Operational Environmental Satellite (GOES), Automated Surface Observation Systems (ASOS), and the Advanced Weather Interactive Processing System (AWIPS). These technologies have greatly improved the spatial and temporal resolution of weather forecasts. Numerical forecast models have also become more powerful and accurate.

Road Weather Information Systems (RWIS) are decisionmaking methodologies incorporating weather data, which are used by several state transportation departments in coordination with local governments, to deploy winter maintenance equipment and emergency response crews to the right place at the right time. RWIS are useful for fast, effective response to winter storms and other weather events that threaten highway safety.

The federally funded Advanced Transportation Weather Information System project in North and South Dakota is fully operational. The project entails collection of weather data through road and weather sensors, GOES observations, and an agricultural surface weather mesonet. The data are converted into site-specific nowcasts[1] and forecasts, which are made available to highway maintenance departments in both states through electronic mail, and to motorists through cellular phone. The Nevada Department of Transportation uses data collected for RWIS to provide advisories to motorists through variable message signs, weather advisory radio, and a local television station.

Technologies still under development could allow the dissemination of up-to-date weather information to operators of surface transportation vehicles in a form suitable for decisionmaking. A new initiative called Foretell aims to develop a nationwide system of roadway weather services that will benefit travelers on and maintenance of highway systems. Foretell is a joint partnership of the Federal Highway Administration, contractors, state departments of transportation, and the National Center for Atmospheric Research.

The increased use of weather information to enhance transportation safety is not merely a question of making weather data available. Decisionmaking methodologies have to be developed with the weather data serving as inputs. Particularly for the highway mode, most final users of the data will be the general public, without training in interpretation of weather data. The data must be accompanied by instructions on route selection, safe speeds, and other driving tips to minimize risk. Research is also required in human factors technology, so that the weather warnings are displayed in a user-friendly format.

[1] A nowcast is a very short-term forecast of current weather conditions with a high spatial resolution.

portation safety. Examples include: earthquakes for pipelines and transportation infrastructure; natural light conditions, icebergs, and submerged rocks for the waterborne mode; rockslides for highways and railroads; and obstructions for airplanes, including buildings, power lines, towers, mountains, and other hazardous objects above the surface.

Detailed data on causation are not available for all modes. This section analyzes existing data that are related to causation, and explains data limitations and gaps. Transit is not discussed because of lack of data; the profile of accident causation for transit, however, is likely to be a combination of the profiles for highway and rail, because most transit submodes operate either on roads (buses, vanpools, demand response) or on rails (light rail, heavy rail, commuter rail).

Highway

The highway mode accounts for the vast majority of transportation fatalities and injuries (see table 3-1). Highway crashes are frequent and widely dispersed geographically, with each crash usually accounting for only a few fatalities and injuries. Cause assignment can be difficult to determine.

Some causation data are collected and reported on a national level about fatal crashes, mainly a list of human factors pertaining to drivers, and similar data for pedestrians and pedalcyclists. Table 3-5 identifies factors for drivers in fatal crashes based on a sample of motor vehicle crash data. Note that the total of the percentages for all factors is greater than 100, because multiple factors can be assigned to the same driver. Categories 7 and 11 in the table include environmental factors, especially weather. Category 13, "other factors," consists exclusively of human factors, as do all categories other than 7, 11, 14, and 15. For categories 14 and 15, no factors were assigned, or the factors could not be determined. Thus, the degree of involvement of human factors can be estimated by subtracting out categories 7, 11, 14, and 15. This is an underestimate, as human factors may have played a role in some of the excluded categories (e.g., the 36 percent that were not assigned a cause), but it is nevertheless an instructive way to estimate the importance of human factors in fatal crashes.

Even with the exclusions listed above, table 3-5 shows that human error was a factor for at least 56 percent of drivers involved in fatal crashes in 1995. Other causative factors are harder to quantify for the highway mode. Relevant data are either not collected, or are collected in insufficient detail for

Table 3-5.
Contributing Factors Attributed to Drivers in Fatal Crashes: 1995

Category	Factor	Number of drivers[1]	Percent[1]
1	Failure to keep in proper lane or running off road	15,873	28.3
2	Driving too fast for conditions or in excess of posted speed limit	11,656	20.8
3	Failure to yield right-of-way	4,868	8.7
4	Inattentive (talking, eating, etc.)	3,323	5.9
5	Failure to obey traffic signs, signals, or officer	3,189	5.7
6	Operating vehicle in erratic, careless, reckless, or negligent manner	2,850	5.1
7	Swerving/avoiding due to wind, slippery surface, vehicle, object, nonmotorist in roadway, etc.	1,926	3.4
8	Drowsy, asleep, fatigued, ill, or blackout	1,816	3.2
9	Driving wrong way on one-way trafficway or on wrong side of the road	1,387	2.5
10	Overcorrecting/oversteering	1,328	2.4
11	Vision obscured (rain, snow, glare, lights, building, trees, etc.)	1,309	2.3
12	Making improper turn	1,253	2.2
13	Other factors	9,096	16.2
14	None reported	20,443	36.4
15	Unknown	990	1.8
	Total drivers	56,155	

[1] The sum of numbers and percentages exceeds the total number of drivers in fatal crashes (56,155 in 1995) because more than one factor may be present for the same driver.

SOURCE: Based on a sample of data from U.S. Department of Transportation, National Highway Traffic Safety Administration, Fatality Analysis Reporting System (FARS, formerly called the Fatal Accident Reporting System) in *Traffic Safety Facts 1995* (Washington, DC: 1996), table 61.

assigning causes or for making correlations. For instance, FARS and the General Estimates System (GES) (see box 3-2) do not include the condition of the infrastructure. (There is a data element on surface condition, but this refers to weather-related conditions such as dry or wet pavement or presence of ice or snow.) FHWA collects data on the surface condition of a sample of roadways (USDOT FHWA annual issues, table HM-63), but there are no corresponding data on crash occurrence by roadway condition, or on exposure (i.e., vehicle-miles traveled) by roadway condition.

FARS and GES include data on atmospheric conditions, as well as surface conditions. In 1995, 86 percent of fatal crashes occurred in normal weather, and 14 percent in bad weather. Because a crash occurs in bad weather does not necessarily mean that the weather caused the crash. Current data are insufficient to determine the *exposure* of highway drivers and passengers to the risk of death or injury in bad weather. Even where the necessary data are available, analyses tend to have little applicability beyond the specific locality and cannot be applied at a national level.[6] For example, to estimate the impact of wet pavement on crashes, it is essential to know the fraction of time for which the pavement is wet, how much driving occurs on wet pavement, and how many crashes occur on wet pavement.

In conclusion, quantitative information about the effect of weather on highway safety is limited; this is an area where extensive research is needed. For example, fog and ice have not received much attention; most of the research has focused on rain. Even for rain, the studies have not yielded a consistent, accurate methodology for integrating crash data and weather data locally and nationally to determine the added risk because of rain-induced loss of visibility and wet pavement.

Aviation

The National Transportation Safety Board publishes detailed accident causation statistics for the four air submodes (i.e., part 121, major carriers; commuter airlines; air taxi; and general aviation) in the *Annual Review of Aircraft Accident Data* (NTSB annual a and b), with multiple causes assigned to each accident. Table 3-6 shows the 10-year average distribution of causes for all the air submodes. Fatal accidents for all submodes except general aviation, and all accidents for major carriers and commuter air, are relatively few in number each year. Even among all accidents for air taxi, there is a considerable degree of volatility in the annual data, a direct statistical result of the small number of accidents. For this reason, trends in the above are not discussed; analysis is confined to the 10-year averages shown in table 3-6.

Besides the "other" category, there are only three cause categories for aviation accidents: human factors, weather, and equipment failure. As shown in the table, human factors contribute to 90 to 100 percent of air accidents, including errors made by pilots, other people aboard (e.g., flight instructors), and air traffic controllers.

The air mode is affected by both surface weather and weather at higher altitudes. It is also affected by very sudden, short-duration weather phenomena such as microbursts and turbulence. Examples of phenomena that affect the air mode are atmospheric turbulence, convection wind shear, and wake vortex (the disturbance associated with the passage of another aircraft). In

[6] One study (Jones et al 1991) examined the correlation between crash frequency and several conditions, including wet pavement and rain, for six highway zones around Seattle, Washington. It found wet pavement had a significant positive correlation with crash frequency in these highway zones, while rain had a significant positive correlation with crash frequency in two of the six zones in which driving requires complex maneuvers. While useful for assessing weather effects on highway safety, this study is too location-specific to identify overall effects of rain or wet pavement on crash rates for U.S. highways.

Table 3-6.
Causes/Factors for Aviation Accidents
(Average: 1985–94)

Causes/ factors	Major carriers, fatal	Major carriers, all	Commuter air, fatal	Commuter air, all	Air taxi, fatal	Air taxi, all	General aviation
Total aircraft	47	256	52	195	274	1,009	23,103
Human factors[1]	42	230	65	221	294	941	20,991
	89%	90%	100%	100%	100%	93%	91%
Equipment failure[2]	18	97	20	78	93	420	7,760
	38%	38%	39%	40%	34%	42%	34%
Weather	9	76	22	60	121	320	5,243
	19%	30%	42%	31%	44%	32%	23%
Other[3]	10	48	25	97	173	570	10,470
	21%	19%	48%	50%	63%	57%	45%

[1] Sum of the categories “Pilot,” “Other Person (Not Aboard),” and “Other Person (Aboard)” for 1987–94. Sum of the categories “Pilot” and “Personnel” for 1985 and 1986.
[2] Sum of the categories “Propulsion System and Controls,” “Landing Gear,” “Systems/Equipment/Instruments,” “Airframe,” and “Flight Control Systems” for 1987–94. Sum of the categories “Powerplant,” “Landing Gear,” “Airframe,” “Systems,” “Rotorcraft,” and “Instruments/Equipment/Accessories” for 1985 and 1986.
[3] Sum of “Terrain/Runway Condition,” “Object (tree, wires etc.),” “Light Conditions,” and “Airport/Airways Facilities, Aids” for 1987–94. Sum of “Terrain,” “Miscellaneous,” “Undetermined,” and “Airport/Airways/Facilities” for 1985 and 1986.

NOTE: Percentages add up to greater than 100% because multiple causes/factors may be assigned to each accident.

SOURCES: All data are from the series of reports by the National Transportation Safety Board, under the general title of *Annual Review of Aircraft Accident Data.* Specifically, data for each category above are from:
Air carrier data: *U.S. Air Carrier Operations*, 1986–94, table 19; tables 23 and 24.
Commuter air: *U.S. Air Carrier Operations*, 1989–94, table 37; 1986–88, table 38; 1985, tables 48 and 49.
Air taxi: *U.S. Air Carrier Operations*, 1989–94, table 55; 1986–88, table 56; 1985, table 65.
General aviation: *U.S. General Aviation*, 1989–94, table 55; 1986–88, table 56; 1985, table 26.

addition, the precipitation, storms, ice, and fog that affect all modes can affect aviation in unique ways. For example, while the effect of ice on runways is analogous to the effect of ice on highways, icing of the airframe of an aircraft causes increased drag. A special case of icing is the occurrence of supercooled drizzle drops (SCDDs), which freeze on impact with the airframe. SCDDs are thought to be a factor in the October 1994 crash of a commuter aircraft near Roselawn, Indiana, which resulted in the deaths of all 68 people aboard.

The importance of the “other” category (e.g., environmental hazards such as terrain, buildings, trees, wires, and natural light conditions) is significantly different between major carriers and all other submodes, particularly general aviation. Major carriers use large, technologically sophisticated aircraft that are less dependent on pilot vision. Hence, if all equipment is working properly, light conditions are relatively unimportant. Also, large aircraft land at big airports, where there are likely to be fewer hazards such as trees and wires.

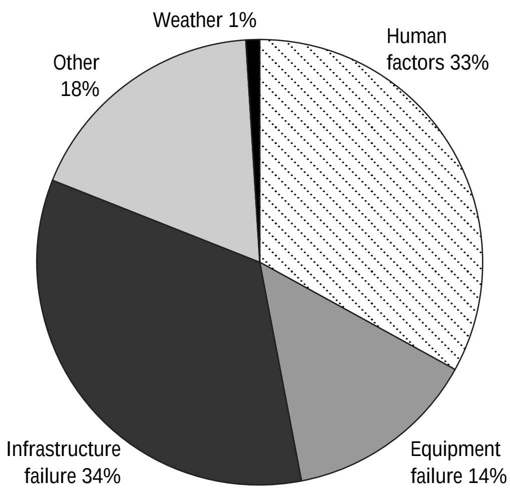
Rail

The Federal Railroad Administration publishes detailed accident causation data, which is grouped into human factors, equipment failure, infrastructure failure, weather, and other causes (see figure 3-4). Several features are noteworthy.

Infrastructure failure as an accident cause is more important for rail (averaging 34 percent

Figure 3-4.
Single Causes Ascribed to Railroad Accidents: 1986–95

(10-year average)



SOURCE: U.S. Department of Transportation, Federal Railroad Administration, *Accident/Incident Bulletin* (Washington, DC: Annual).

between 1986 and 1995) than for other modes examined. Because rail operates on a fixed guideway, the condition of the infrastructure is critical. Typical infrastructure defects include settled or soft roadbeds, track geometry defects, rail and joint bar defects, and signal failures.

Human error by train operators and traffic controllers is responsible for about one-third of rail accidents—a smaller fraction than for other modes because of the fixed guideway operation.

Equipment failure declined as a cause of accidents, from nearly 16 percent in 1986 to nearly 11 percent in 1995. There is also a distinct decline in the absolute number of accidents caused by equipment failure over this period, some of which may be attributed to the retirement of old rolling stock (locomotives and freight cars) and their replacement by rebuilt or new rolling stock. Data published by the Association of American Railroads show that the percentage of new and rebuilt freight cars in the fleet increased from a low of 0.9 percent in 1986 to a high of 5.4 percent in 1995, and the percentage of new and rebuilt locomotives in the fleet increased from 2 percent in 1986 to 6 percent in 1995 (AAR 1997). (Overall, the freight car and locomotive fleets decreased during this period.)

Weather contributed to only 1 to 2 percent of all rail accidents over the period. Once again, the fixed guideway operation of the rail mode is a factor. Because of signaling and switching procedures, visual judgment is relied on less when there is fog or precipitation. Major weather-related safety concerns focus on how the tracks are affected—washout by flash floods and mudslides, warping from thermal expansion, brittleness from extreme cold, and derailment because of snow or ice.

WATERBORNE TRANSPORTATION

Waterborne transportation, both commercial shipping and recreational boating, faces exposure to environmental hazards not present for other modes. These hazards can be important factors causing or contributing to accidents, and may be navigational, such as silting, shoaling, and debris, or weather-related. In the case of weather-related hazards, the risk of persons being swept overboard by wind and waves, or falling overboard due to the rolling and pitching motion in rough waters, has no counterpart in other modes. Two other weather-related hazards are the risk of vessels sinking because of excessive water intake through the hull (associated with rough waters), and the risk of capsizing in strong winds or roughs waters. These phenomena affect recreational boats, in particular, because of their small size.

Commercial Waterborne Transportation

The U.S. Coast Guard investigates waterborne accidents and assigns four categories of causes: human factors, equipment failure, weather, and hazardous materials. The information collected is entered into the Marine Safety Management Information System (MSMS database) (USDOT USCG 1997).

USCG often assigns multiple causes to a single accident. The categories of causes examined here are: human factors, equipment failure, weather, and other.[7]

Figure 3-5 shows that, as with all modes except rail, human factors are the dominant cause of accidents (75 percent). Examples of human error include misinterpreting or ignoring hazard warnings, operating in adverse conditions without adequate monitoring, and navigational errors. Equipment failure is the next largest category (16 percent). Typical cases of equipment failure include malfunctioning deck machinery, steering system, propulsion system, electrical system, and fuel system.

Weather accounts for 7 percent of accident causes. A hazard for operations in confined waterways, particularly with high vessel traffic, is the risk of collision between vessels, or between a vessel and a facility such as a pier or bridge, in conditions of poor visibility caused by fog or precipitation. This is especially a factor for inland waterways such as the Mississippi River, and in and around ports. (Weather-related causes are discussed in greater detail under recreational boating.)

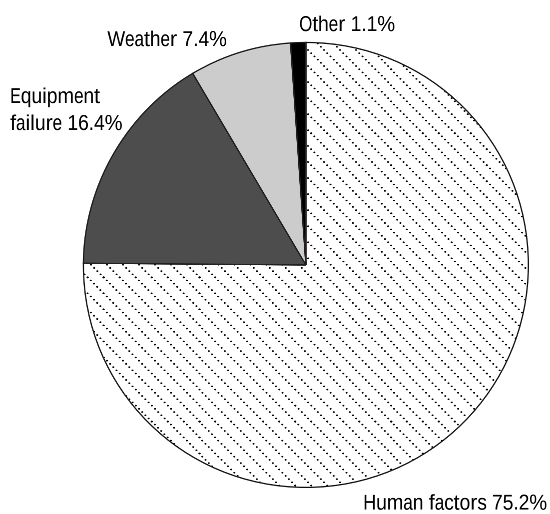
[7] The first two categories correspond to those in the MSMS data. For the last two categories, the data have been combined to make them more comparable to the discussion of the other modes. For weather, in addition to the condition of the air and water (e.g., storms, fog, waves, and currents), the MSMS database includes navigational hazards such as silting, shoaling, and debris. These navigational hazards are combined with the MSMS hazardous materials category and are shown as "other" in figure 3-5.

Recreational Boating

USCG publishes accident causation data for recreational boating in its annual publication, *Boating Statistics* (USDOT USCG annual). These data are shown in figure 3-6, covering the period 1985 through 1994. The data are based on single-cause assignments, as for rail.

As with most other modes, human factors are the dominant cause of recreational boating accidents, as was the case for three out of five boats involved in accidents between 1985 and 1994. (Note that the recreational boating data are for number of vessels rather than for number of accidents. Thus, if one vessel failed to yield the right-of-way because of improper lookout, and rammed another vessel, the accident would appear as two boats involved in accidents caused by human factors: one case of improper lookout, and one case of other vessel being at fault.

Figure 3-5.
Causes Ascribed to Commercial Marine Transportation Accidents: 1990–June 1996

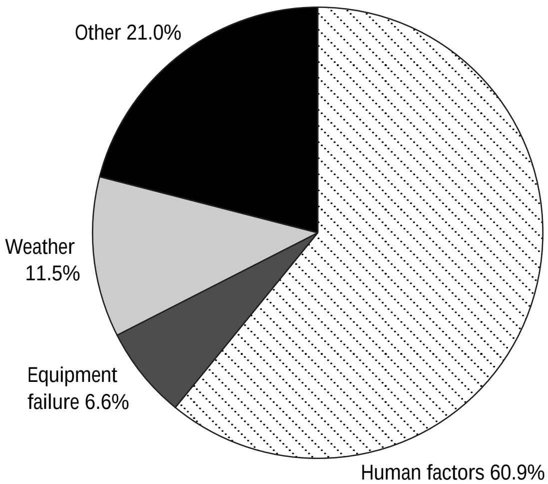


NOTES: Only accidents involving a fatality, a missing person, or an injury, o at least $25,000 in damages are included. More than one cause may be ascribed to an accident.

SOURCE: U.S. Department of Transportation, U.S. Coast Guard, Marine Safety Information Management System (MSMS) database.

Figure 3-6.
Causes Ascribed to Recreational Boating Accidents: 1985–94

(10-year average)



SOURCE: U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington, DC: Annual issues).

In recreational boating, there are two broad classes of human factors: incorrect loading of passengers and gear, including overloading, improper weight distribution, and leaning over the edge of the boat; and incorrect operation of vessel, including improper lookout, inattention and carelessness, errors by other vessels, high-speed maneuvers, and navigational errors. Human factors are relatively less important for recreational boating than for commercial shipping, because weather and miscellaneous causes are relatively more important.

Weather was cited as a cause for about one out of every eight recreational boats involved in accidents. The percentage is slightly higher than the corresponding percentage for commercial waterborne transportation, because recreational boats are smaller and more vulnerable to wind and waves. The weather category includes strong currents and rough waters, wake or wave striking vessel, free water in boat, and poor visibility.

Equipment failure caused less than 7 percent of recreational boating accidents in this period. Equipment failure is relatively less important for recreational boating than for commercial waterborne transportation, because of the greater importance of weather and miscellaneous causes.

Other causes not classifiable into any of the previous three categories are collectively the second largest accident cause category for recreational vessels, an average of 21 percent between 1985 and 1994. Most of these are submerged objects, or classified as other and unknown in the *Boating Statistics* data.

Pipelines

DOT's Office of Pipeline Safety collects data on the causes of hazardous liquid pipeline and gas gathering and transmission pipeline accidents. These data are not published, nor are they sufficiently detailed for the kind of analysis done for the air, rail, waterborne, and recreational boating modes.

The cause categories used by OPS for hazardous liquid pipelines are: 1) corrosion, 2) equipment malfunction, 3) failed pipe, 4) failed weld, 5) incorrect operation, 6) outside force damage, and 7) other. For the 1986 to 1996 period, the first four categories (all involving equipment failure), accounted for 41 percent of incidents. (Note that for pipelines, the distinction between infrastructure and equipment is hard to draw; all of these causes may also be treated as infrastructure failure.) Incorrect operation accounted for slightly more than 6 percent of the incidents. This percentage only accounts for a portion of human factors as a cause of pipeline incidents, however. The "other" category also includes cases of human error, such as damage caused by pipeline construction and maintenance activities including replacement of pipeline sections and recoating (USDOT RSPA OPS 1998).

While human factors are clearly a large part of the outside force damage category, the unpublished OPS data do not distinguish between different types of this damage. An NTSB analysis of causation data for hazardous liquid pipelines found that 85 percent of outside force damage was caused by excavation by the pipeline company or its contractors, or by third parties such as utility companies, clearly cases of human error (NTSB 1996). Another 8 percent is attributable to fishing, ship anchors, and other marine activity (all human factors-related) and landslides, earthquakes, or washouts (all environmental factor-related). The remaining 7 percent of outside force damage cases are classified by NTSB as "other and unknown" (USDOT RSPA OPS 1998).

The cause categories used by OPS for gas pipelines are: 1) corrosion, 2) construction/material failure, 3) outside force damage, and 4) other. The first two can be classified as equipment failure, and together averaged about 36 percent of incidents between 1986 and 1996 (USDOT RSPA OPS 1998). As for the last two categories, it is not possible to determine the magnitude of human factors and environmental conditions from the data. As with hazardous liquid pipelines, the high proportion of accidents caused by outside force damage underscores the need for developing detailed, accurate local maps of pipeline location to prevent excavation and marine activity accidents.

TRANSPORTATION SAFETY AND THE ELDERLY

The number of older people in the United States is growing, in absolute numbers and as a percentage of the population, as it is in other industrialized countries. As of 1996, there were approximately 24 million people aged 70 or over. Their share of the population has been rising for over 10 years, and the U.S. Census Bureau projects that the fraction of the population over 75 years of age will increase from 12.1 percent in 2000 to 18.5 percent in 2025. It will be a rapidly expanding age group, rising over 78 percent during the period, compared with an increase of 22 percent for the population as a whole (USDOC 1997, 25).

The average level of health, and the associated motor skills and perceptual skills such as vision and hearing, of older people (e.g., 65 to 74 years old) is better today than it was in 1970, and is expected to continue improving with advances in health care.

From 1985 to 1995, the number of licensed drivers over the age of 70 grew 48 percent, compared with a 13 percent increase in the total population of licensed drivers. There are now almost 17 million drivers who are 70 years or over (USDOT NHTSA 1997). Older motor vehicle operators will become increasingly common in the future given demographic trends. Many older people also work part time or do volunteer activities that require them to drive. Because of these trends, a growing number of older people will be exposed to transportation risks as operators, passengers, and bystanders.

A recent study found that the mobility requirements of older people diminish only slightly once they have left the civilian labor force (Coughlin and Lacombe 1997). For most, the daily exigencies of life are such that they still need transportation to achieve their goals. The dispersion of housing, shopping, and services that has accompanied widespread suburbanization during the past few decades has lessened the effectiveness of most traditional mass transit solutions. Hence, the elderly must continue to provide for their own mobility; those who do not want to drive, or who cannot drive, are dependent on family members or their communities for transportation.

While some elderly drivers may have shortfalls in physical and cognitive abilities, and reduced abilities to survive injuries like those incurred in transportation crashes, age and experience also can have beneficial effects on vehicle operator performance. Elderly drivers are less likely to drive under the influence of alcohol; in 1996, of all drivers in fatal crashes in the United States, 19 percent were intoxicated, while of drivers 70 years and older in fatal crashes, only 4 percent were intoxicated (USDOT NHTSA 1997). Similarly, younger drivers are more likely to speed than older drivers. Studies in California have shown that the rate of speeding violations per mile traveled is at least three times as high for drivers in the 16 to 19 age group as it is for drivers over 30 years of age. Furthermore, NHTSA analysis found that the proportion of speed-related fatal crashes decreases with increasing driver age, from 37 percent for drivers aged 14 to 19, to 7 percent for drivers aged 70 and above (IIHS 1998). Other potential beneficial effects of age and experience on driving are harder to quantify. These include the possibility that older people drive less aggressively and with greater caution, and drive less in riskier situations, such as at night and in poor weather.

With improvements in health and healthcare, it is possible that the number of older commercial vehicle operators will increase, to the extent that retirement age is at the discretion of the operator. The *Code of Federal Regulations* (49 CFR 391, Subpart E) specifies health requirements for commercial motor vehicle operators, but no age requirement other than that they be above 21 years of age. Under Federal Aviation Administration regulations, pilots of certificated air carriers must be under 60 years of age. There is no age limit for other commercial pilots or for general aviation pilots. Individual trucking companies, school districts, transit agencies, railroads, and other employers, however, have their own policies on retirement age for those who drive as part of their profession.

Private Motor Vehicle Operators

Based on estimated miles driven by age group, the fatality rate for drivers aged 65 and older is 17 times as high as for drivers aged 25 to 65 (USDOT NHTSA 1997). The reasons for this dramatic difference are unclear. It may reflect the small sample size (by age group) of the survey used to estimate mileage, rather than real conditions. It is plausible, however, that fragility may be a factor. Older motor vehicle drivers and occupants are more likely to be killed in crashes in which younger, more physically robust people may suffer injuries that are nonfatal. Greater incidence of posttraumatic cardiac risk is one example of increased fragility with age (DeMaria 1993).

Motor vehicle crash profiles for aging drivers are somewhat different from those of other age groups: there are more crashes involving left turns, intersections crashes, and crashes where no evasive actions were taken. Research is underway on techniques such as larger, brighter, and more legible signs and widely spaced, raised pavement markers, which might be helpful for older drivers (TranSafety 1997).

There are some safeguards built into the driver license renewal system, which protect against the possibility of physically impaired drivers, *elderly or otherwise*, renewing their licenses and thereby endangering themselves as well as other highway users (USDOT FHWA 1996, US-8). Of the 50 states, the District of Columbia, and Puerto Rico, only 12 did not require a vision test for drivers renewing their licenses in 1995. Some states require reexamination of general driving knowledge and knowledge of signs and signals, and at least one state (Utah) also requires reexamination of vehicle operation skills for renewal, subject to discretionary waivers. In addition, some states require medical examinations of renewal applicants above a certain age; this age varies depending on the state. In some states, medical examinations are at the discretion of the examiner.

Older Pedestrians

Persons aged 70 and above (about 9 percent of the total population) represented 17 percent of all pedestrian fatalities in 1996. This group had a pedestrian fatality rate per capita about twice that of the entire population (39 fatalities per million persons, as compared with an overall rate of 20 fatalities per million persons, in 1996). It is unclear whether the higher fatality rate of older pedestrians reflects increased exposure due to more time spent walking, a slower pace and decreased attentiveness when crossing streets, or frailty when injured.

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chapter four

Transportation, Energy, and the Environment

There are many complicated interactions among transportation, energy use, and environmental quality. This chapter highlights trends and events of the past year that reflect the importance of transportation to the nation's energy security and the quality of our environment. The year 1997 saw record-high oil imports, a dramatic international agreement to reduce emissions of greenhouse gases (GHGs), and an Environmental Protection Agency (EPA) decision to toughen federal air quality standards. These developments have major implications for the future of transportation in the United States and the world.

Most of the oil consumed in the United States goes to transportation. In 1997, transportation-driven oil demand together with declining domestic production brought about the highest levels of oil imports ever (48 percent of oil use). Yet, the question of oil dependence is far removed from the national consciousness. In the first part of this chapter, the importance of growing oil dependence in a world of plentiful and low-cost oil is examined.

The U.S. transportation system is about 95 percent petroleum dependent, down about two percentage points from a decade ago. While federal programs have boosted the numbers of alternative fuel vehicles in use in recent years, most of the increase in nonpetroleum energy has come via the blending of alcohols and ethers in gasoline.

The composition of gasoline sales has changed dramatically over the past 15 years, primarily as a result of environmental regulations.

In December 1997, in Kyoto, Japan, the nations of the world reached a historic agreement to limit GHG production resulting from human activities. Greenhouse gases in the Earth's atmosphere trap heat energy that would otherwise escape into space, thereby warming the Earth's climate. Many scientists contend that the continued addition of GHGs to the atmosphere, especially from the combustion of fossil fuels, threatens to alter the world's climate in potentially harmful ways (IPCC 1996). Emissions of GHGs from transportation, mainly produced when hydrocarbon fuels are burned and produce carbon dioxide (CO_2), continue to increase because of the steady growth of freight and passenger travel, the slowing of energy efficiency gains, and continued reliance on carbon-based fossil fuels.

Emissions of all criteria pollutants have decreased over the past two decades as a result of ever-improving vehicle emissions controls, despite the doubling of vehicle travel. These improvements have produced tangible benefits in the form of better air quality for U.S. cities. While transportation and the economy as a whole have made significant progress in curbing pollutant emissions, evidence continues to mount on the adverse health effects of air pollution, especially fine particulates and ozone. As a result, EPA has decided to impose stricter air quality standards on cities, with potentially significant implications for transportation vehicles and fuels.

Past air quality standards have had an overwhelmingly beneficial effect, according to a recent study of the costs and benefits of the first two decades of Clean Air Act (CAA) regulations (USEPA OAR 1997). Emissions of lead, hydrocarbons, carbon monoxide, oxides of nitrogen, and sulfur have all been significantly reduced.

Transportation's other environmental impacts include increased noise and solid waste, deterioration of water and groundwater quality, damage to habitats, and direct and indirect effects of land use. The lack of information with which to comprehensively assess the role of transportation in these environmental concerns remains a problem.

ENERGY USE

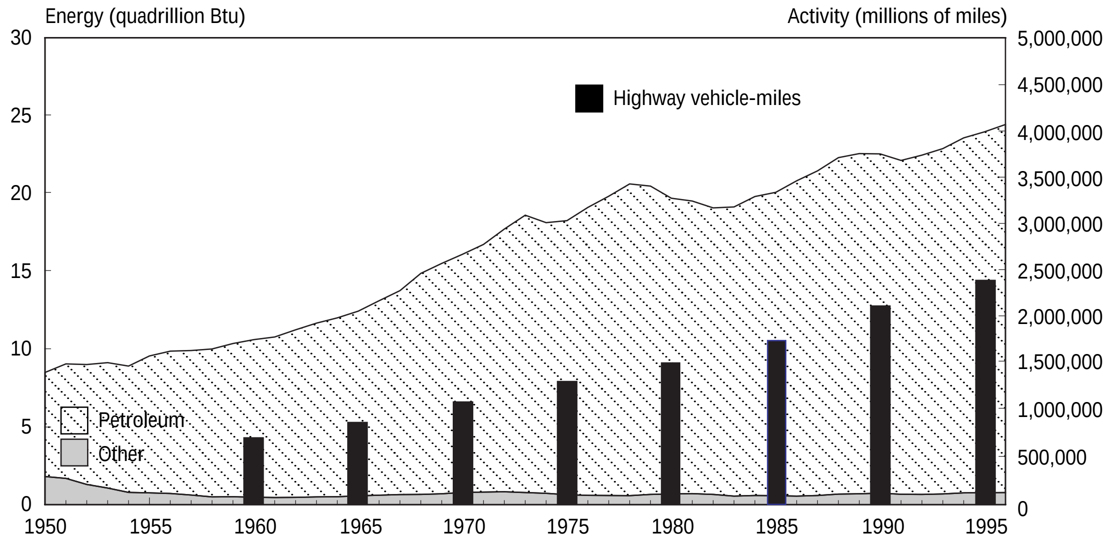
The energy needed to power the U.S. transportation system grew at almost the same rate as the economy in 1996: 2.3 percent versus 2.4 percent for Gross Domestic Product (GDP) (USDOE EIA 1997a, table 2.1). In general, however, passenger and freight transportation are growing faster than the economy as a whole. Highway vehicle-miles increased at an average rate of 3.2 percent per year between 1970 and 1996 (see figure 4-1). Highway vehicles continue to dominate transportation energy use (see figure 4-2). Light-duty passenger vehicles alone account for over 60 percent of all energy used in transportation.

The growth of transportation energy use reflects the combined effects of increased transportation activity and changes in energy efficiency. As described in chapter 1, passenger travel and freight activity continue to grow, resulting in more vehicle-miles traveled and airplane use. These trends show little sign of slowing down in the near future.

Transportation and Oil Dependence

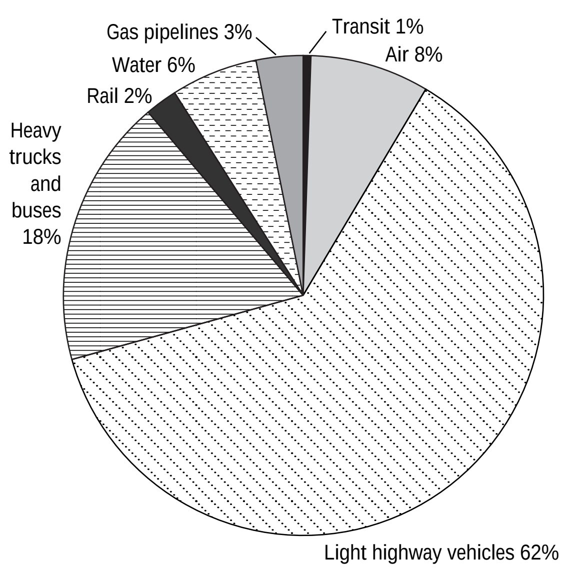
In 1997, the U.S. economy imported more oil than ever before. Yet, 25 years after the oil price shock of 1973–74, petroleum dependence is no longer a front-page news story. Oil supplies are plentiful, world oil demand is growing more slowly, and oil prices, though in 1996 nearly 70 percent higher than 1972 levels (in constant dollars), are much lower than the price peaks of the early 1980s. (A gallon of gasoline, in constant

Figure 4-1.
Transportation Energy Use and Highway Vehicle-Miles: 1950–96



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at http://www.bts.gov/ntda; U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996,* DOE/EIA-0384(96) (Washington, DC: 1997), table 2.1.

Figure 4-2.
Transportation Energy Use by Mode: 1996

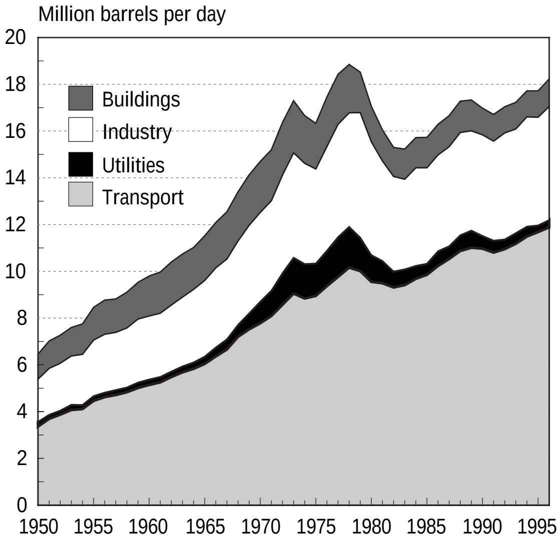


SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics 1998, available at http://www.bts.gov/ntda, table 4-10.

dollars, costs no more today than in 1970.) Members of the Organization of Petroleum Exporting Countries (OPEC), however, still supply more than 40 percent of the world's oil and own the majority of the world's oil resources. As U.S. oil production declines and consumption rises, dependence on OPEC will most likely increase. This section describes the energy and economic aspects of oil dependence and some of its implications. There are geopolitical implications as well, which are topics of heated debate but are outside the scope of this report (see, e.g., *Harvard International Review* 1997).

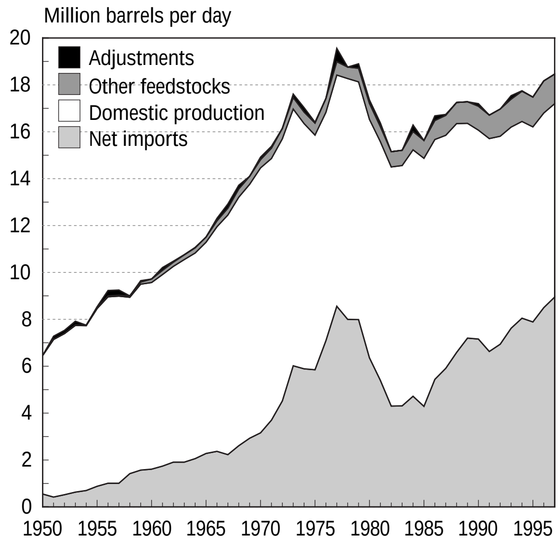
U.S. dependence on imported petroleum is more than ever a result of transportation's reliance on oil. Transportation is the only sector of the economy that consumes significantly more petroleum today than in 1973 (see figure 4-3). Use of petroleum in electricity generation decreased from 3.1 quadrillion Btu (quads) in 1972 to 0.7 quads in 1996 (USDOE EIA 1997a, table 8.5). Over the same period, the residential and

Figure 4-3.
Transportation's Share in U.S. Petroleum Use: 1950–96



SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC: 1997), table 5.12.

Figure 4-4.
U.S. Petroleum Imports, Domestic Production, and Other Feedstocks: 1950–96



NOTE: Adjustments include crude oil losses and changes in stocks.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC: 1997), table 5.1.

commercial buildings sectors cut petroleum use in half, from 4.4 quads to 2.2 quads, while industrial sector petroleum use remained stable: 9.1 quads in both 1973 and 1996. In contrast, transportation's petroleum use increased by one-third over the same period, from 17.8 quads to 23.7 quads. In 1973, transportation accounted for roughly half of U.S. petroleum demand; today it comprises almost two-thirds.

In 1997, the United States imported 8.95 mmbd of crude oil and petroleum products.[1] This exceeds the previous record high for imports of 8.56 million barrels per day (mmbd) (see figure 4-4). U.S. petroleum imports nearly tripled between 1967 and 1973, from about 2 mmbd to 6 mmbd. A combination of declining domestic production, rapidly growing demand, and low prices made imported oil attractive. The OPEC oil embargo, which began in the fourth quarter of 1973, and the consequent higher oil prices and economic recessions in 1974 and 1975, temporarily held oil imports in check. With economic recovery, oil imports shot up in 1976 and 1977, reaching a high of 46.5 percent of total consumption in 1977. That record stood for two decades as a second round of oil price shocks and economic recessions in 1979 and 1980 depressed demand.

Oil prices in 1981 were almost five times their 1972 level (in constant dollars), depressing demand and stimulating domestic supply. Imports remained low for several years, as OPEC continued to cut back its production to sustain the higher price levels. Responding to shrinking market share and revenues, OPEC members abandoned the defense of higher oil prices in 1986. The resulting increase in oil supply caused prices to plummet and U.S. oil

[1] The numbers reported here are net imports, which equal total imports minus total exports. The United States exports just under 1 mmbd of petroleum.

imports to rise once again. Since 1986, U.S. oil imports have continued to increase, temporarily interrupted by the oil price jump and recession associated with the Persian Gulf War in 1990–91 and by a substantial drawdown of domestic petroleum stocks in 1995.

Whether a high level of oil imports poses serious strategic and economic problems for the United States depends on a number of factors, some of which can be readily measured, while others cannot. The potential for oil dependence to harm the U.S. economy hinges on the ability of the OPEC cartel to raise world oil prices above competitive market levels. According to economic theory, the *potential* market power of a cartel, such as OPEC, is a function of its share of the market and the ability of both oil users and other suppliers to respond to price increases. The more of the world's oil needs OPEC supplies, the greater its ability to influence prices, other things being equal. At the same time, the greater the ability of oil consumers to reduce consumption when prices increase, whether through efficiency improvements, substitution of alternative energy sources, or cutting back on activities that use oil, the less market power the cartel can wield. Also, the more easily non-OPEC oil producers can expand production when prices rise, the smaller the cartel's market influence. Finally, in a dynamic market, the faster the demand for oil grows, the greater the impact of a reduction in supply.

A key complicating factor is the very large difference between the oil market's short-run and long-run ability to respond to sudden changes in supply and demand. Because it takes time to find and develop new oil supplies, and even longer to turn over transportation vehicle stock and other oil-using capital equipment, a rapid reduction in supply will produce a much larger change in price than the same reduction phased in over several years. This means that sudden supply shocks, whether intentional or unintentional, can have a huge impact on oil prices. The doubling of world oil prices in 1973–74 and again in 1979–80 were associated with reductions of world oil supplies on the order of 5 percent (Greene et al 1998).

Several factors determine the impacts of price shocks on oil consuming economies: 1) the economic significance of oil (e.g., the oil cost share of GDP), 2) the ability to substitute other factors for oil quickly and cheaply (best indicated by the price elasticity of oil demand), 3) the policy response to the supply shock (e.g., tightening or loosening of money supplies or price controls), and 4) the quantity of oil imported. The quantity of oil imported matters to the U.S. economy, because a price shock transfers wealth from oil consuming nations to oil producing nations. (This transfer is not a cost to the world economy, but a redistribution of wealth among economies. The size of the loss to an oil importing economy is directly proportional to the quantity of oil imported.) The quantity of oil imports may also have strategic implications in the case of a military conflict, since essentially all U.S. oil imports arrive by sea. About 53 percent of U.S. oil import needs, however, are now supplied by Western Hemisphere countries: 4.0 mmbd of the 7.5 mmbd of U.S. crude oil imports in 1996 came from Canada, Mexico, and Central and South America, which are relatively secure suppliers (USDOE EIA 1997d, 72).

In 1973, OPEC members supplied more than half of the world's oil needs. OPEC's market share dropped to a low of 29 percent in 1985, but rebounded to 42 percent by 1993, where it has remained through 1996. For the past few years non-OPEC producers, especially in the North Sea region, have expanded production sufficiently to supply the majority of the world's growing demand. The U.S. Department of Energy (DOE) foresees continued growth in non-

OPEC supply due to improved technology for oil discovery, development, and production (USDOE EIA 1997b, 29). Even so, the Energy Information Administration's (EIA) Reference Projection for world oil markets anticipates OPEC's share surpassing 50 percent of world production between 2010 and 2015. The technological advances that have enabled the recent increases in non-OPEC supply may also increase the price responsiveness of non-OPEC oil supply, but this has yet to be established (USDOE EIA 1997d, 61). Increased price responsiveness of non-OPEC supply would reduce the likelihood of severe oil market disruptions in the future.

Transportation sector oil demand is less "price elastic" than that of other sectors of the economy (USDOE EIA 1997d, 67), so an increase in the fraction of oil used in the transportation sector may imply a decrease in the price responsiveness of petroleum demand. Decreased price elasticity of petroleum demand would tend to increase the risk of future oil price shocks. To what extent technological gains on the supply side may offset an increased concentration of oil demand in transportation and whether advances in transportation technology may enhance the sector's ability to respond to price increases are important issues for future research.

More than 95 percent of transportation's energy comes from petroleum (USDOE EIA 1997a, table 2.1; 1997b, table 2.5). The small fraction of energy from other sources is growing, but this does not yet indicate a trend away from petroleum. As shown in last year's analysis (USDOT BTS 1997, chapter 4), far more nonpetroleum energy is used in the form of gasoline blending agents (primarily for environmental reasons) than is used by all the alternative fuel vehicles on the road.

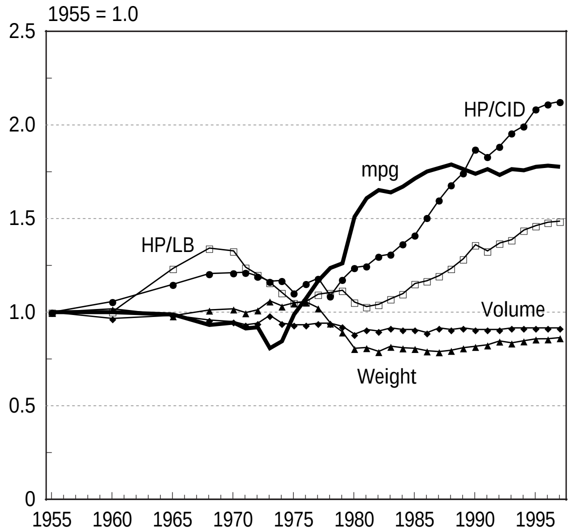
Vehicle Efficiency

Over the past quarter century, transportation energy use and CO_2 emissions increased more slowly than transportation activity because of improvements in the efficiency of energy use. From 1985 to 1995, transportation's CO_2 emissions and energy use both increased by 19 percent. Over the same period, passenger-miles traveled grew by 35 percent and ton-miles by 24 percent. As pointed out in past editions of the *Transportation Statistics Annual Report*, however, the improvement of transportation energy efficiency has slowed and may even have stopped.

Light-duty highway vehicles—passenger cars, light trucks, and motorcycles—account for almost 60 percent of transportation energy use (Davis 1997, table 2.10). Because light-duty vehicles are subject to federal automotive fuel economy standards, accurate records are kept of their fuel economy and some related characteristics (USDOT NHTSA 1997).

New passenger car fuel economy declined gradually from 1955 to 1973 and then shot upward to 26.6 miles per gallon (mpg) in 1983. It then increased gradually to 28.5 mpg in 1987, where it has remained, more or less, for the past decade (see figure 4-5). Although neither new car nor new light truck fuel economy has increased in the past decade, technological improvements to vehicles and engines have continued at a rapid pace. The ratio of horsepower to engine size (HP/CID), one indicator of the status of engine technology, has increased steadily and has approximately doubled since 1975. From 1985 to 1996, the percentage of new cars and light trucks equipped with fuel injection (versus carburetion) increased from 55 percent to 100 percent, and from 14 percent to 100 percent, respectively. The number of cars with four-valve (versus two-valve) engines increased from 1 percent to over 50 percent over the same period

Figure 4-5.
Passenger Car Fuel Economy and Related Indices 1955–97



KEY: HP/CID = ratio of horsepower to engine size; mpg = miles per gallon; HP/LB = horsepower per pound.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, "Production Weighted Data from Manufacturer's Fuel Economy Reports," data tables, 1997.

(Heavenrich and Hellman 1996, table H-3). Use of lock-up torque conversion in transmissions (a technology that reduces slippage and thereby improves energy efficiency) and front-wheel drive also increased by about 20 percent. These technologies can be used either to increase mpg or to provide increased power and weight at the same mpg. While mpg has changed little, cars and light trucks have become much more powerful and somewhat heavier. The ratio of engine horsepower to vehicle weight increased by almost 50 percent from 1985 to 1997 (see figure 4-5). At the same time, the average weight of a passenger car increased by 200 pounds, and the average weight of a light truck increased by 600 pounds (USDOT NHTSA 1997).

In effect, passenger car fuel economy has not changed significantly in the last decade, which is roughly the expected lifetime of a new automobile (Davis 1997, table 3.5). It would be reasonable to expect, therefore, that the fleet average fuel economy improvement rate would be slowing down as the efficiency of cars on the road approaches that of new vehicles. This appears to be happening.

According to Federal Highway Administration (FHWA) estimates, the average fuel economy of all passenger cars on the road increased from 13.8 mpg in 1976 to 21.2 mpg in 1991, an average annual improvement rate of 2.9 percent per year (USDOT FHWA 1997, table VM-201A). From 1991 to 1996, FHWA estimates that mpg increased to 21.3, for an average annual rate of only 0.1 percent per year. Data from EIA's Residential Transportation Energy Consumption Survey (RTECS) are similar although not identical to the FHWA mpg estimates. Although RTECS data cover only passenger cars and light trucks domiciled at residences, this is still the vast majority of all light-duty vehicles (roughly 80 percent or more).[2]

As for new light trucks, the average fuel economy has not increased since 1982 (20.5 mpg in 1982 v. 20.4 mpg in 1997). From 1991 to 1995, FHWA estimates that the onroad fuel economy of two-axle, four-tire trucks (approximately equivalent to EPA's definition of light trucks) improved only 0.3 mpg, from 17.0 to 17.3. The clear implication is that, unless new car fuel economy begins to increase once again, we are nearing the limits of onroad fleet mpg gains.

In addition, the greater popularity of light trucks may well offset the remaining mpg gains from stock turnover. Light trucks' share of the light-duty vehicle market has grown from 10 percent in 1979 to over 40 percent today. In recent years, the greatest gains have been made by the larger four-wheel drive light trucks and

[2] As discussed in chapter 5, RTECS has been discontinued due to budget reductions.

passenger vans. Four-wheel drive large pickups and four-wheel drive sport utility vehicles increased their combined share of the light truck market from 29 percent in 1984 to 44 percent in 1997. Passenger vans doubled their share of new light truck sales from 8 percent to 17 percent over the same period. At the same time, light truck mpg improvement has been quite modest in comparison to that of passenger cars. In 1979, the fleet average mpg for new cars was 20.3 mpg and stands at 28.6 today. New light truck mpg averaged 18.2 in 1979 and stands at only 20.4 in 1997. The combination of booming light truck sales and modest improvement in light truck mpg has restrained the overall gains in light-duty vehicle fuel economy. Had the light truck market share remained at its 1979 level, the average fuel economy of new light-duty vehicles in 1997 would have been 27.5, instead of the 24.3 actually recorded (USDOT NHTSA 1997). It should be noted that 1979 was a particularly poor year for light truck sales and that the choice of a different base year for comparison would indicate a smaller effect on light-duty vehicle mpg.

Alternative Fuels

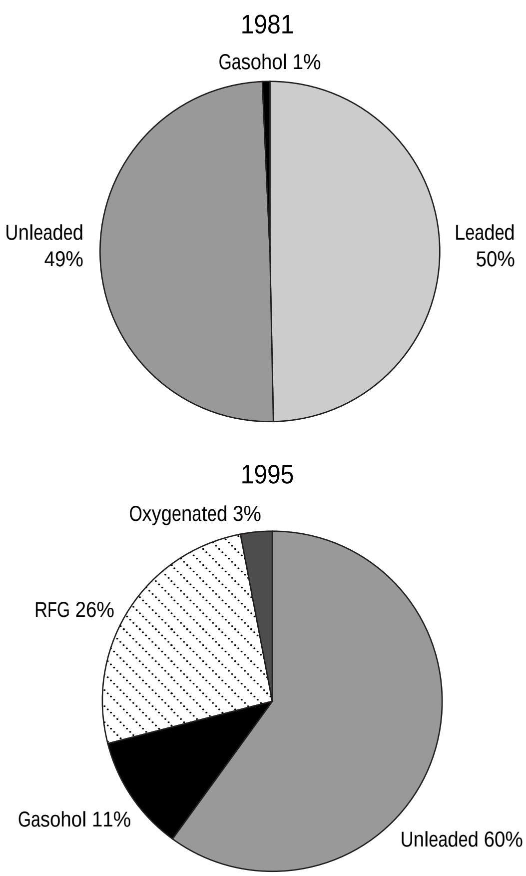
Regulating fuels to achieve environmental benefits started with the gradual elimination of lead from gasoline in the United States (Thomas 1995). The Clean Air Act of 1970 established a schedule for reducing the lead content of gasoline to lessen the amount of harmful lead in the environment. Before CAA regulations, adding 2.5 grams of lead per gallon of gasoline was typical. By 1982, the maximum amount of lead allowed in gasoline was reduced to 1.1 grams per gallon. In July 1985, the allowable lead content was reduced to 0.5 grams per gallon, and then to 0.1 grams per gallon in January 1986 (USDOE EIA OOG 1991, 12). The introduction of catalytic converters on vehicles to control emissions of hydrocarbons, carbon monoxide (CO), and nitrogen oxides (NO_X) gave further impetus to the lead phasedown program. Since the precious metal catalysts were rendered ineffective by lead, new vehicles with catalytic converters were required by law to use only unleaded gasoline. (Unleaded gasoline is defined as containing less than 0.05 grams of lead per gallon.) Leaded gasoline has now disappeared from the U.S. market (see figure 4-6) and only trace amounts remain in gasoline.

In recent years, the idea of coordinating fuel characteristics with vehicular emissions controls to maximize clean air benefits has become firmly established. Oxygen in the form of alcohols and ethers is added to gasoline to help reduce CO emissions. Ethanol, which is an oxygenate, has been blended with gasoline to create gasohol. Adding ethanol or methyl-tertiary-butyl-ether (MTBE) to gasoline has an added benefit of boosting its octane rating. Federal reformulated gasoline (RFG) standards put in place in late 1994 not only require the addition of oxygenates, but the reduction of toxic constituents such as benzene, the control of vapor pressure to reduce evaporation, and adherence to other fuel characteristics, as well.

Oxygenates, including ethanol now comprise 14 percent of the gasoline pool, up from only 1 percent in 1981 (some gasohol shown in figure 4-6 may be double counted as oxygenated gasoline). RFG, which was nonexistent in 1990, comprised 26 percent of all gasoline sold in 1995 and increased its share to 30 percent of all gasoline sold in the United States in 1996 (USDOE EIA 1997e, table 17).

The impacts of these sweeping changes in market shares on the price of fuel, however, have been relatively small. Taking the lead out of gasoline is estimated to have cost less than 1/2¢ per gallon (Thomas 1995). The observed price differential, however, has varied from 2¢ to 11¢ per gallon. RFG costs about 4¢ more per gallon

Figure 4-6.
U.S. Motor Gasoline: 1981 and 1995



SOURCES:
For U.S. production and imports of reformulated gasoline (RFG) and oxygenated gasoline, U.S. Department of Energy, Energy Information Administration, *Petroleum Supply Annual* (Washington, DC: 1993–1996 editions), tables 17 and 20.

For U.S. supply of leaded and unleaded gasoline, U.S. Department of Energy, Energy Information Administration, Office of Oil and Gas, *The Motor Gasoline Industry: Past, Present, and Future*, DOE/EIA-0539 (Washington, DC: January 1991), table 5.

For U.S. highway gasoline use and gasohol sales, U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics Summary to 1995* (Washington, DC: 1995), tables MF-226 and MF-233GLA.

to produce and deliver to the consumer than conventional gasoline (USDOE EIA 1997d, 21). RFG is typically sold in large cities with ozone nonattainment problems. National average prices for RFG tend to be about 6¢ per gallon higher than conventional gasoline of the same grade. This compares with a typical seasonal variation in the price of gasoline of about 5¢ per gallon.

Changes in the composition of gasoline have had a far greater impact on the nature of transportation energy use than all alternative fuel use to date. From 1992 to 1997, use of alternative and replacement fuels in the U.S. transportation sector almost doubled, from 2.1 billion to a little more than 4.0 billion gasoline equivalent gallons (see table 4-1).[3] Of the 2 billion gallon increase, 1.86 billion is attributable to increased use of MTBE, other ethers, and ethanol as oxygenates in gasoline. Only 11 million gallons are attributed to alternative fuel use in alternative fuel vehicles. Vehicles using liquefied petroleum gas and compressed natural gas remain by far the most common types of alternative fuel vehicles on U.S. highways.

GREENHOUSE GASES: THE CHALLENGE OF KYOTO

Growing concern about increasing concentrations of greenhouse gases in the atmosphere and the resultant potential for global climate changes (such as increasing temperatures, loss of coastal land to rising oceans, and greater frequency of violent weather) has led to an international agreement to reduce emissions of six GHGs. In December 1997, representatives of 159 countries met in Kyoto, Japan, on the Protocol to the United Nations Framework Convention on Climate Change, a convention resulting from the 1992 Earth Summit in Rio de Janeiro. In Kyoto, the United States and other industrialized countries agreed to binding commitments to reduce GHG emissions. Many issues remain contentious, and

[3] A gasoline equivalent gallon is defined as the lower heating value energy content of one gallon of gasoline. Lower heating value equals the Btus released by combustion, excluding the energy released by condensing water vapor produced in combustion.

Table 4-1.
Estimated U.S. Consumption of Alternative and Replacement Fuels: 1992–97
(Thousand gasoline-equivalent gallons)

Fuel	1992	1993	1994	1995	1996	1997[1]
Total fuel consumption[2]	134,230,631	135,912,964	139,847,642	143,019,659	145,634,659	148,289,767
Total alternative and replacement fuels	2,105,631	3,122,534	3,145,852	3,879,407	3,707,131	4,032,889
Alternative fuels						
Subtotal	229,631	293,334	281,152	277,507	297,231	321,389
Liquefied petroleum gas (LPG)	208,142	264,655	248,467	232,701	239,158	244,612
Compressed natural gas (CNG)	16,823	21,603	24,160	35,182	46,923	63,258
Liquefied natural gas (LNG)	585	1,901	2,345	2,759	3,247	4,567
Methanol, 85%[3] (M85)	1,069	1,593	2,340	2,887	3,390	3,625
Methanol, 100% (M100)	2,547	3,166	3,190	2,150	347	347
Ethanol, 85%[3] (E85)	21	48	80	190	694	1,416
Ethanol, 95%[3] (E95)	85	80	140	995	2,699	2,628
Electricity	359	288	430	663	773	936
Replacement fuels (oxygenates)						
Subtotal	1,876,000	2,829,200	2,954,700	3,601,900	3,409,900	3,711,500
Methyl-tertiary-butyl-ether (MTBE)[4]	1,175,000	2,069,200	2,108,800	2,691,200	2,749,700	2,923,700
Ethanol in gasohol	701,000	760,000	845,900	910,700	660,200	787,800
Traditional fuels						
Subtotal	134,001,000	135,619,630	139,566,490	142,741,750	145,334,920	147,950,950
Gasoline[5]	110,135,000	111,323,000	113,144,000	115,943,000	117,768,000	120,125,000
Diesel	23,866,000	24,296,630	26,422,490	26,798,750	27,566,920	27,825,950

[1] Estimated numbers.
[2] Total fuel consumption is the sum of alternative fuels and traditional fuels. Replacement fuels are included in gasoline consumption.
[3] The remaining portion of 85% methanol and both ethanol fuels is gasoline.
[4] Includes a very small amount of other ethers, primarily tertiary-amyl-methyl-ether (TAME) and ethyl-tertiary-butyl-ether.
[5] Gasoline consumption includes ethanol in gasohol and MTBE.

NOTES: Fuel quantities are expressed in a common base unit of gallons of gasoline-equivalent (GGE) to allow comparisons of different fuel types. GGE does not represent gasoline displacement. GGE is computed by dividing the lower heating value of the alternative fuel by the lower heating value of gasoline and multiplying this result by the alternative consumption value. Lower heating value refers to the Btu content per unit of fuel excluding the heat produced by condensation of water vapor in the fuel. Totals may not equal sum of components due to rounding.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1996*, DOE/EIA-0585(96) (Washington, DC: December 1997), table 10.

U.S. ratification of the agreement requires approval by a two-thirds majority vote of the U.S. Senate. Until the United States ratifies the protocol, it is not formally bound by its provisions.

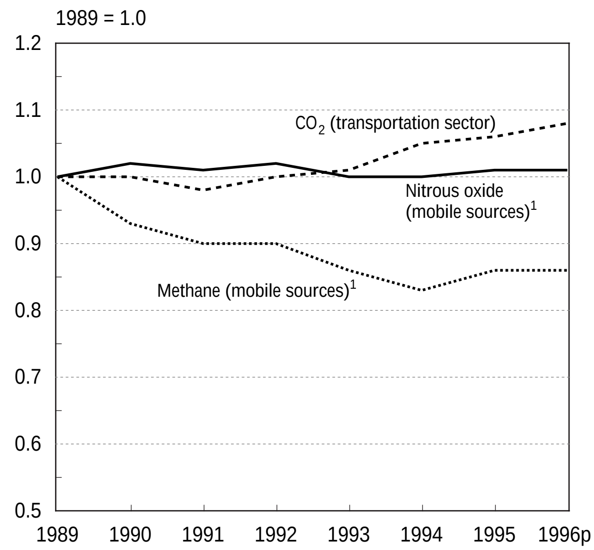
Energy use, especially the combustion of fossil fuels, is the principle source of GHG emissions from human activity (anthropogenic). For the United States, energy-related CO_2 emissions account for 84 percent of total GHG emissions (USDOE EIA 1997c, figure ES1). Methane emissions contribute another 10 percent, more than one-third of which is attributable to energy production and use. CO_2 emissions not related to energy use account for just over 1 percent of U.S. GHG emissions, and all other sources combined (including nitrous oxide—N_2O) account for less than 5 percent. Thus, it is reasonable to focus on CO_2 emissions as the predominant GHG and fossil fuel use as the predominant cause of CO_2 emissions.

Transportation accounts for about one-third of total CO_2 emissions from anthropogenic sources (USDOE EIA 1997c, 15). The growth of U.S. GHG emissions may have to be reversed if the United States is to meet the Kyoto protocol goals for the 2008 to 2012 period. Reducing transportation emissions of GHGs is not a necessary condition for reducing overall U.S. emissions. If transportation emissions continue to grow, however, it will be that much more difficult for other sectors to make up the difference.

In 1996, U.S. transportation-related GHG emissions grew 3.4 percent over 1995. This was the largest increase since 1989, the first year for which EIA provides a detailed accounting of total U.S. emissions of all types of GHGs (USDOE EIA 1997c, ix). This rate of increase is faster than the growth of energy consumption from transportation (3.2 percent) and faster than the growth of the economy (2.4 percent). Transportation, however, was not a significant factor in the accelerated growth of GHG emissions. Severe winter weather caused emissions due to residential and commercial buildings' energy use to increase by 6.3 percent and 5.5 percent, respectively. An increase in natural gas prices prompted a shift to coal for electricity generation that caused an extra 2.3 percent increase in carbon emissions over and above the 2.4 percent increase due to the growth of electricity sales.

Figure 4-7 shows how CO_2 and other transportation-related emissions of methane and N_2O have changed between 1989 and 1996. For example, in 1996, transportation's CO_2 emissions amounted to 469 million metric tons of carbon, compared with 433 million metric tons in 1989 (USDOE EIA 1997c, table 9). Transportation-related emissions of methane have remained steady over the past several years, but account for less than 1 percent of all methane emitted from anthropogenic sources (USDOE EIA 1997c, 31). Transportation-related sources produced 148,000

Figure 4-7.
Transportation-Related Greenhouse Gas Emissions Index: 1989–96



[1] Mobile sources include emissions from farm and construction equipment, in addition to transportation sources.

KEY: p = preliminary.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 1996*, DOE/EIA-0573(96) (Washington, DC: October 1997).

metric tons of N_2O in 1996, about the same as in 1989 (USDOE EIA 1997c, 41).

As discussed in the previous section, energy use has increased steadily in recent years because it is inexpensive and readily available. This growth would have to be curbed for the United States to reduce domestic GHG emissions. In this case, transportation would likely be responsible for some of the reductions, which could be achieved from improved vehicle efficiency or alternative fuels that do not contain as much carbon. As noted previously, the gains in vehicle efficiency initiated in the 1970s and 1980s appear to have run their course. If changes in vehicles and fuels are to significantly reduce growth in domestic transportation CO_2 emissions by the 2008 to 2012 period, fuel economy of new vehicles will have to start increasing quite soon to achieve substantial fleet penetration.

THE ENVIRONMENT

The many benefits of our nation's transportation system come at an environmental cost, including air and water pollution, unwanted noise, generation of solid wastes, and damage to wildlife habitat and ecosystems. *Transportation Statistics Annual Report 1996* (USDOT BTS 1996) discussed in more detail the environmental impacts of transportation. This section briefly updates trend data about transportation-related air pollution, aircraft noise, aviation-related deicing and anti-icing, leaking underground storage tanks, dredging of sediments, scrap tire disposition, and habitat impacts.

Air Pollution

Air pollution is the most visible and pervasive environmental impact of transportation, and its constituents contribute to ill health, acid deposition, smog, and stratospheric ozone depletion. Air pollutants include:

- criteria pollutants, such as CO, volatile organic compounds (VOC), nitrogen dioxide (NO_2), lead, ozone, and particulate matter of various sizes;
- chlorofluorocarbons (CFCs), which destroy the Earth's protective ozone layer; and
- toxic pollutants, also called hazardous air pollutants, such as benzene, 1,3-butadiene, formaldehyde, and acetaldehyde.

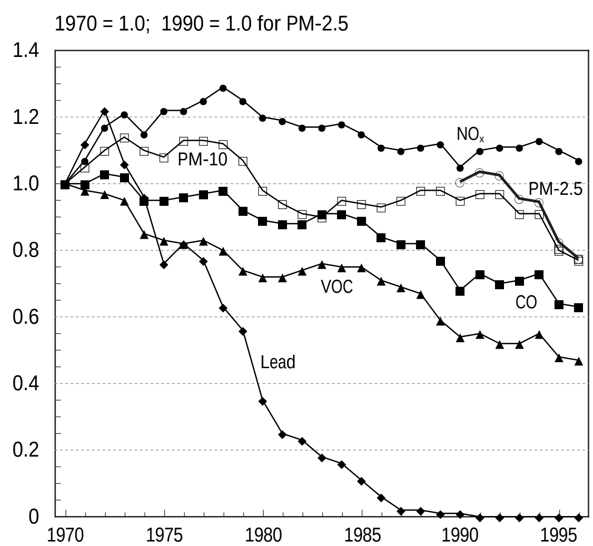
Emissions of many of these pollutants have been regulated and monitored since the advent of the CAA in 1970. Subsequent amendments to the CAA expanded regulations and tightened air quality standards, resulting in improved air quality.

Overall emissions of key air pollutants from transportation decreased between 1970 and 1996, despite an increase in vehicle-miles traveled. Most of the reduction came from light-duty passenger vehicles, which are the main source of most of these emissions. Decreases in these vehicle emissions are due primarily to tailpipe and evaporative emissions standards established by EPA, fuel economy improvements, and the ban on lead in motor vehicle fuel. Recently, EPA has focused regulatory efforts on fuel composition, in-use vehicle tailpipe emissions, and previously unregulated nonhighway vehicles in an attempt to further reduce transportation-related emissions (see USDOT BTS 1997).

EPA reports that most emissions declined in 1995 and 1996, following increases in some pollutants estimated for 1992 through 1994[4] (see figure 4-8). There were sizable reductions in estimated emissions of PM-10 and PM-2.5 (particulate emissions less than 10 microns and 2.5

[4] Emissions from transportation and other sources are estimated by EPA using a number of complex models and methodologies. Air quality, conversely, is directly measured by monitoring stations that collect and record pollutant concentrations in the ambient air.

Figure 4-8.
National Transportation Emissions Trends
Index: 1970–96



SOURCE: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Pollutant Emission Trends, 1900–1996* (Research Triangle Park, NC: 1998).

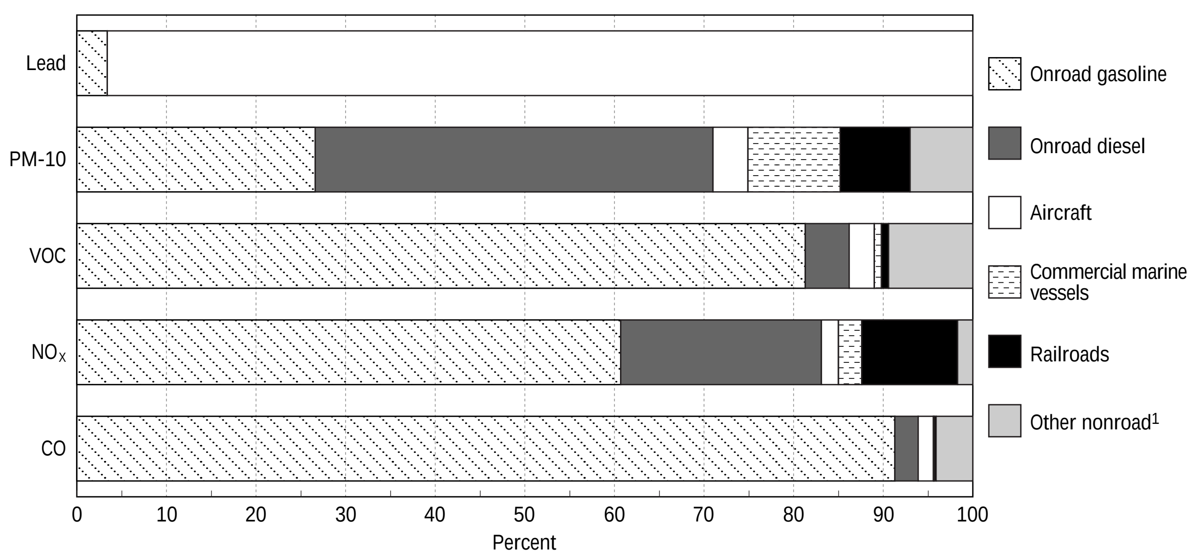
microns in size, respectively), while CO and VOC decreased only slightly. Only NO_X emissions remain above 1970 levels, decreasing moderately but still above their 1990 low point (USEPA OAQPS 1998a, A1–A29).

With the exception of lead, highway vehicles were the primary source of several key transportation-related emissions, accounting for 94 percent of CO, 83 percent of NO_X, 86 percent of VOC, and 71 percent of PM-10 emissions in 1996 (see figure 4-9) (USEPA OAQPS 1998a, A1–A29). Of these onroad emissions, gasoline-powered vehicles were responsible for most emissions, except for PM-10. Diesel-powered onroad vehicles accounted for 44 percent of all nonfugitive PM-10. Use of leaded fuel in general aviation aircraft is responsible for almost all transportation-related lead emissions (97 percent) and 14 percent of lead emissions from all sources. The Federal Aviation Administration (FAA), EPA, and the aviation industry are examining ways to reduce the release of lead. FAA has certified several general aviation aircraft engines to use alternative fuels.

► Air Quality Trends

Air quality is a measure of the concentration of pollutants in the atmosphere. Since 1975, air quality trends nationwide have improved considerably, according to EPA data (see figure 4-10). Lead concentrations show the greatest reduction, followed by CO. Ozone and NO_2 concentrations have dropped, but improvements since 1990 are less consistent. In 1996, national average air quality trends for most transportation-related pollutants showed a slight improvement or remained unchanged from 1995 levels. Ground-level ozone concentrations decreased, although this is mostly relative to the small upward spike in the 1995 average concentration. CO and PM-10 concentrations continued a general slow and steady decrease, while NO_2 and lead concentra-

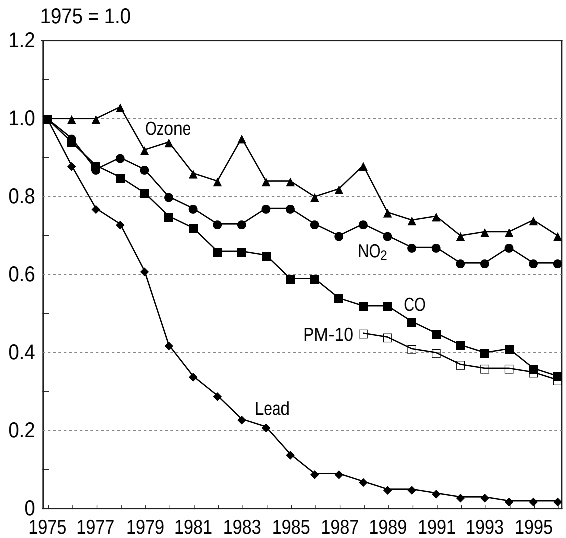
Figure 4-9.
Modal Shares of Key Pollutants from Transportation Sources: 1996



[1] Includes recreational vehicles, recreational marine vessels, and airport services vehicles. Does not include construction equipment, industrial logging equipment, and lawnmowers.

SOURCE: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Pollutant Emission Trends, 1900–1996* (Research Triangle Park, NC: 1998).

Figure 4-10.
National Air Quality Trends Index for Criteria Pollutants: 1975–96



SOURCES: U.S. Environmental Protection Agency, *National Air Quality and Emissions Trends Report, 1994* (Research Triangle Park, NC: 1995), table A-9.
______. *National Air Quality and Emissions Trends Report, 1995* (Research Triangle Park, NC: 1996), table A-9.
______. *National Air Quality and Emissions Trends Report, 1996* (Research Triangle Park, NC: 1998), table A-9.

tions remained at 1995 levels (USEPA OAQPS 1998b, 88).

The number of areas in nonattainment for ozone decreased from 68 in 1995 to 60 in 1996; for CO, from 31 to 29; for lead, from 11 to 10; and for PM-10, from 81 to 80. Consistent with previous years, Los Angeles is still the only nonattainment area for NO_2. EPA estimates that nearly 118 million people lived in areas that were in nonattainment for one or more of these transportation-related pollutants in 1996, compared with nearly 125 million in 1995 (USEPA OAQPS 1998b, 88).

In July 1997, EPA issued new National Ambient Air Quality Standards (NAAQS) for ground-level ozone and particulate matter.[5] Under the Clean Air Act, EPA is required to review and revise (as necessary) NAAQS for the six criteria pollutants every five years. After reviewing thousands of new health studies conducted since the previous standards were established, EPA decided that revisions to ozone and particulate matter standards were necessary to protect public health. EPA is also proposing a program to reduce regional haze resulting from air pollution, with final regulations expected in 1998.[6]

Costs and Benefits of the CAA: 1970 to 1990

In 1990, the U.S. Congress directed EPA to conduct a comprehensive study to evaluate the costs and benefits of the first two decades of CAA regulations. The results of EPA's study are in a 1997 report to Congress, *The Benefits and Costs of the Clean Air Act, 1970 to 1990* (USEPA OAR 1997). Although EPA and others estimated the costs of pollution abatement and control in previous studies, this is the most detailed study of the costs and benefits of all CAA regulations. The study quantifies the direct capital, operation and maintenance, abatement, regulatory, and research and development costs of CAA measures; emissions reductions; air quality improvements; visibility improvements; human health benefits in both reduced cases of illness and the corresponding monetary savings; and reduced agricultural damage.

Between 1970 and 1990, according to EPA, Americans invested about $523 billion in air pollution abatement and control. Nearly $179

[5] For ozone: 62 *Federal Register* 38652 (18 July 1997); for particulate matter: 62 *Federal Register* 38856 (18 July 1997).
[6] 62 *Federal Register* 41138 (31 July 1997).

billion (approximately 34 percent) paid for mobile source controls, while approximately $334 billion covered stationary source controls[7] (USEPA OAR 1997, A1–A31; Gillis 1997).

EPA made two very different estimates of the range of benefits arising from this spending over the 20-year period. The higher estimate (favored by EPA) found that benefits ranged from $5.6 trillion to $49.4 trillion, with the mean estimate at $22.2 trillion. This method valued each human life at $1.6 million to $8.0 million, with the mean at $4.8 million. Under an alternate method, EPA estimated the benefits would be lower, ranging from $4.8 trillion to $28.7 trillion, with a mean estimate of $14.3 trillion. The alternate method, called for by EPA's scientific advisory council for the analysis, estimated years of life lost compared with life expectancy. In doing so, EPA applied a constant cost of $293,000 per year of life lost. In either method, the benefits of clean air investments far exceeded the costs. Whether either of these estimates accurately encompasses the range of probable benefits depends in part on assumptions about the economic costs assigned to premature mortality. In fact, a report appendix notes that avoidance of premature mortality was both the largest source of benefits and the major source of quantified uncertainty in the analysis (USEPA OAR 1997, app. J, J-1). EPA notes that this is an area where further research could reduce uncertainty in future studies.

EPA estimates that actions taken under the CAA significantly decreased emissions of most criteria pollutants. In 1990, CO emissions were 50 percent lower than they would have been otherwise, lead emissions were 99 percent lower, VOC emissions were 45 percent lower, and NO_X emissions were 30 percent lower (USEPA OAR 1997, ES-2, ES-3). Regulation of mobile sources is responsible for most of the reductions in criteria pollutant emissions. Reductions from highway vehicles accounted for most of the overall reductions in CO, VOC, lead, and NO_X, as nonhighway transportation sources of these pollutants were regulated less strictly during this period.

The reductions in emissions from both transportation and nontransportation sources improved air quality in the nation. In turn, reduced exposure to criteria pollutants resulted in improved health for many Americans, prevented many thousands of premature deaths from particulate and lead exposure, and reduced cases of cardiac and respiratory symptoms and ailments (USEPA OAR 1997, 37–38).

Emissions reductions also decreased damage to natural habitats and ecosystems (e.g., wetlands, forests, and aquatic environments) and agricultural areas due to acid deposition and ozone (USEPA OAR 1997, F-9). The benefits stemming from the preservation of natural aquatic and terrestrial ecosystems currently cannot be adequately quantified, although they are likely to be significant.

Aircraft Noise

Aircraft noise first became a widely recognized problem in the United States in the mid-1960s, as the popularity and use of commercial jet aircraft rapidly increased. Congress directed FAA to begin regulating aircraft noise in the late 1960s, establishing the first federal noise standards for new-design turbojet and transport category jet aircraft. These so-called Stage 2 aircraft noise standards were subsequently applied to all newly produced planes, including those of older designs. Still, in 1974, FAA estimated that approximately

[7] Transportation and stationary source cost shares were based on the EPA data and methodology given in the *Benefits and Costs* report, as well as data provided by Thomas Gillis of EPA. Since the costs for abatement, regulations, monitoring, research, and development were not calculated separately for each source category by EPA, it was assumed that they were distributed equally between stationary and mobile sources.

7 million people were severely affected by jet aircraft noise (USDOT FAA 1989). Thus, in 1976, FAA required that all subsonic aircraft in operation (i.e., not just new aircraft) meet Stage 2 requirements by January 1, 1985.[8]

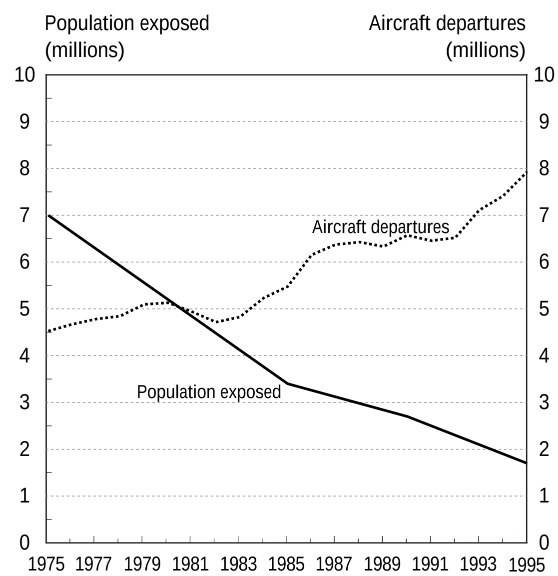
FAA implemented more stringent Stage 3 noise standards for new aircraft in 1977 and, in 1990, required a phased elimination of civil, subsonic Stage 2 turbojet airplanes over 75,000 pounds flying into or out of airports in the contiguous United States by December 31, 1999. These regulations, known as the Stage 3 transition rule, required operators to meet intermediate fleet composition goals by the end of 1994, 1996, and 1998. Operators were allowed to meet these goals by gradually reducing the number of Stage 2 aircraft in their own fleets by a given percentage or by reducing the percentage of Stage 2 aircraft within their fleet mix—both must be zero by the end of 1999. To date, the transition to Stage 3 aircraft has remained on schedule. By the end of 1996, 75.5 percent of the total fleet operating to and from U.S. airports met Stage 3 compliance requirements, up from 70.7 percent in 1995 and 66.3 percent in 1994 (USDOT FAA 1997).

Stage 2 and 3 regulations, along with airport compatibility planning,[9] have reduced the population exposed to excessive aircraft noise from airports. Recent estimates by FAA indicate that, in 1995, 1.7 million people were exposed to day-night noise levels greater than 65 decibels. Thus, exposure decreased by over 75 percent from 1975 to 1995, while commercial aircraft departures increased by over 75 percent (see figure 4-11) (USDOT FAA OEE 1997).

Airport and Aircraft Deicing and Anti-Icing

Airports and airlines deice and anti-ice runways and aircraft to ensure safe and efficient operations during wintry weather and when aircraft may encounter freezing conditions in the air. The FAA's "Clean Aircraft Concept" advisory prescribes that wings and other aircraft control surfaces be rendered free of frost, ice, or snow through use of manual methods, heated water, or

Figure 4-11.
Estimated Population Exposed to Airport Day-Night Noise Levels of 65 Decibels or More



SOURCES: Exposure estimates: U.S. Department of Transportation, Federal Aviation Administration, Office of Environment and Energy, 1997.

Departures 1975–93: U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation*, 1993, 1990, and 1980.

Departures 1994–95: U.S. Department of Transportation, Bureau of Transportation Statistics, *Airport Activity Statistics of Certificated Air Carriers: Twelve Months Ending December 31, 1995* (Washington, DC: 1996).

[8] Under Federal Aviation Regulation Part 36, aircraft sound levels are categorized by stages. Stage 1 refers to aircraft certified before FAA noise regulations. Stage 2 is the aircraft sound level needed to meet FAA 1969 noise regulations. Examples of Stage 2 aircraft include the B-727-200 and the DC 9. Stage 2 regulations are being phased out. Stage 3 refers to aircraft sound levels needed to meet FAA's more stringent 1975 noise regulations. Examples of Stage 3 aircraft include the B-737-300, the B-757, the MD-80, and the A-310.

[9] Airport compatibility planning is a noise management strategy for achieving compatibility between airport noise levels and land use in the area surrounding the airport (USDOT BTS 1996, 154).

freezing-point depressant fluids (Sills and Blakeslee 1991). The common practice is to spray or spread chemicals that lower the freezing point of water. Most of these chemicals end up in surface waters on or near airports.

Only ethylene or propylene glycol-based chemicals are certified by the Society of Automotive Engineers and approved by FAA (Mericas and Wagoner 1994). Propylene glycol costs more, while ethylene glycol is thought to have greater environmental impacts. In 1993, the U.S. Air Force prohibited the purchase of ethylene glycol-based chemicals for deicing. A Joint Service document required that propylene glycol-based chemicals be used in all but special circumstances (US Navy 1996).

The total amount of glycols released by U.S. airports is uncertain, and varies from year to year with weather, number of aircraft departures, and size and type of aircraft. A report for EPA estimated that the 17 busiest airports in the northern United States release a total of 58 million pounds of glycol per year (SAIC 1994). Another report estimated aircraft deicing product use nationwide to be 43.5 million pounds per year, based on the 1989 to 1990 season (Sills and Blakeslee 1991).

Both ethylene and propylene glycol chemicals cause environmental concerns. Although the propylene version is considered environmentally preferable, data do not suggest a clear choice. Both are highly soluble chemicals that greatly increase the biological oxygen demand (BOD) of receiving waters, but propylene exerts a higher BOD. Both can biodegrade rapidly, consuming oxygen and threatening oxygen-dependent aquatic life. Both contain additives; ethylene glycol-based deicers may also contain contaminants (SAIC 1994). Ethylene glycol is acutely toxic to mammals at relatively low concentrations. Glycols are not known to be carcinogenic, but some formulations of ethylene glycol are contaminated with trace amounts of 1,4-dioxane, an animal carcinogen (Sills and Blakeslee 1991).

Half or more of the glycols sprayed on aircraft typically fall to the ground where they may enter the stormwater drain system and mingle with other substances, be separately collected, seep through pavement into the ground, and/or mix with snow moved off pavement. The rest is retained on aircraft or dispersed into the air. At takeoff, anti-icing fluids are sheared off onto the runway area. Depending on how the airport is regulated, the stormwater containing glycols may be treated before release into surface waters. At airports with special deicing collection systems, the chemicals may be treated before release or diverted to a recycling system and processed for reuse elsewhere. There is no aggregated information on how U.S. airports handle this chemical runoff.

Environmental impacts may be mitigated through the location of deicing operations, choice of chemicals, application methods, and improved collection systems. An FAA advisory on standards and specifications for aircraft deicing facility design (mandatory for airport projects receiving federal grant assistance) recommends drainage and collection systems that isolate chemicals from the airport's central drainage system and allow deicing in gate areas or at centralized or remote facilities (USDOT FAA 1993). FAA notes that facilities close to runways can reduce the time between deicing and takeoff, thus improving safety and decreasing the amount of fluids used.

Denver International Airport has one of the most comprehensive deicing systems in the country, and uses only propylene glycol. After limited deicing at the gate area, aircraft go to one of three remote pads for deicing just prior to takeoff. Glycol runoff drains into holding ponds, and is released in allowable amounts to a local treatment works. The higher concentrated remote pad runoff is collected for processing. Yet, officials estimate that only about 60 percent of the used glycol is collected. A $2.8 million interceptor system to capture solution dripping from taxiing aircraft was installed last year, and more improvements are being sought.

Large computerized structures (or gantry systems) with numerous nozzles may reduce glycol consumption by passing over stationary aircraft and spraying specific amounts of deicer over particular areas with little waste material (USEPA OECA 1995). Some of the gantries may also have collection systems. United Parcel Service installed the system at its Louisville Airport facility about 10 years ago, but stopped using it 3 years ago because heavy, wet snow there interfered with effective operations.

Research on approaches to reduce environmental impacts include application procedures that reduce glycol consumption, and alternative chemicals and technologies. Currently, alternatives for deicing runways are more readily available than those for deicing aircraft. Technologies for deicing are now being tested. For example, DOE is funding a demonstration of a mobile unit with adjustable horizontal boom arms through which an aircraft can taxi and receive, from two separate nozzles, heated compressed air for deicing and precise amounts of glycol for anti-icing. An FAA-approved system—installed at Buffalo, New York, and Rhinelander, Wisconsin, airports—uses infrared heat to deice an aircraft as it passes through an open-ended hanger.

Leaking Underground Storage Tanks

Leaking underground storage tanks (USTs), especially those at retail gas stations, are one of the most common sources of groundwater contamination (USEPA OUST 1997b). Congress recognized the problem of leaking USTs over 10 years ago, and in September 1988 issued new standards for both new and existing USTs. These standards require newly installed USTs to be constructed of fiberglass-reinforced plastic or steel equipped with a noncorrosive lining or other corrosion protection, and to have adequate protection against spills and overflows, such as catchment basins and automatic shutoff devices or overfill alarms. Tanks that preexisted the standards must be closed, at least temporarily, if they are not upgraded or replaced by December 22, 1998.

Data compiled by the EPA Office of Underground Storage Tanks suggest that progress is being made in reducing leaking USTs. Although the number of newly confirmed UST releases increased from nearly 14,000 in 1996 to over 24,000 in 1997, the 1997 number is still fewer than the newly confirmed releases for all monitored years prior to 1996. Also, the number of cleanup efforts initiated during the year increased from 14,000 to nearly 40,000, and the number of cleanups completed during the year increased from about 21,000 to almost 26,000. As of November 1997, 163,476 leaking tank releases had not been cleaned up, the lowest number since 1994 (USEPA OUST 1997a).

Contaminated Sediment from Dredging Operations

Most ports and harbors need periodic dredging to maintain adequate depths for large ships used in world trade. The dredging, and resulting need to dispose of dredged materials, has resulted in environmental problems and conflicts, as is discussed in more detail in *Transportation Statistics Annual Report 1997*.

Dredging of sediment is carried out by the U.S. Army Corps of Engineers and U.S. port authorities. Ports spent $142 million on dredging in 1996, and between 1992 and 1996, dredging averaged 9 percent of total port capital expenditures (USDOT MARAD 1997). For 1992 through 1996, the Corps dredged an average of

265 million cubic yards per year of sediment in ports and harbors, for an annual average cost of $515 million.[10] The most costly dredging involves sediment contaminated with heavy metals or other pollutants. This contaminated sediment constitutes an estimated 5 to 10 percent (by volume) of all sediment dredged nationally each year, although the proportion varies widely by region (NRC Marine Board 1997).

In 1997, EPA published a preliminary assessment of the national incidence and severity of sediment contamination (USEPA OST 1997). EPA found that 96 watersheds in the country have areas of potential concern for sediment contamination. These areas are clustered in coastal and inland territory primarily east of the Mississippi River and in California and Washington. Limitations in available data and evaluation tools narrowed the scope of EPA's analysis. Hence, the data are not sufficient to determine the extent of contamination on a national scale. EPA considers the study output analogous to a screening assessment, not a confirmation of sediment that requires special management. The agency recommends further investigation and assessment of contaminated sediment. EPA is also conducting a contaminated sediment management study (due in 1998).

Approaches and technologies that would reduce the costs of managing existing contaminated marine sediment could improve the benefits of dredging. A 1997 National Research Council report rated a range of technologies for feasibility, effectiveness, practicality, and cost of managing contaminated marine sediment on an interim or long-term basis (NRC Marine Board 1997). No single approach emerged—four had high scores and each had one low or moderate ranking.

NRC also found a need for decisionmaking improvements, such as greater use of risk, cost-benefit, and decision analysis, and simplification of the applicable regulatory framework. Several agencies (at the federal, state, and local level) are involved at various stages of decisionmaking and implementation.[11] The agencies now work together as the National Dredge Team and seven Regional Dredge Teams as the result of a 1994 interagency report to the Secretary of Transportation (see USDOT BTS 1997).

Trends in Scrap Tire Disposition

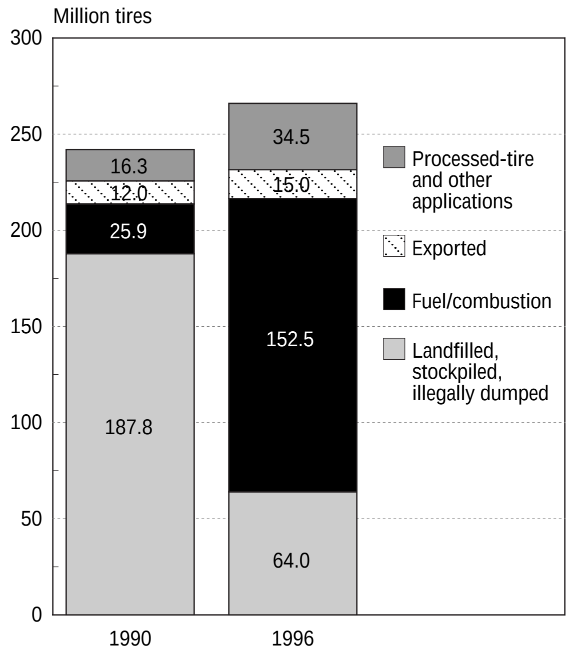
Scrap tires are a major source of solid waste from both highway and nonhighway transportation. Tire replacement is a part of regular vehicle maintenance; several sets of tires may be used and discarded during a vehicle's lifetime. Approximately 250 million scrap tires are generated annually in this country, many of which are disposed in landfills, scrap tire stockpiles, or illegally dumped. Advances in technology and applications have provided important markets for scrap tires over the past several years, greatly reducing the number of tires disposed.

EPA and the Scrap Tire Management Council estimate that the number of scrap tires stockpiled, landfilled, and dumped annually may have fallen by as much as two-thirds, while the annual number of scrap tires generated increased 10 percent (see figure 4-12) (STMC 1997, 3; USEPA SWER 1991). Scrap tire disposal decreased primarily because of a dramatic increase in their use as tire-derived fuel, currently the single largest market for these tires. From 1990 to 1996, the number of tires used as fuel increased nearly fivefold, reaching more than 150 million (STMC 1997, 3). Nonfuel markets for processed and whole tires consumed 34.5 million scrap tires in

[10] Port and Corps expenditures on dredging cannot be combined because data sources and methodologies differ.

[11] Prime actors are EPA, the Army Corps of Engineers, and the National Oceanic and Atmospheric Administration.

Figure 4-12.
Comparison of U.S. Scrap Tire Disposition: 1990 and 1996



SOURCES: 1996 data—Scrap Tire Management Council, *Scrap Tire Use/ Disposal Study: 1996 Update* (Washington, DC: 1997). 1990 data—U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Summary of Markets for Scrap Tires* (Washington, DC: 1991).

1996, twice the 1990 level. These markets include ground rubber applications, such as asphalt products, new tires, bound rubber products, and athletic surfaces; civil engineering applications, such as fill material, road bed material, and aggregate; and other applications such as artificial reefs, playground equipment, and crash barriers. Export of scrap tires has increased more modestly since 1990, from 12 million tires in 1990 to 15 million in 1996 (STMC 1997, 3).

Federal-Aid Highway Land Use and Wetlands

The most obvious land-use impact of transportation is the direct loss and degradation of natural habitats from constructing and expanding infrastructure such as roads, airports, rail lines, and ports. Many types of habitats are affected, and damage to and loss of wetland habitats are of interest because of the many benefits they provide humans and animal species, their relative fragility, and the magnitude of historical wetlands losses.

A recent EPA-sponsored study examined the impacts of the Federal-Aid Highway Program (FAHP) on wetland losses between the mid-1950s and 1980. During this period, the FAHP was very active and fewer environmental controls regulating road construction were in place compared with today. The study concluded that FAHP road construction potentially contributed to the loss of approximately 310,000 to 570,000 acres of wetlands between 1955 and 1980. This amounts to approximately 3 to 5 percent of the net wetlands acreage lost during this time. The study estimated the replacement cost for these wetlands at roughly $153 million to $6 billion (Apogee 1997). The direct impacts of rights-of-way affected approximately 184,000 to 449,000 acres. In addition, roughly 123,000 acres were lost due to agricultural draining facilitated by roadway ditches in the Prairie Pothole region, which includes most of North Dakota, roughly half of Minnesota and South Dakota, and about one-third of Montana.

The study has limitations, though. First, the wetlands losses are only rough estimates and replacement costs are orders-of-magnitude. Second, the study includes only road impacts, and the FAHP roads covered by the study constitute only one-quarter of the linear roadway mileage in the United States—non-FAHP roads include all rural minor collectors and urban and rural local roads. Finally, the study did not include many indirect impacts on wetlands, such as habitat fragmentation and alteration of hydrology. Nor did it estimate wetlands filled or affected by urban development stemming from FAHB activity.

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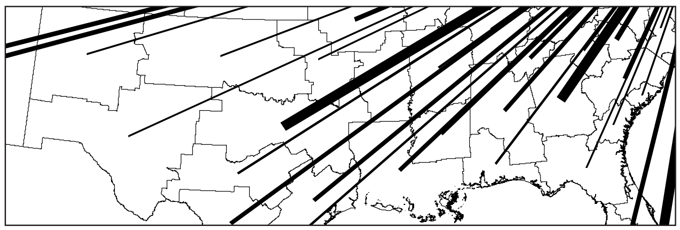
chapter five

The State of Transportation Statistics



The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991,[1] which established the Bureau of Transportation Statistics (BTS), funded a renaissance of data collection on freight activity and passenger travel as well as analytical work. These activities improved the state of transportation statistics and ameliorated many key information gaps decisionmakers faced in 1991, but many critical challenges remain.

The topics covered by ISTEA-funded information programs will continue to be relevant in the post-ISTEA era. The speed of technological, economic, and social change, however, increases pressure for more timely data. Furthermore, decision-makers need data that provide more specific geographic and demographic detail to deal with issues such as connecting former welfare recipients with jobs.

There is also increased demand for information on the cost, speed, and reliability of transportation, on intermodal connections and the condition of transportation facilities and services, and on the relationships between transportation and land use. These demands result from the continuing geographic dispersion of communities and economic activity, and from the pressures of a global market in which American goods and services must compete. In addition, post-ISTEA pressures on the public sector for increased accountability, most notably through the Government Per-

[1] Public Law 102-240, 105 Stat. 1914 (1991).

formance and Results Act of 1993[2] are creating demands for information on the performance of the transportation system and for methods to determine how transportation performance is affected by government programs.

The complete picture of the transportation system and its consequences requires accurate and comprehensive information on freight activity, passenger travel, and vehicles; transportation facilities and services; and pertinent economic, safety, energy, and environmental data. The information gaps for each of these topics are summarized below, and treated more fully in the BTS report, *Transportation Statistics Beyond ISTEA: Critical Gaps and Strategic Responses.*

FREIGHT ACTIVITY

The nation's freight transportation activities are changing rapidly, reflecting the dynamic nature of the national and global economies. 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 freight movement in the United States.

To gain information about domestic freight activity, BTS and the Census Bureau undertook the Commodity Flow Survey (CFS) in 1993 and 1997.[3] (See box 7-1 in chapter 7 for a description of the CFS.) Although the CFS greatly improved our knowledge of domestic freight activities, that knowledge continues to be incomplete. The survey does not cover establishments involved in farming, forestry, fishing, construction, and crude petroleum production; households; governments; foreign establishments; and most retail and service businesses.[4] To keep from becoming too burdensome to respondents, the CFS does not collect national-level information about shipment frequency, travel time from origin to destination, and shipment cost. Since the CFS covers shipments sent rather than received, it covers exports but not imports.

The need for information on imports and exports is being driven by the dramatic growth in international freight movement and expanding competition between transportation service providers throughout North America. Limitations of current data sets make it difficult to identify the location, mode, and other transportation characteristics of U.S. imports and exports.

U.S. foreign trade data traditionally have been oriented toward economic transactions rather than physical transportation flows. For example, the Transborder Surface Freight Data, processed for BTS by the Census Bureau, provide information on shipments between the United States and Mexico and the United States and Canada based on trade data filed at Customs Service districts and ports. The location is often misrepresented because trade documents are not always filed where shipments physically cross the border. Intermodal shipments are poorly represented in foreign trade data, because the mode of transport is recorded as the mode upon entry or exit via a Customs port. The domestic leg of the shipment journey (i.e., point of origin to port of export) does not necessarily use the same mode.

Another critical constraint of foreign trade data is the inconsistent availability of shipment weight for surface exports. Having accurate shipment weight, however, is fundamental for estimating and forecasting how international trade impacts domestic transportation infrastructure.

[2] Public Law 103-62, 107 Stat. 286 (1993).

[3] The Federal Highway Administration was a major financial contributor to the 1993 CFS.

[4] The national totals for some industries not covered were estimated by Oak Ridge National Laboratory from other data sources. Efforts to estimate state and regional values have been less successful.

Despite the growing importance of international trade, surveys to remedy transportation gaps in foreign trade data have not been updated since the mid-1970s. These surveys collected data on the inland destinations of imports and the origins of exports, the means of transportation between inland locations and the port or border crossing, and shipment weight.

Still another data gap is the lack of detailed information on commodity movements by air, both for domestic and international freight. Air freight is a small but growing portion of domestic transportation and carries a significant share of the value of transoceanic trade. Air freight is particularly important for retail and service establishments, few of which were included in the CFS, and may be best measured through a sample of air waybill documents.

Freight transportation is a local issue as well as a national and international concern. The CFS provides the larger context for local freight activity—how much is entering, leaving, or circulating within an area—but no national survey can capture local patterns of freight movements. There is a need for locally collected data to provide insight into transportation demand, the relationships between freight movement and local business patterns, and freight flows through key corridors. This need is shared by both urban and rural jurisdictions.

PASSENGER TRAVEL

The Nationwide Personal Transportation Survey (NPTS) and the American Travel Survey (ATS) are key elements in the intermodal transportation database called for in ISTEA. The NPTS provides detailed information most thoroughly for local daily travel, while the ATS covers long-distance passenger movements. These surveys do not include data on travel costs, fuel use, economic activities served, and the domestic travel of foreign visitors. They also lack geographic detail on routes where local travel is concentrated and information on trips in the 50- to 100-mile range.[5] In addition, they provide very little information about passenger travel by persons with disabilities. BTS and the Federal Highway Administration (FHWA) are exploring ways to address these problems through integration of the two surveys.

Many large metropolitan planning organizations have conducted large-scale surveys of local travel over the years, but costs of such surveys have made updates prohibitively expensive. Planners have become increasingly dependent on the journey-to-work questions in the decennial census to recalibrate models of local travel and meet the analytical requirements of the Clean Air Act.[6] This dependence underscores the critical importance of the long form of the year 2000 census, which is threatened by cost and methodological issues.

VEHICLES AND VESSELS

There are more than 200 million motor vehicles in the United States. In recent years, rapid changes in the number and type of personal-use vehicles and a blurring of traditional distinctions between business and personal-use vehicles have occurred. Pickup trucks and vans are often used as personal vehicles, while many businesses use cars to deliver goods and services (e.g., fast food delivery).

Accurate data are needed on the number and type of motor vehicles and how they are used, the vehicle occupancy rate for cars, light trucks, and buses, and load factors for heavy trucks. Such data help in analysis of future growth in transportation, and are needed to calculate high-

[5] Data for these distances are poorly reported in both the NPTS and the ATS.

[6] 49 U.S.C. 7401.

way user fees and cost allocations, and to allocate funding among states. The data are also important for evaluating safety risks for travelers, and the energy efficiency and environmental impacts of the U.S. transportation system.

FHWA is evaluating alternatives for improving the quality of vehicle data received from states. Better vehicle information could also be obtained by expanding the Truck Inventory and Use Survey (TIUS) to include automobiles and buses. The TIUS currently includes light trucks and vans, as well as heavy trucks, and is a critical source of information on miles traveled, vehicle age, fuel consumption, and economic activities served. BTS is considering options for expanding the survey and conducting it annually rather than once every five years.

BTS is also working with the U.S. Coast Guard, the Maritime Administration, and the Army Corps of Engineers to determine how many ships, barges, and boats operate in the United States. Each agency counts different parts of the fleet, reflecting an agency's specific mission. BTS hopes to identify overlaps and fill in any gaps in the year ahead.

THE TRANSPORTATION SYSTEM

The transportation system includes facilities and services that connect geographic locations. Facilities data cover the location, connectivity, use, and condition of individual highways, railroads, rail transit lines, airports and air space, ports and waterways, pipelines, and intermodal terminals. Such data need to be assembled and updated on a regular basis to monitor the state of the U.S. transportation system for planning and investment decisionmaking. Detailed data are generally available on the location and connectivity of major highways, most railroads, rail transit facilities, public-use airports, and ports and navigable waterways. Facility-specific use data are available for ports and waterways, airports, and a sample of highways. Data on the use of specific railroad segments can be estimated. Although the location of truck and rail terminals is generally known, especially those identified by states when defining intermodal connector roads to the National Highway System, publicly available information about the use of those facilities is often limited. Detailed information about the location, connectivity, and use of pipelines is currently being developed by a cooperative effort between the pipeline industry and the federal government.

More information is needed on the location, connectivity, capacity, and condition of railroads to assess mergers, abandonments, and safety concerns, and to evaluate proposals for public investment in railroad capacity improvements and intermodal facilities. Some of the requisite data were last collected in the 1970s and are now obsolete, given ongoing changes in ownership and trackage rights.

There is also a need for information on transportation facilities and services that link the United States to other nations, especially Canada and Mexico. This information would complement efforts to measure the overall condition, performance, and use of the transportation system within this country, and guide efforts to reduce physical barriers between domestic businesses and international markets.

Selected geographic information is available for fixed-route public transit and Amtrak, but similar data are not available for other providers of surface passenger transportation. These data are particularly important for efforts to help former welfare recipients get to jobs, since social services agencies may provide transportation links beyond the reach of conventional public transit.

From the perspective of travelers and shippers, time, reliability, and cost data are important factors in measuring the performance of transportation services. National information on scheduled travel time and ontime performance is limited to major air carriers and Amtrak. The NPTS reports the commute-to-work time for the nation as a whole, while the decennial census provides such information for specific metropolitan areas. Only anecdotal information exists on travel time and reliability of other passenger trips or about freight transportation.

The most detailed cost data are for commercial aviation. For other modes, most cost data are no longer available in a publicly accessible form. Such data would be useful to understand the economic consequences of transportation, the degree of competitiveness within the transportation sector, the financial health of carriers, and other economic conditions that concern public agencies, shippers, and the investment community.

Transportation decisions must take into account the geographic context of the transportation system, including both the distribution of population and economic activities that require transportation, and environmental conditions and human activity affected by transportation. In addition to journey-to-work data, the long form of the decennial census collects a wealth of data on the demographic and economic characteristics of residents and their places of employment. At the present time, the long-form Census data provide the only nationwide source of information on economic activity finer than the county level of geographic detail.

ECONOMIC DIMENSIONS OF TRANSPORTATION

Understanding the economic dimensions of transportation is essential to determine effective public and private investment in transportation infrastructure, prioritize transportation projects, estimate the number of jobs created by transportation spending, understand regulatory costs, monitor competitiveness and the economic health of the transportation sector, and forecast revenues from transportation facilities and activities. This understanding requires data on how much transportation buys from other industries, how much other industries spend on transportation, the value of transportation capital, and productivity.

As is discussed in chapter 2, BTS and the Bureau of Economic Analysis of the Department of Commerce have developed the Transportation Satellite Accounts. As a result, BTS can now estimate the contribution of transportation to the cost of specific industries and products, and analyze how changes in the cost of resources consumed by transportation (e.g., gasoline) might affect the industries and products that use transportation.

Other measures of transportation's economic importance still need to be developed. BTS and FHWA plan to develop capital stock accounts to measure the value of transportation infrastructure. To develop these accounts, a better analytic understanding of the depreciation and obsolescence of transportation facilities is needed. Several conceptual issues, such as basing measures on economic concepts of wealth versus potential productivity, must be resolved.

Many of the concerns addressed by national accounts and productivity analyses are pertinent to states. In particular, states require data and analytical tools to: 1) determine the appropriate level of investment in transportation in order to encourage economic health, 2) prioritize projects within a multimodal transportation program, and 3) estimate revenue from tolls, regionwide taxes, and other sources.

TRANSPORTATION SAFETY

There is a sizable body of data with which to track trends in transportation safety. The most detailed data are for highway vehicles and modes involving commercial passenger transportation. Significant data limitations remain, however, that hinder informed decisionmaking on safety issues. Data needs include: 1) more uniform reporting of crashes and incidents throughout the nation; 2) comprehensive and consistent measures of risk exposure, especially with respect to hazardous cargo; 3) comprehensive information on the causes of crashes and incidents, including human factors, weather and other environmental factors, and equipment and infrastructure failure; and 4) more accurate and complete reporting of injuries and costs.

Safety statistics are difficult to compare across different data systems because of inconsistent definitions and reporting criteria. For example, thresholds and scales for reporting injury severity are not uniform among modes. Inconsistent information about injuries complicates cross-modal analysis.

More accurate, comprehensive, and consistent measures of risk exposure could help elucidate the relative importance of factors contributing to transportation crashes and improve analysis of safety trends. Better exposure measures require data not only on the number of fatalities, injuries, and accidents, but also data that indicate the overall level of transportation activity (e.g., number of licensed drivers, vehicle-miles traveled (vmt), person-miles traveled, and hours flown). Improving data on vmt and passenger car occupancy rates (e.g., through a vehicle inventory and use survey) could be helpful in safety analysis.

Analyses of safety trends for the commercial waterborne, pipeline, and nonmotorized modes —bicycling and walking—suffer from the absence of exposure measures. Nonmotorized mode exposure is especially important given that more than 6,100 pedestrians and bicyclists died in 1996 in crashes involving motor vehicles. Bicyclists and walkers often take trips too short in length to be counted in national travel surveys. Furthermore, trips that begin and end at a residence, without an intermediate stop, are typically not counted, thus excluding much recreational bicycling and walking.

There is also a need for exposure information on specific populations (e.g., children and elderly drivers). For example, inadequate exposure data on children under five years of age makes the evaluation of some transportation risks difficult.

Moreover, better exposure measures and incident data are needed for evaluating the risks associated with the transportation of hazardous materials. Because all modes are involved in transporting these materials, multiple data sources must be reviewed and analyzed to establish risk levels.

Even with adequate data, analysts must contend with different ways to combine the data into measures of safety risk. Total distance traveled is appropriate in some cases, while high-risk portions of travel are more relevant in others.

Within modes, data-collection efforts need to take into account changes that could affect safety, such as consumer preferences for vehicles. For example, more people are buying sport utility vehicles and light trucks for personal use, making crashes between these vehicles and smaller passenger cars more likely. Moreover, when data on risk exposure are broken down by vehicle type and other factors, such as time of day and highway type, the data may not be accurate enough for rigorous statistical analyses. Data on crashes involving two modes of transportation, such as highway vehicles and trains at grade crossings, need special attention to avoid double counting. Better information is needed on safety incidents involving both freight and passenger modes, which often share the same road or facility, but have their own set of risks.

With state governments assuming increasing responsibility for safety, standardizing and computerizing local, state, and national safety databases are important issues. Greater standardization of basic measures of loss across modes and throughout the country would help. Examples include injury and accident reporting thresholds, how to tally injuries to crews and operators and to pedestrians and other people not in a vehicle, and how to avoid double counting in collecting statistics about cross-modal crashes and incidents.

In addition, more comprehensive data are needed on factors contributing to crashes and incidents. Human error, equipment problems, and environmental conditions (e.g., weather) account for most crashes and incidents, but modal profiles vary significantly. In terms of weather, data collected on conditions at the time of the crash are not adequate to determine the importance of weather as a cause of highway crashes. It would be useful to have quantitative information about risks arising from adverse weather conditions to compare with risks during fair weather. Moreover, there is a need for better information about how factors interact when there are multiple causes of crashes.

The underreporting of transportation injuries, along with inconsistencies in injury reporting, further complicate the assessment of transportation safety. The consequences of injury may be as devastating as those of motor vehicle fatalities in terms of time and money lost. The reporting of injuries, however, is less comprehensive and consistent than the reporting of fatalities. Data about the number, severity, and costs of injuries from highway crashes are inadequate. More comprehensive data await linkage of highway crash reporting and medical data systems, a step being taken by at least 14 states with the urging of the National Highway Traffic Safety Administration.

TRANSPORTATION ENERGY USE

The nation's continuing dependence on imported petroleum, as well as efforts to promote alternative fuel use, initiated by the Energy Policy Act of 1992,[7] and the Alternative Motor Fuels Act of 1988,[8] suggest a continuing need for an accurate accounting of transportation energy use and trends. Much of the necessary information is available in Energy Information Administration (EIA) publications. There is, however, no comprehensive and accurate source of information on the types and quantities of nonpetroleum energy used as blending components in petroleum fuels. *Transportation Statistics Annual Report 1997* (TSAR97) noted that roughly 10 times as much nonpetroleum energy enters transportation's energy supplies by this route than is used by all alternative fuel vehicles combined.

Better accounting of the nonpetroleum components that are blended with gasoline is needed to more fully understand the nature of transportation energy use and its implications for reducing carbon and other emissions (see box 5-1). TSAR97 presented rough estimates of the nonpetroleum components of U.S. gasoline. While many components of these estimates are well understood, there is growing uncertainty in two areas: 1) the quantities of some additives, especially ethers, produced at refineries and blended with gasoline are not presently accounted for, and 2) imports of reformulated gasoline, the exact composition of which is unknown, are growing in importance.

Information on the fuel economy actually achieved by light-duty vehicles is available from three separate sources: 1) FHWA's *Highway Statistics,* table VM-1; 2) the U.S. Department of Transportation's *Nationwide Personal Transportation Survey*; and (3) EIA's *Residential Transportation Energy Consumption Survey* (RTECS).

[7] Public Law 102-486, 106 Stat. 1776 (1992).
[8] Public Law 100-494, 102 Stat. 2441 (1988).

Box 5-1.
Transportation and Greenhouse Gas Emissions

The climate change issue is at the nexus of many energy and environmental concerns, since combustion of fossil fuels produces 97 percent of the U.S. transportation sector's greenhouse gas emissions Should it be ratified, the Kyoto Protocol will create a range of new transportation data needs pertaining to measuring, monitoring, and validating transportation greenhouse gas (GHG) emissions. Total inventories of GHGs by sector have already been developed and published by the Energy Information Administration. These will probably form the basis for determining compliance with national emissions targets. U.S. greenhouse gas reduction policies, however, may well require linking transportation choices to their consequences for both upstream (e.g., fuel processing or vehicle manufacture) and downstream (e.g., solid waste disposal or recycling) emissions. International emissions trading programs, a key element of the Kyoto Protocol, will require information systems for monitoring, evaluating, reporting, and verifying changes in GHG emissions, though at what level (national, regional, sectoral, or firm) remains to be determined.

Efforts to constrain transportation's GHG emissions will also reinforce the need for basic information about transportation energy use and efficiency. Expanding the Truck Inventory and Use Survey (TIUS) to include all light-duty vehicles, as well as odometer-based vehicle use data and vehicle fuel economy estimates, will be important. Interest will grow in valid and accurate measures of the efficiencies of freight movement. These depend critically on improved estimates of ton-miles (the 1993 Commodity Flow Survey has already made a contribution here) and load factors (which will require enhancement of the TIUS or creation of a new source of data). Accurate indicators of efficiency and fuel use trends will increase in importance.

Data presented in *Highway Statistics* table VM-1 are not based on direct measurement of fuel economy, but are estimated based on data provided to FHWA by states. These estimates are then reconciled to match known totals for fuel use and vehicle travel. In 1995, the NPTS included (for the first time) odometer-based vmt estimates for household vehicles. The NPTS does not permit accurate estimates of fleet fuel economy, however, because it does not identify vehicles in sufficient detail to allow them to be matched with Environmental Protection Agency (EPA) miles-per-gallon (mgp) values. RTECS numbers are based on a statistically valid survey of household vehicles (households own or house more than 80 percent of all light-duty vehicles). Initially, RTECS calculated fuel economy directly from recorded purchases of gasoline and reported vehicle odometer readings. In order to cut costs, the more recent RTECS estimated vehicle fuel economy by matching vehicles to their EPA mpg ratings and using adjustment factors to estimate actual in-use mpg. Due to budget cuts, EIA plans to discontinue RTECS. Results from the 1994 survey are the last that will be available.

The RTECS gap could be largely filled if the TIUS were expanded to include passenger cars and other types of vehicles, as discussed earlier. Such a survey would improve on RTECS by including vehicles owned by businesses, as well as by households, but the current TIUS survey methods would have to be adapted to allow odometer-based vmt estimates. Additional processing of the survey results would also be required to add mpg estimates. There are many reasons for broadening the TIUS to include passenger cars and other vehicles. A fuller vehicle inventory and use survey is under consideration, but has yet to be launched.

TRANSPORTATION AND THE ENVIRONMENT

Each year, knowledge of environmental impacts improves, but national-level data to adequately quantify impacts in several areas is still lacking. Air quality and emissions data are the most comprehensive, since the Clean Air Act requires annual air quality monitoring, and emissions inventories are produced to steer control strategies. A nationwide air monitoring system records daily variations in air quality at about 4,000 sites nationwide. Moreover, emissions estimates of mobile sources of air pollution are much improved. Indeed, EPA recently improved its estimation of motor vehicle emissions in real-world conditions. Also, recent efforts by EPA to quantify health benefits from reductions in air pollutants have improved what is known about the ultimate impact of air pollution on human health, although the exact amount attributable to transportation has not been quantified. Also, no reliable time series on transportation-related toxic air pollutants, such as benzene, are produced on an annual basis.

Data on the impact of water pollutants released from transportation sources is much less complete. No comprehensive inventory of the amount released each year exists. Estimates are available for oil spills from vessels, but they do not include the amount of water ultimately contaminated. Similarly, EPA maintains a record of the number of leaking underground storage tanks, but the quantity of material released, the extent of contamination, and the amount of contaminants recovered through cleanup are not know. Data on other sources of water pollution, such as improper disposal of motor oil, releases of deicer at airports, and highway runoff, are not regularly produced or are not produced at the national level. Finally, there are no estimates of transportation's contribution to water quality problems, nor are there estimates of the extent of health impacts on humans, animals, or vegetation.

Two kinds of transportation-related noise are of particular interest: aircraft noise at airports and traffic noise from highways. Over the past 20 years, the Federal Aviation Administration has produced data intermittently showing populations exposed to unacceptable levels of aircraft noises, but no national-level data quantifying exposure to highway traffic noise have been produced for over a decade.

Data on solid waste are slowly improving. Much of the solid waste stream from transportation vehicles and infrastructure is recyclable or reusable, and many private companies have begun to capitalize on these markets, although the exact effect of these activities on the waste stream is unclear. Private organizations are starting to produce estimates of scrap tire use, oil filter recycling, and other aspects of the solid waste stream. Still, a total annual inventory of transportation-related solid waste has yet to be produced.

The impacts of transportation on land use and habitats are poorly understood. There is very little information available regarding the total amount of land occupied and habitats degraded or destroyed by transportation infrastructure. Studies that do exist are limited in scope to small regions or to particular plant and animal species or habitat types. Furthermore, the relationship between transportation and land-use patterns is a topic of some debate, making it difficult to estimate secondary land-use impacts caused by expansion of the transportation infrastructure. The U.S. Fish and Wildlife Service is currently developing a National Wetlands Inventory, which may aid researchers in estimating the impact of road construction on wetlands in the near future.

For the most part, the current environmental management system continues to treat each kind of pollution separately, even though there are complex interactions among different media. Similarly, most analyses of transportation's environmental impacts focus on individual modes rather than on comparative environmental performance among modes. A complete analysis of the environmental impacts of transportation would need to take into account upstream activities (e.g., oil field development, petroleum refining, and vehicle production) that make transportation possible. In conducting such analyses, special care to avoid double-counting impacts would be needed.

Finally, a weakness of environmental data is that they do not show the effect of pollutants produced by transportation. To what extent does transportation pollution damage human health? What are the effects of transportation pollution on crop yields? How and to what extent do transportation activities affect ecosystems? These are difficult questions, but they must be answered in order to assess the actual environmental impacts resulting from transportation.

Such an effort will likely be an important part of developing indicators of progress toward sustainability. Proponents of such an approach have proposed goals such as the conservation of nature, stewardship of natural resources, and improvements in health and the environment. Appropriate indicators are needed to measure progress toward the goals that are adopted.

TOWARD THE FUTURE

The state of statistics depends on methodologies for collecting and displaying data and making information available. Geographic information systems and other communications tools hold much promise for presenting data in clear, concise, and compelling ways for data users. Inconsistencies in geographic data formats and definitions hinder progress in this area, and improvements are needed in methodologies to integrate geographic data with other kinds of information.

In time, intelligent transportation systems (ITS) may allow the replacement of many surveys and other traditional forms of data collection, particularly if traffic control, shipment management, and other systems can be integrated. Almost all of the information obtained in roadside interviews of truck drivers, plus other freight information, could be captured from monitoring systems that public agencies are considering to manage congestion and collect user fees. Similar information could be captured from monitoring systems used by carriers to track their vehicles, shipments, and drivers.

In the near term, however, important barriers impede full realization of the potential of ITS for data collection. First, most systems are designed to manage day-to-day or minute-to-minute conditions, in itself a challenge. Additional requirements for integration and archiving of data are often secondary, especially if integration must be achieved across organizations. There are also legal issues, privacy concerns, and limitations on the use of proprietary data that need to be resolved. 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 by an agency of an unsafe condition 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 generated in transportation monitoring and control functions are not saved. The transportation community must continue to depend on more costly and burdensome data collection until technological and institutional issues can be resolved.

Improvements need to be made in the traditional forms of data collection. The use of computers for 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 gaining extensive experience with using computer-aided interviewing, and FHWA has sponsored research on the use of inexpensive, handheld computers for data collection.

Whether collected by new technologies or traditional methods, data are subject to increasingly rigorous quality standards as decisionmaking becomes more information-intensive. Quality issues are highlighted in the 1997 National Academy of Sciences review of BTS (see box 5-2).

Finally, data are not useful unless they are made available to the transportation community and the community is aware of how to make effective use of them. New approaches to training are needed, because sophisticated models, complex analysis, and large data sets are no longer restricted to experienced users in the largest public agencies and private firms. Personal computers and CD-ROMs allow small planning agencies, local transportation firms, citizen groups, and individual consultants to manipulate data sets that required expensive mainframe computers just two decades ago.

New computer technology, especially the Internet, is making data easy to distribute and store, but the institutions that make sure that information is organized and archived are in decline. Many transportation libraries have closed or are downsizing. Preventing loss of such resources is an objective of the National Transportation Library, now part of BTS's legislative mandate.

The ability to respond to longstanding concerns of the transportation community will depend, in part, on available resources. BTS will continue to strive toward measuring in a more complete, accurate, and timely manner the importance of transportation (including transportation's positive and negative consequences) and providing insights to decisionmakers on how to make transportation better unite what geography divides.

Beyond ISTEA: The TEA-21 Mandate

Congress reauthorized the surface transportation programs and the programs of the Bureau of Transportation Statistics in the Transportation Equity Act for the 21st Century (TEA-21), signed into law by President Clinton on June 9, 1998.[9] TEA-21 reaffirms BTS's broad mandate under the Intermodal Surface Transportation Efficiency Act of 1991, increases the Bureau's authorization to $31 million per year, and adds a number of topics and functions for BTS to pursue in the years ahead.

- New topics include factors affecting global competitiveness, the relationships between highway transportation and international trade, information on bicycle and pedestrian travel, and data on expenditures and capital stocks related to transportation infrastructure.
- TEA-21 mandates the National Transportation Atlas Database and gives BTS responsibility for the Intermodal Transportation Data Base (ITDB), adding requirements for data on expenditures and capital stocks.
- TEA-21 establishes the National Transportation Library to organize and share the knowlege base of the transportation profession. This is the only national library for transportation mandated by Congress.
- TEA-21 broadens the BTS role in statistical policy to "review and report to the Secretary of Transportation on the sources and reliability of the statistics proposed by the heads of the operating administrations of the Department to measure outputs and outcomes as required by the Government Performance and Results Act of 1993" (GPRA).

[9] Public Law 105–178, 112 Stat. 107 (1998).

■ TEA-21 makes explicit the need for BTS programs to be relevant to transportation decisionmaking by federal, state, and local governments, as well as by transportation-related associations, private businesses, and consumers. This goes well beyond the normal mandates for national statistical agencies, which are focused primarily on needs of the federal government.

Box 5-2.

BTS Priorities for the Future: The Views of an Expert Panel

In 1997, the National Academy of Sciences published a review of the first four years of operation of the Bureau of Transportation Statistics (BTS) by a special panel of experts.[1] The review was required by Section 6008 of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which established BTS. In its report, the panel examined BTS statistical programs and practices, and strongly recommended that Congress reauthorize BTS. The panel also made nine other recommendations concerning BTS's potential role in improving data quality and relevance, and institution building (Panel 1997).

The panel urged BTS and the Department of Transportation (DOT) as a whole to place more emphasis on data quality, pointing to the need for BTS to help decisionmakers and other data users distinguish between useful, high-quality data and suspect or inappropriate data. For example, it called on BTS to improve documentation of the statistics it makes available, to help users assess the quality of the information provided. It also called for development of departmental statistical standards, with BTS in a leadership role, and for a report to Congress every other year on progress made.

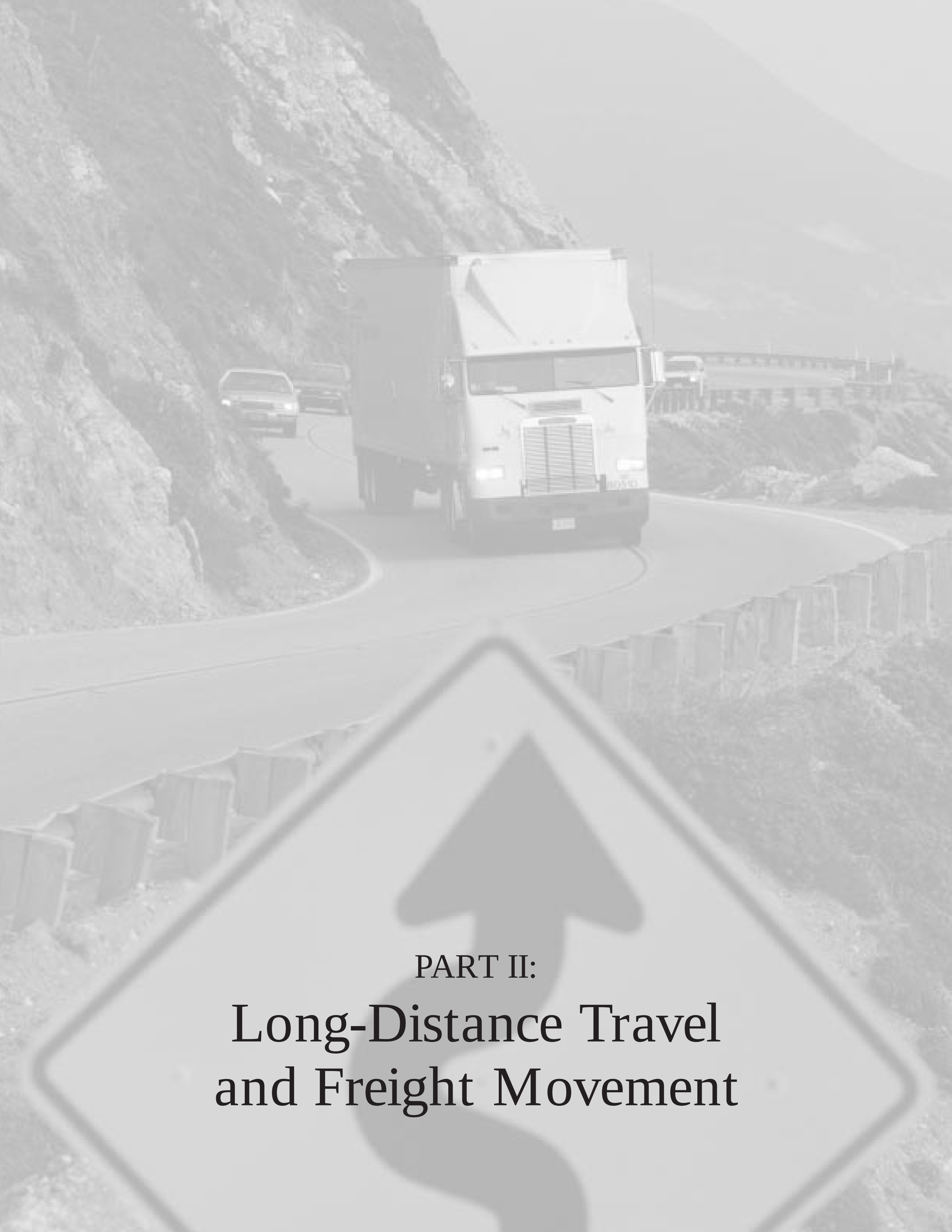
The need to ensure the continued relevance of transportation statistics was also a theme emphasized by the panel. Among other things, it called for more emphasis on the development of key national statistical indicators of transportation, and for technical assistance to states and metropolitan planning organizations to help them make greater use of data from BTS and other providers.

To sum up, the panel urged that BTS and DOT in the post-ISTEA era move beyond initial efforts to fill in key gaps in transportation statistics by bringing fundamental concerns about the quality, comparability, and relevance of existing data about the transportation system to central stage. The ability to address these longstanding concerns of the transportation community will depend in part on resources available, but BTS has begun to address many of the panel's concerns in its program.

[1] The 13 member panel was organized by the Committee on National Statistics and the Transportation Research Board, and chaired by Janet L. Norwood, Senior Fellow at the Urban Institute and a former commisioner of labor statistics at the U.S. Department of Labor. Other members of the panel were drawn from industry, academia, and transportation organizations, representing both statistics and transportation professions.

REFERENCE

Panel on Statistical Programs and Practices of the Bureau of Transportation Statistics, C.F. Citro and J. L. Norwood, eds. 1997. *The Bureau of Transportation Statistics: Priorities for the Future.* Washington, DC: National Academy Press.



PART II:

Long-Distance Travel and Freight Movement

Long-Distance Travel in the United States

Although people take long-distance trips (over 100 miles one way) infrequently, these trips have a big impact on the transportation system. Long-distance travel accounts for approximately 20 to 25 percent of all passenger-miles traveled (pmt) in the United States. Reasons for taking intercity trips include: to conduct business; for health care; to see family and friends; and for recreation, including sightseeing, outdoor activities, and entertainment. Often this travel brings economic benefits and strengthens social and economic links among regions. Indeed, long-distance transportation is the lynchpin of the tourism industry. It is estimated that the revenues of the travel and tourism industry in the United States exceed $400 billion a year (Han and Fang 1997), and that the industry employs nearly 7 million people (Cook 1997).

For the first time since 1977, data from the 1995 American Travel Survey (ATS) provide detailed and comprehensive information on the long-distance travel of Americans. Conducted for the Bureau of Transportation Statistics by the Bureau of the Census, the ATS collected information on the origin, destination, volume, and characteristics of long-distance travel from 80,000 households in the United States. The survey addresses many questions that other data sources, more attuned to local travel patterns, are not well equipped to answer. These include: how often do people travel over 100 miles from home in a year, for what reasons (business or pleasure), where do they go, and by what means? The ATS also allows examination of the

Box 6-1.
Data Limitations of the American Travel Survey

The American Travel Survey (ATS) provides the most comprehensive and accurate data available on long-distance travel. Even so, there are several gaps in the survey, and questions about its compatibility with other data. Defining nonlocal trips of 100 miles or more one way omits some intercity travel. Using this definition, trips between the downtown areas of Washington, DC, and Baltimore, Toledo and Detroit, and Madison and Milwaukee, for example, were not covered by the ATS. Moreover, trip distances that might be considered local travel in one part of the country may be considered nonlocal in another. Nonlocal trips in New England, for example, might have a lower threshold than 100 miles one way, and as such are not counted in the ATS.

An important gap in national travel data exists for trips between 50 and 100 miles. The Nationwide Personal Transportation Survey (NPTS) collects information on all travel on a national basis[1] (see chapter 1 for a discussion of the 1995 NPTS), but generally captures local travel, particularly trips under 50 miles.

Combining ATS with NPTS data to provide an overall picture of travel presents several compatibility problems. These include: 1) different reference periods (the time over which travel behavior is measured), even though data collection was done in the same year; 2) the sample in the NPTS is not large enough to estimate state and metropolitan travel behavior, except in very limited cases (a few states and metropolitan areas funded larger samples for their areas); 3) different sampling frames (i.e., the people who may be included in the surveys differed): the NPTS used random digit dialing procedures to interview households by telephone, while the ATS frame consisted of household addresses assembled during the decennial census; 4) mileage estimates for car trips from the NPTS are based on odometer readings or respondents' estimates, while the ATS used a network model based on zip codes of the origin and destination of the trip to calculate mileage.

The ATS lacks information on the travel of foreign residents in the United States, because the sampling frame included only U.S. households. The number of foreign visitors and their country of origin can be estimated using data from the Department of Commerce and the Immigration and Naturalization Service. Some details are collected on these foreign visitors, but there is no information on their miles of travel while in the United States.

All surveys, including the ATS, have associated sampling and nonsampling errors. These errors include coverage errors, where relevant sampling units (households in this case) are excluded from the possibility of being selected, response errors from survey participants (including recall errors and mistakes made when reporting on someone else's travel), and interviewer errors. Adjustments were made for these sorts of errors in the final data. More detailed information on ATS data quality can be found in Appendix C of the ATS Technical Documentation entitled, "Accuracy of the Data." This document can be accessed through the BTS Internet home page at http://www.bts.gov/programs/ats. While every effort was made to statistically test the estimates in this chapter, not all implied comparisons in tables and figures are statistically significant.

[1] Studies are underway to determine whether longer distance travel may be underreported in the NPTS, because of the short reference period for which respondents were asked to report (14 days for long-distance travel).

socioeconomic and demographic characteristics of travelers, and the influence of household income and type, age, race/ethnicity, sex, and other variables on travel behavior. The survey is scheduled to be conducted again in 2000 and periodically thereafter. See box 6-1 for a discussion of the ATS and data quality.

This chapter uses ATS data to examine long-distance travel in 1995, and where possible compares the data with the 1977 National Travel Survey (NTS) and with local travel using data from the 1995 Nationwide Personal Transportation Survey (NPTS). The 1977 NTS was the most recent long-distance national travel survey conducted prior to the 1995 ATS.

The chapter begins with a discussion of overall travel growth and some of the factors accounting for such growth, including details of how and why people travel, trip length and duration, and accommodations. The second and third sections of the chapter examine the geography of travel and the relationships between socioeconomic characteristics and long-distance travel, respectively. The final section explores possible future trends in long-distance travel.

TRENDS AND FACTORS OF CHANGE

In 1995, Americans traveled 827 billion miles on over 1 billion domestic long-distance trips, nearly twice the number of trips taken in 1977 and more than twice the miles traveled (see table 6-1). Individuals averaged about 4 domestic and international long-distance roundtrips in 1995, compared with 2.4 trips in 1977. People averaged over 3,100 miles on domestic long-distance trips in 1995, up from 1,700 in 1977, and the average trip length was 826 miles. These trips accounted for about 20 to 25 percent of all pmt in 1995.[1] Local tripmaking grew only 17 percent, from 2.9 daily trips in 1977 to 3.4[2] daily trips in 1995 (USDOC Census 1979; USDOT FHWA 1997).

Some common factors have spurred the growth of both long-distance and local travel over the past two decades, including population and household growth, higher median income, and greater vehicle availability (see figure 6-1). Other factors, like increasing regional interdependencies (including globalization) of economic production and consumption, and lower airfares (adjusted for inflation), have also spurred this growth.

Disposable personal income per capita (in chained 1992 dollars) increased from $14,100 in

[1] Based on data from the 1995 ATS and the 1995 NPTS. The NPTS estimates that all local and nonlocal person-miles in 1995 were 3,407 billion and the ATS estimates that there were 827 billion person-miles of domestic long-distance travel in that year, plus another 36 billion person-miles made on international trips.

[2] For comparability, this figure is adjusted to reflect the use of new survey methods in 1995.

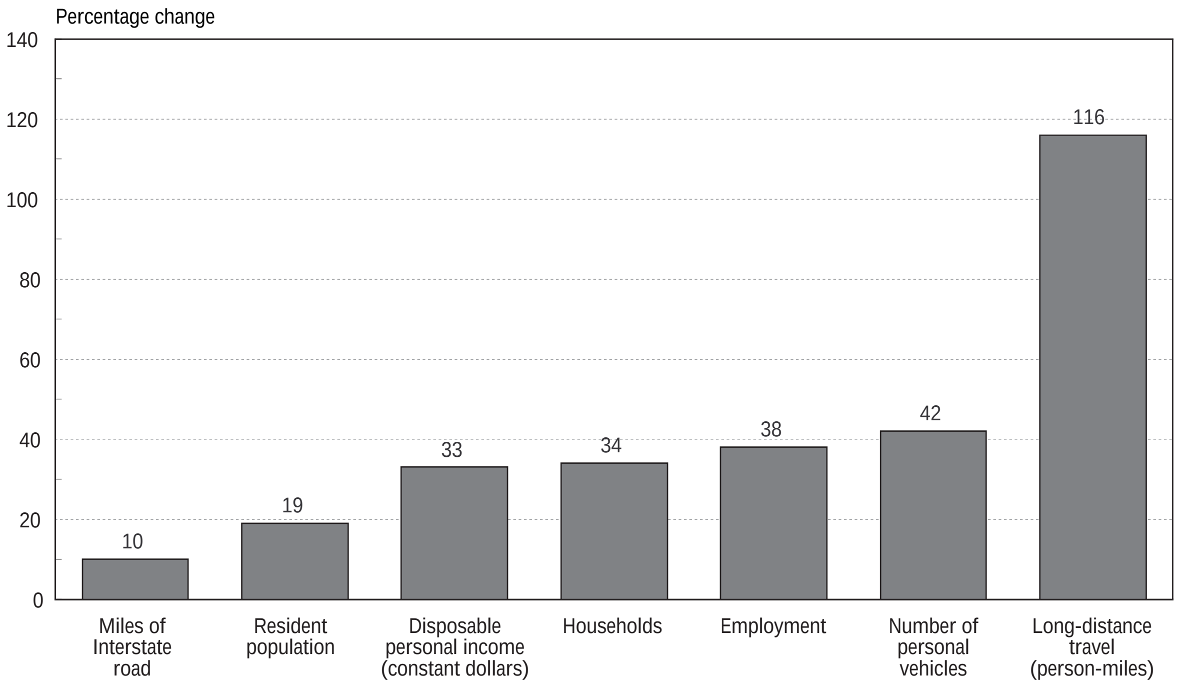
Table 6-1.
Population and Long-Distance Travel: 1977 and 1995

	1977	1995	Percentage change 1977–95
Resident population (thousands)	220,239	262,755	19.3
Person-trips (thousands)	539,289	1,042,615	93.3
Domestic	521,427	1,001,319	92.0
International	17,862	41,296	131.2
Person-trips per capita	2.45	3.97	62.0
Domestic	2.37	3.81	61.0
International	0.08	0.16	93.8
Person-miles (millions)	U	862,665	NA
Domestic	382,466	826,804	116.2
International	U	35,861	NA
Person-miles per capita (domestic only)	1,737	3,147	81.2
Mean trip length (miles, domestic only)	733	826	12.6

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

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997; U.S. Department of Commerce, Bureau of the Census, *National Travel Survey: Travel During 1977* (Washington, DC: 1979); U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1997* (Washington, DC: 1997).

Figure 6-1.
Growth in Long-Distance Travel and Related Factors: 1977– 95



SOURCES: Interstate road mileage and number of personal vehicles: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Various years). Population, income, households, employment: U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1997* (Washington, DC: 1998). Long-distance travel: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997; U.S. Department of Commerce, Bureau of the Census, *National Travel Survey, Travel During 1977* (Washington, DC: 1979).

1977 to $18,800 in 1995, a 33 percent rise in real terms (USDOC 1997, 452). Higher incomes have contributed in part to the increasing availability of personal-use vehicles. From 1977 to 1995, household size declined from 2.86 to 2.65, but the number of vehicles per household increased—from 1.59 in 1977 to 1.78 in 1995. Over that period, the number of households without a vehicle declined from 11.5 million to 8.0 million, with a corresponding increase in households with at least one vehicle. Households with two vehicles increased the most (54 percent), from 26 million households in 1977 to 40 million in 1995 (USDOT FHWA 1997).

The quality of vehicles is particularly important for long-distance travel. Despite the fact that the stock of vehicles has become older overall, the median age for passenger cars rose from 5.6 in 1977 to 7.7 in 1995 (AAMA 1994 and 1997), households are now more likely to have reliable and comfortable vehicles. Many new cars today are designed to go 100,000 miles without a tune-up. Personal vehicles are also becoming roomier, and often are equipped with features once available only in luxury vehicles (AAMA 1997).

As incomes have generally increased, the price of transportation, on the whole, has declined, making long-distance travel more affordable. This is particularly true for air travel, where the average price per passenger-mile declined from 21¢ in 1975 to 14¢ in 1995 (in constant 1995 dollars), a 37 percent decline (USDOT BTS 1998). In part, the decline in airfares resulted from deregulation, which allowed the entry of low-priced carriers (USDOT BTS 1996.)

Intercity bus (not including charter bus) and train fares have declined less, by 10 and 8 percent, respectively. In 1995, bus revenue per mile was 12¢ and train revenue was 15¢ per mile.

The inflation-adjusted cost of owning and operating an automobile, however, is much higher than these other modes at around 40¢ a mile (in 1995 dollars), the same as in the mid-1970s. In the mid-1980s, the cost declined to 30¢ a mile. Efficiencies in automobile manufacturing and operation have been offset by increases in the size and quality of new automobiles over at least the past 15 years. Indeed, the variable cost per mile (including gas and oil, maintenance, and tires) declined from 45 percent of the total cost in 1975 to 23 percent in 1995, while the fixed costs (including the cost of the vehicle, insurance, taxes, and finance charges) rose from 55 percent to 77 percent.

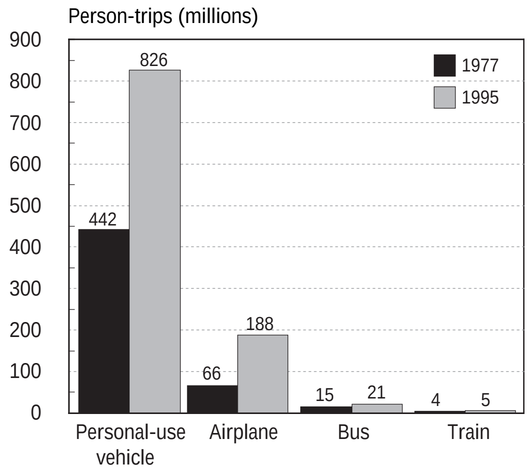
In addition to population growth, the changing profile of households and age cohorts have affected travel over the past 20 years. The households most likely and able to travel are nonfamily households and married couples without children, because of greater income per person and fewer family responsibilities. The number of all households rose by 25 million between 1977 and 1995, of which nearly half were nonfamily households and another 24 percent were married couples without children. In 1995, individuals living in nonfamily households took on average 4.6 trips each and married couples without children took 5.2 trips each. (USDOC 1998).

Increases in long-distance travel are the result of more travel in every age group, particularly by people over 45, rather than the growth of age cohorts that have a high propensity to travel. While the over-65 cohort increased in size, more importantly, people of this age are traveling much more than in the past. Between 1977 and 1995, the per capita trip rate for people in this group increased from 1.5 to 2.9 trips a year, a 92 percent increase (see below for a discussion of travel trends by age, including a breakdown of the 65 and over age group). An increase in travel for business and leisure, especially leisure, is the reason for much of this growth. A less important demographic factor contributing to travel growth during this period is the maturation of the baby boomers (the very large population cohort born between 1946 and 1964). Baby boomers are now at ages more likely to be traveling long-distance, but demographic changes such as the growth of the over-65 population (from 11 to 13 percent of the population between 1977 and 1995) have counteracted some of the baby boom contribution to travel growth.

Mode Choice

Personal-use vehicles—cars, light trucks, motorcycles, and recreational vehicles—are the dominant means of transportation for long-distance trips, reflecting their widespread availability and the relatively low operating costs (once a vehicle is purchased and insured). In 1995, they accounted for nearly 80 percent of person-trips, about the same as in 1977 (see figure 6-2). Air travel, the second most popular means of long-distance travel in 1995, grew in market share accounting for 18 percent of trips by 1995, up from 12 percent in 1977. Because trips taken by air are typically much longer than those made by personal-use vehicle, the share of person-miles by air is greater than the share of person-trips. In 1995, air accounted for 43 percent of all domestic intercity person-miles, up from 33 percent in 1977. The car and truck share of person-miles, consequently, declined from 60 percent in 1977 to 55 percent in 1995. Nevertheless, the total number of person-miles made by personal-use vehicle nearly doubled over these years from 230 billion to 450 billion.

Figure 6-2.
Long-Distance Trips by Mode: 1977 and 1995



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997; U.S. Department of Commerce, Bureau of the Census, *National Travel Survey, Travel During1977* (Washington, DC: 1979).

Other modes of transportation constituted a small and declining share of long-distance trips and miles in 1995. Buses were used for 2 percent of person-trips in 1995, falling from 3 percent in 1977. Charter or tour buses were the main type of bus used, accounting for 70 percent of bus trips in 1995, while intercity buses carried 16 percent of trips and school buses accounted for 14 percent. Passenger trains accounted for 0.5 percent of intercity person-trips in 1995, about the same as in 1977. The declining importance of buses and the stable share of train use is, however, only relative to other modes. In absolute terms, people took more trips and traveled more miles on buses and trains in 1995 than in 1977. The absolute number of long-distance person-trips by bus increased by 43 percent and the number of train trips increased by 23 percent. On a per capita basis the number of train trips stayed constant and the number of bus trips increased by 20 percent.[3]

[3] It is not possible to calculate the growth or decline of *intercity* bus trips alone, because they were not measured separately in 1977.

Personal-use vehicles, including taxis, are the primary mode of transportation to get to and from airports and other terminals for long-distance travel. On domestic trips, nearly 9 out of 10 travelers used a car or taxi to reach the airport, and most of the rest reached the airport by limousine or shuttle bus. Of course, these national averages hide a good deal of variation. In New York City, for instance, 26 percent reached the airport by taxi compared with only 6 percent nationally. Nationally, only 1.5 percent used a form of transit to reach an airport in 1995, but the percentage is generally greater in cities such as Boston and Washington, DC, where transit use was 8.7 percent and 6.9 percent, respectively. Transit is more commonly used by travelers to reach intercity bus or train terminals. Nationwide, 13 percent of intercity bus travelers and 15 percent of train travelers reached the station by transit.

Trip Purpose

In terms of person-trips, long-distance trips that are not business-related outnumber business trips, although the relative share of business trips has risen over the past 20 years. Moreover, an increasing proportion of nonbusiness trips are consumption-oriented, such as those taken for vacations, entertainment, and shopping purposes, included in the "leisure" category. As a result, the economic impact of leisure travel has become more important. (See box 6-2 on cruise ships, a popular form of leisure travel.)

Trips to visit friends and relatives are still the most common reason to travel long-distance (33 percent), followed by leisure travel (31 percent), business (22 percent), and personal business, such as school activities, weddings and funerals, and health care (14 percent) (see table 6-2). Business trips are on average longer in distance than pleasure and personal business trips and, thus, are a slightly higher proportion of person-miles than of person-trips. Between 1977 and 1995, the fastest

Box 6-2.
Cruise Ship Travel

In 1995, people took 279,000 long-distance trips by cruise ship, a tiny fraction of all long-distance trips. Cruises, however, were a slightly higher proportion of person-miles traveled, because trips by cruise ship tend to be very long (a mean distance of nearly 3,000 miles compared with the overall mean of about 830 miles). Most cruises (nearly 90 percent) were taken for leisure and another 8 percent were taken for business.

Nearly 45 percent of person-trips were taken in travel parties consisting of two adults and no children. Another 15 percent were taken by single adults traveling alone. Most of the rest were taken by two adults and at least one child (very few were taken by a single adult with children). Over 40 percent of cruises were taken by people over the age of 50, with over 20 percent taken by people over 65. A relatively large number of cruise ship passengers were retired (27 percent). Nevertheless, almost one-third of cruises are taken by people under 30 years of age. Most cruises were taken by whites (70 percent), but a proportionately large number were also taken by Asians and Pacific Islanders (22 percent). Only 8 percent of cruise ship passengers came from households with yearly incomes under $25,000. Much larger shares came from households with yearly incomes over $50,000 and between $25,000 and $50,000 (44 and 48 percent, respectively).

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

growth took place in personal business trips, business trips, and leisure trips. As a result, all increased their share of total person-trips. Trips to visit friends and relatives also grew, albeit more slowly than other types of trips. As a result, the share of this type of trip declined from 37 percent of all trips to 33 percent.

Some of the increase in long-distance travel reflects the propensity of people to reside farther from extended family members and friends, and may be influenced partly by the availability of improved, lower cost long-distance transportation. For example, a large number of people provide long-distance care for elderly relatives and friends (Wagner 1997). In 1995, according to a survey by the National Council on the Aging, 7 million Americans provided care to people over one hour away, a number that is expected to double in the next 15 years.[4] About two-thirds of these caregivers lived more than 100 miles away from their care recipient. The trends are reflected, to some extent, in a more than doubling of person-trips taken for personal business (from 67 million to 151 million), and, thus, a slight rise in their share of all person-trips from 12.5 percent to 14.5 percent.

[4] Long-distance care is defined as providing or managing care for a friend or relative aged 55 or older who lives one hour away. The survey found the average care recipient lived 304 miles away from the care provider.

Table 6-2.
Long-Distance Trips by Purpose: 1977 and 1995

	Person-trips		Percentage change
	1977	1995	1977–95
Total	539,289	1,042,615	93
Visit friends and relatives	198,479	339,690	71
Leisure	144,302	318,345	121
Business	105,404	233,752	122
Personal business	67,164	150,792	125

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997; U.S. Department of Commerce, Bureau of the Census, *National Travel Survey, Travel During 1977* (Washington, DC: 1979).

Long-distance travel to visit friends and relatives is particularly heavy during the holiday season (including Thanksgiving, Christmas, and New Year's Day) (USDOT BTS 1997a). Such visits account for two-thirds of domestic long-distance trips on the five days surrounding each holiday (compared with one-third of trips for the whole year).

Holiday travel[5] to visit friends and relatives mixed with some business, leisure, and personal business trips places the greatest demand on the passenger transportation system (USDOT BTS 1997a). In 1995, the heaviest travel days of the year were the Sunday after Thanksgiving, the day after Christmas, Easter weekend (both Saturday and Sunday), Labor Day, the Fourth of July, and several weekends in July and August. On the Sunday after Thanksgiving in 1995, for instance, 13.7 million one-way long-distance trips were made, compared with the annual daily average of 5.5 million. Of those trips, about 11.5 million trips were made by automobile and nearly 2 million were made by air.

Business travel rises as the economy grows and labor force participation increases. Changes in the way in which business is conducted also contributed to more long-distance travel for business purposes. By capitalizing on improvements in communications, production, and transportation technologies, businesses increasingly seek to position themselves to operate on a national and international scale (see USDOT BTS 1997b, chapter 9). Companies often have branch plants, distribution centers, and supplier networks at far-flung locations, with employees, suppliers, vendors, and other business personnel in frequent transit among facilities. Worldwide use of wide-bodied jet aircraft and containerized shipping have reduced costs, spurring the transportation of goods and people, and contributing to the rapid expansion in international trade. In addition, globally integrated communications systems and travel companies make both pleasure and business travel increasingly easy (e.g., with a telephone and a credit card, a flight, rental car, and hotel room can be secured in most of the world's large cities in just a few minutes).

Although new communications technologies may reduce the need for some long-distance travel (e.g., by substituting videoconferencing for face-to-face meetings), the overall result probably has been more demand for business travel (USDOT BTS 1997b). Faxes, computers, and e-mail make it easier to do business on a wider geographic scale demanding more not less long-distance travel for meetings with colleagues or customers. Moreover, a businessperson who can keep in close touch with the home office may be less reluctant to travel.

Trip Duration

Although people are taking more trips than 20 years ago, they are of shorter duration. Thus, the mean number of nights spent away from home per long-distance trip declined from 4.0 nights in 1977 to 3.5 in 1995. Some of the reduction results from changes in the way people take pleasure trips. Although people earn more vacation time now compared with 20 years ago (USDOL BLS 1998), they are less likely to take leave in large blocks. For example, it may be more difficult to schedule vacations when there are two wage earners in a household rather than one. At one time it was not unusual for some manufacturing plants to shut down production for a week or two in the summer, the time allotted for most vacations. This is less common today. Many retail stores and other service firms stay open at night, on weekends, and most holidays, making it difficult for employees to take off more than a few days at a time. Finally, some people may prefer taking short vacations spread out over the course of the year, rather than one long vacation.

[5] Data in this paragraph are for domestic trips only.

Although people are taking trips of shorter duration, they traveled farther in 1995 than they did in 1977.[6] Median person-trip length in 1995 was 425 miles, a 10 percent increase (or about 40 miles) from 1977.[7] The increase in trip length is the result of more trips being taken by air, and trips taken by air becoming longer. The median domestic trip distance by air was 1,760 miles in 1995, 10 percent (or 170 miles) longer than in 1977, while trip distance by all other modes changed very little. Clearly, today's transportation system allows people to travel farther and at greater speeds because of a modal shift toward air. The number of flights available, the reliability of air travel, and its relatively low price means that people are more apt to fly somewhere for a few days than was the case 20 years ago.

The rise of shorter duration trips might be considered the passenger equivalent of just-in-time delivery systems in freight transportation. Shorter duration trips increase the pressure on the transportation system for speed and reliability. The rise in air travel, in particular, also highlights the fact that a trip might encompass more than one transportation mode, placing importance on: 1) the coordination of different modes of transportation; and 2) the link between local and long-distance systems of transportation, such as the ability to get to and from an airport or bus terminal.

[6] Mileage was not calculated for long-distance international trips taken in 1977. Thus, all calculations in this paragraph are based on domestic trip mileage.

[7] Nearly 10 percent were over 2,000 miles, up from 8 percent in 1977.

Trip Accommodations

Although trip duration has decreased, the near doubling in the number of trips has resulted in a large increase (70 percent) in the total number of nights travelers spent away from home, an important fact for the hospitality industry, realtors, and the construction industries among others (see table 6-3). The greatest absolute increase was in the total number of person-nights spent in hotels, motels, bed and breakfast establishments, or resorts—over 1.3 billion in 1995—an increase of more than 600 million person-nights from 1977. Person-nights in owned cabins, condominiums, or vacation homes more than doubled, reaching nearly 266 million in 1995. Person-nights in friends' or relatives' homes increased less (51 percent), but remained the most common type of accommodation for trips including an overnight stay.

Table 6-3.
Person-Nights Spent Away from Home by Type of Accommodation: 1977 and 1995

	1977 (thousands)	1995 (thousands)	Percentage change 1977–95
Total	2,164,362	3,680,755	70
Home of friends or relatives	1,082,931	1,636,994	51
Hotel/motel or resort, rented cabin	705,423	1,336,697	89
Owned cabin, condominium, or vacation home	127,142	265,813	109
Camper, trailer, recreational vehicle, tent	129,825	125,179	–4
Other accommodations[1]	119,041	316,071	166

[1]Includes among other things corporate, military, dormitory, youth hostel, parked vehicle, and as a passenger.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997; U.S. Department of Commerce, Bureau of the Census, *National Travel Survey, Travel During 1977* (Washington, DC: 1979).

GEOGRAPHY

This section examines the geography of long-distance travel, relying for the most part on ATS data. Through the prism of travel geography, one can gain a keener sense of the pattern of interdependencies within and between U.S. regions, and between the United States and other countries.[8] More than half of domestic long-distance trips in 1995 were to out-of-state destinations, and 4 percent of trips were to other countries. Some states or substate areas are important origins or destinations of travel; others serve a critical role as "bridges" between the two; all are supported by an uneven but geographically pervasive transportation system. Patterns of long-distance travel vary widely from state to state, and within states, as is discussed below.

Not surprisingly, people travel the most to and from states with the largest populations (e.g., California, Texas, New York, Florida, and Pennsylvania). Nevertheless, people who live in sparsely populated states, such as Nevada, Wyoming, Vermont, Montana, and Maine, take more long-distance trips per capita. Residents of western states with large land areas, including Alaska, Wyoming, Montana, and Colorado, travel the most miles (see figure 6-3), and a large proportion of their trips are in-state. Some less urbanized states with a high proportion of low-income households (e.g., West Virginia, Alabama, and Mississippi) have low per capita rates for trips and person-miles.

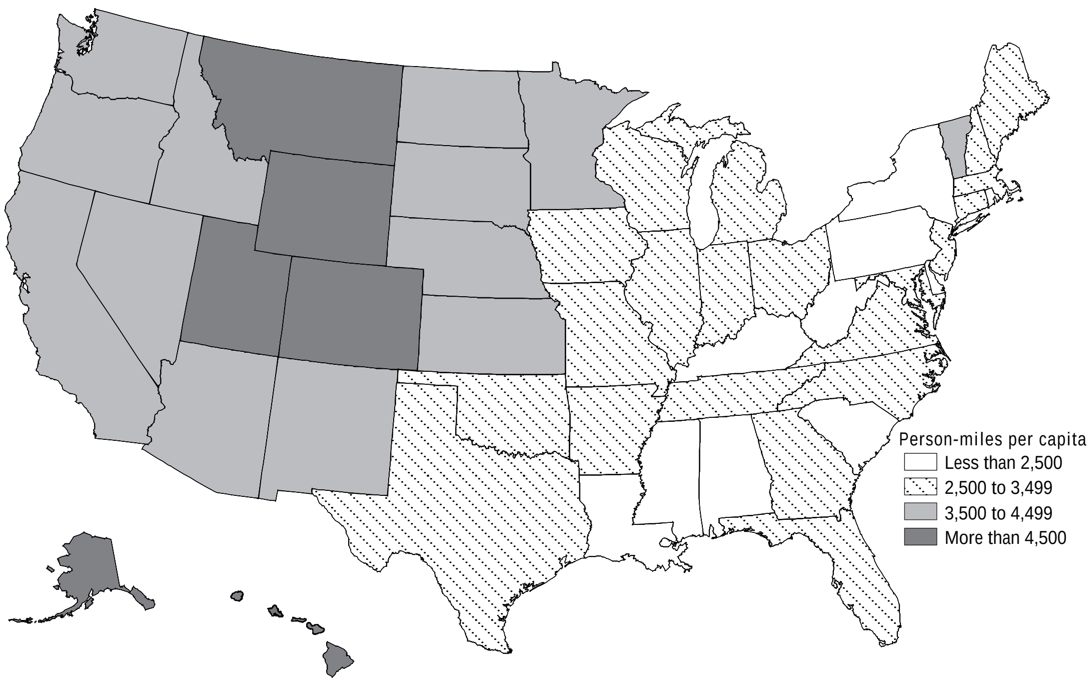
People who live in rural and small metropolitan areas (population under 250,000) take more long-distance trips per capita (4.9 domestic trips per capita in 1995) than their counterparts in large metropolitan areas (3.4 trips on average). It is plausible that they travel farther to meet needs (e.g., conduct personal business, visit friends or relatives, or partake in entertainment) than residents in large metropolitan areas. Compared with those in large metropolitan areas, they also are more likely to take their trips in automobiles (90 percent versus 76 percent) and less likely to travel by air (8 percent versus 21 percent). There were no significant differences in the number of trips taken by bus or train. While taking fewer trips, people in large metropolitan areas travel farther on domestic trips (a mean of 920 miles compared with 650 miles). Hence, annual average person-miles on domestic trips is similar—3,200 miles by rural and small metropolitan area residents and 3,100 miles by large metropolitan area residents.

Another useful measure is the total person-miles of long-distance travel within a geographic unit. Person-miles are concentrated in corridors within densely populated regions. Examples include the Northeast corridor, the Texas triangle between Dallas-Fort Worth, San Antonio, and Houston, and the corridor between San Diego and San Francisco (see Intraregional section below). Figure 6-4 shows the person-miles of long-distance travel made by road in each state (such trips account for more than 50 percent of all long-distance person-miles). The states with the most highway person-miles are in the middle and south Atlantic regions, the Midwest, Texas, and California.

The total highway-miles traveled in each state and the District of Columbia can be divided into miles taking place entirely on trips within the home state ("in-state"), miles in the home state as part of out-of-state trips ("from"), miles in the home state that is the destination of an out-of-state trip ("to"), and the miles passing through a state that is neither the origin nor the destination state ("through"). Adding in-state and from miles together provides the travel-miles of state residents on their own infrastructure. Adding the

[8] Most of this section reports on domestic long-distance travel unless otherwise noted; international long-distance travel is discussed later in this section.

Figure 6-3.
Per Capita Long-Distance Travel by State of Origin: 1995



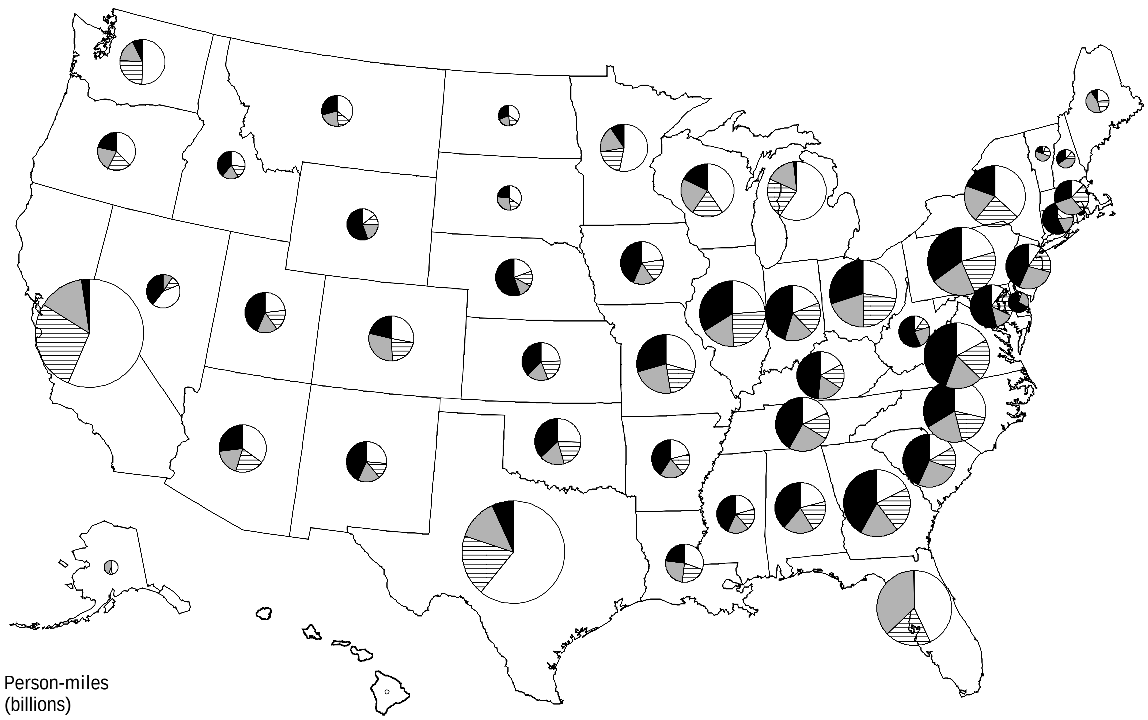
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997.

to and through miles provides travel-miles of out-of-state residents on a state's infrastructure. Dividing the mileage of out-of-state residents by the mileage of arterials in each state provides a measure of the intensity of out-of-state residents' use of a state's highway infrastructure.

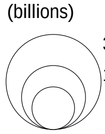
Approximately half of all highway-miles on long-distance journeys occur out of state. The states most highly impacted by such nonresident travel are those in the East and Midwest. Several western states, such as Nebraska and New Mexico, accommodate heavy through traffic by people on their way east or west. States with low rates of long-distance travel by out-of-state residents include Alaska, Hawaii, Vermont, North Dakota, New Hampshire, and Maine. A few states (e.g., Florida) have little through traffic, but are impacted heavily by the travel of people coming to the state.

If the miles traveled are related to the miles of roads that are arterials in each state, then it is possible to compare the relative intensity of use that long-distance trips place on each state's infrastructure (see figure 6-5). The states with the highest number of miles traveled per mile of arterial are Delaware, Maryland, Virginia, Utah, and Arizona. The states with the least intensively used road infrastructure for long-distance trips (not including Hawaii and the District of Columbia) are mostly large western states, including the Dakotas, Kansas, Montana, and Nebraska. In the east, the states most affected by through traffic include Delaware, Maryland, Virginia, Connecticut, and Kentucky. Utah,

Figure 6-4.
Person-Miles of Long-Distance Highway Travel Within Each State: 1995



Person-miles
(billions)



Person-miles in each state pie take place in the state. Each pie slice represents person-miles for the following kinds of trips:

- entirely in-state
- from the home state to another state
- to a destination in the state from another state
- through the state

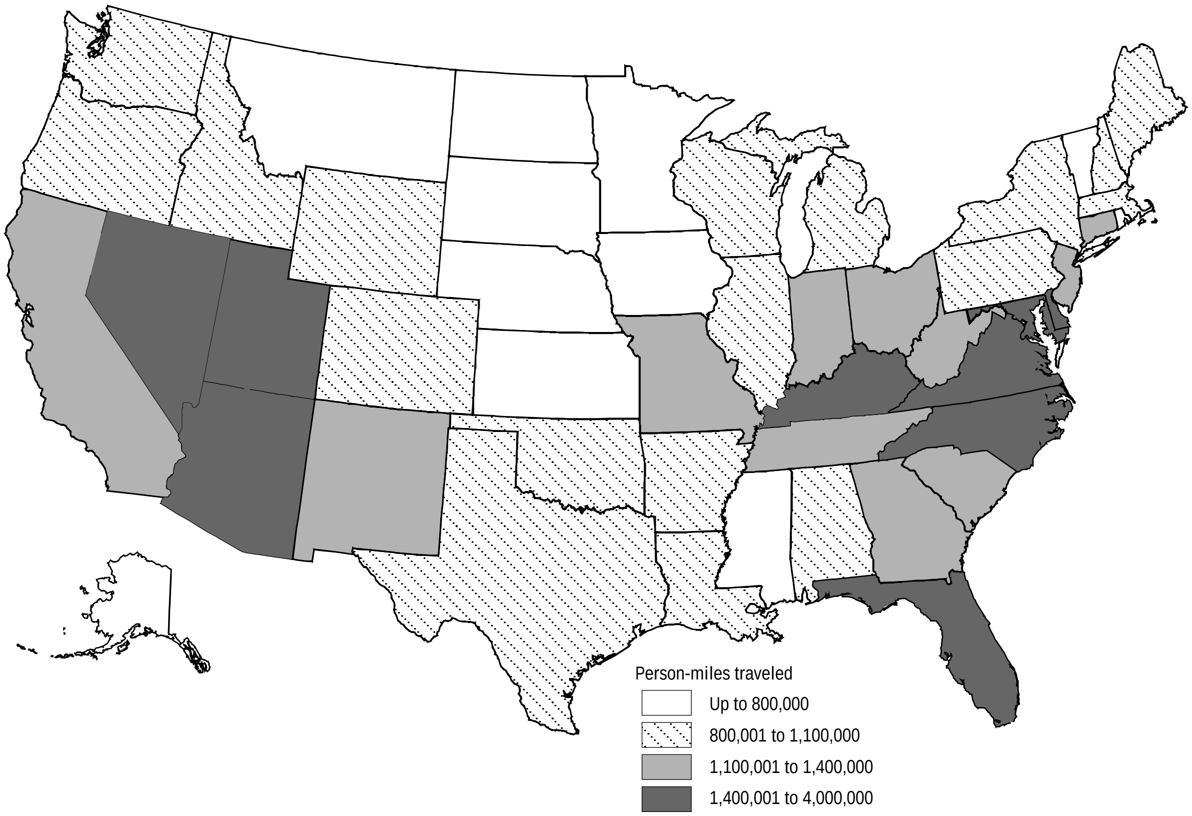
NOTE: Person-miles traveled by state were estimated by Oak Ridge National Laboratory by assigning flows to the most likely routes on the National Highway Planning Network.

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

Nevada, Wyoming, and New Mexico are the most affected in the west. The infrastructure of states with little through traffic, such as Florida, and states with a large number of miles of highway, such as South Dakota, have low measures on this dimension of highway use.

Travel flows are often highly concentrated on certain routes within and between states. Figure 6-6 shows the 100 largest flows between metropolitan pairs (with population greater than 250,000) in 1995. These heavily traveled routes can be separated into three different types of transportation markets: intraregional, interregional, and transcontinental. A fourth market is not included on the map—transoceanic and international, including travel between the continental United States and Hawaii.

Figure 6-5.
Person-Miles of Long-Distance Highway Travel Per Mile of State Arterial Road



NOTE: Hawaii is not shown; long-distance person-miles per mile of arterial road and above are very low.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, 1995 American Travel Survey data, October 1997.

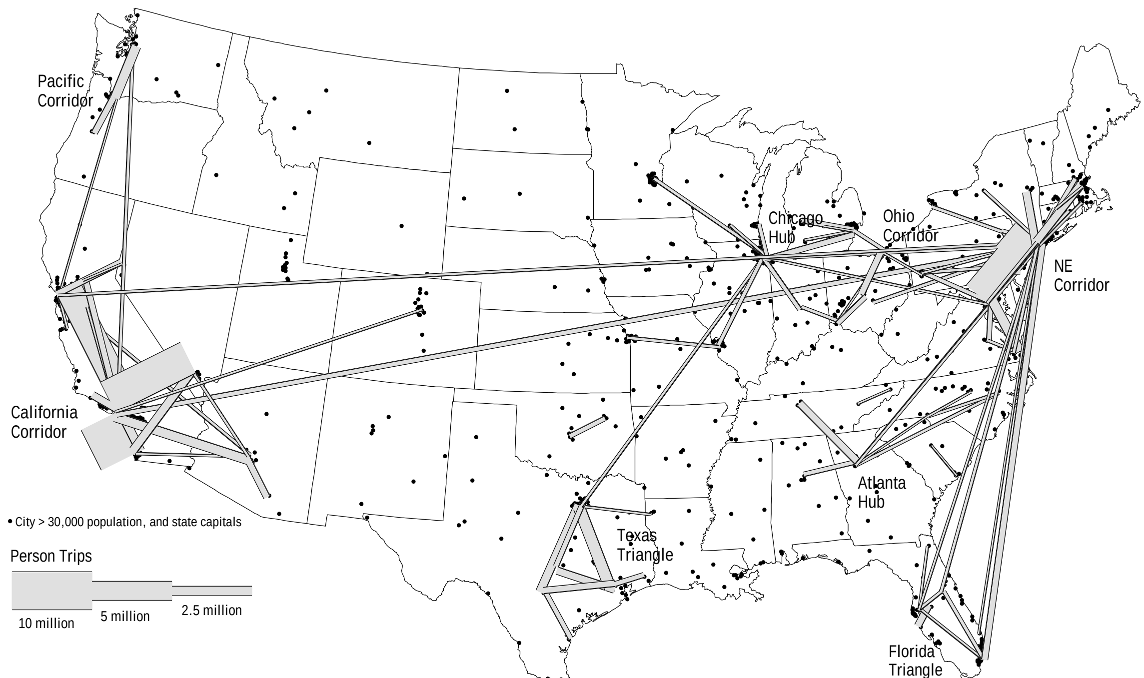
Intraregional

There are several types of intraregional markets (i.e., markets where trips are 100 to 500 miles one way), including corridor flows, triangular flows, and hub flows (see figure 6-6). These markets contain the greatest density of travel flows.

The top corridor markets are the Northeast corridor from Washington to Boston (40 million roundtrips); the California corridor from San Diego to San Francisco, extended to Sacramento (27 million trips); the Pacific Northwest corridor from Eugene, Oregon, to Seattle (continuing on to Vancouver, Canada) (5 million trips domestically), and the corridor between Cleveland and Cincinnati, Ohio (4 million trips). Corridor traffic is the most highly concentrated of all travel markets where travel between one city pair merges with travel between other city pairs. For instance, travel between Washington and Boston merges with travel between Philadelphia and New York. By contrast, trips from Nashville and Birmingham to Atlanta do not merge onto one route. (See box 6-3 for a discussion of corridor flows not included in the ATS.)

The Texas triangle (11 million trips) has corners at Dallas/Fort Worth, Houston, and San Antonio, and Austin, on the length between San

Figure 6-6.
Top 100 Metropolitan Pairs for Long-Distance Travel



NOTE: Cities database provided by Caliper Corp., Newton, MA.

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

Antonio and Dallas/Fort Worth. Each length of the triangle and each corner has a flow of roughly the same order of magnitude. Florida's intraregional flows (9 million trips) are also triangular between Orlando, Miami/Fort Lauderdale, and Tampa, with several other cities lying between these points.

Hub intraregional flows exhibit omnidirectional flow patterns centered at one point. Los Angeles, as well as being part of a corridor, is also a hub with flows radiating to Las Vegas (the second largest flow after Los Angeles-San Diego), Phoenix, and Santa Barbara. Los Angeles also has the largest number of trips over 100 miles one way within its consolidated metropolitan statistical area (CMSA), including trips between Los Angeles and Riverside, San Bernardino, Orange, and Ventura Counties (a five-county area of nearly 34,000 square miles). Similarly, the New York hub has large flows within the CMSA, which includes parts of New Jersey and Connecticut, and flows between it and Albany, Buffalo, and Syracuse in New York and Scranton/Wilkes-Barre, Lancaster, Harrisburg, and Pittsburgh in Pennsylvania. Other hub markets are Chicago and Atlanta.

There are similarities between all the intraregional markets, such as median trip distance, the prominence of personal-use vehicles, and average travel party size (in the range of 2 to 3 persons compared with transcontinental markets where the average party size is about 1.5). Differences in flow patterns can be seen in the travel mode and trip purpose, many of which have to do with the trip distance distribution (see figures 6-7 and 6-8). A greater number of longer trips translates into a high proportion of air travel, whereas a large amount of shorter trips

Box 6-3.
Flows Not Captured by the ATS

The American Travel Survey (ATS) excludes trips under 100 miles one way. As a result, flows between places less than 100 miles apart are not included in the data set. The table shows metropolitan pairs of over 1 million people that are about 100 miles apart or less. Because these distances are measured central city to central city, some trips between a far suburb in one city to a central city in another may be over 100 miles one way and hence included in the ATS.

Selected Metropolitan Pairs
Less than 100 Miles Apart

Between		Approximate distance (miles)
Cincinnati	Columbus	100
New York	Hartford	100
Indianapolis	Cincinnati	100
Boston	Hartford	90
Chicago	Milwaukee	90
Baltimore	Philadelphia	90
New York	Philadelphia	80
San Francisco	Sacramento	80
Orlando	Tampa	80
Buffalo	Rochester	60
Baltimore	Washington	40

account for a high proportion of personal-use vehicle, and bus and train use. For example, people in the California corridor and the Texas triangle took more longer distance trips translating to a relatively high proportion of air trips. The Ohio corridor, however, has a high proportion of shorter trips and the largest percentage of trips in personal-use vehicles.

Trips in the Ohio corridor and the Florida triangle were most likely to be for business. Trips to visit friends and relatives predominated in the California corridor, the Texas triangle, and the Pacific corridor, while leisure trips predominated in the Northeast corridor. Travelers in the Ohio and Northeast corridors had the highest income. The characteristics of travelers were most different in the Florida triangle where retirees, with relatively low household income, predominated. The California corridor had the youngest travelers, while racial and ethnic diversity of travelers was greatest in the Texas triangle, the California corridor, and the Northeast corridor.

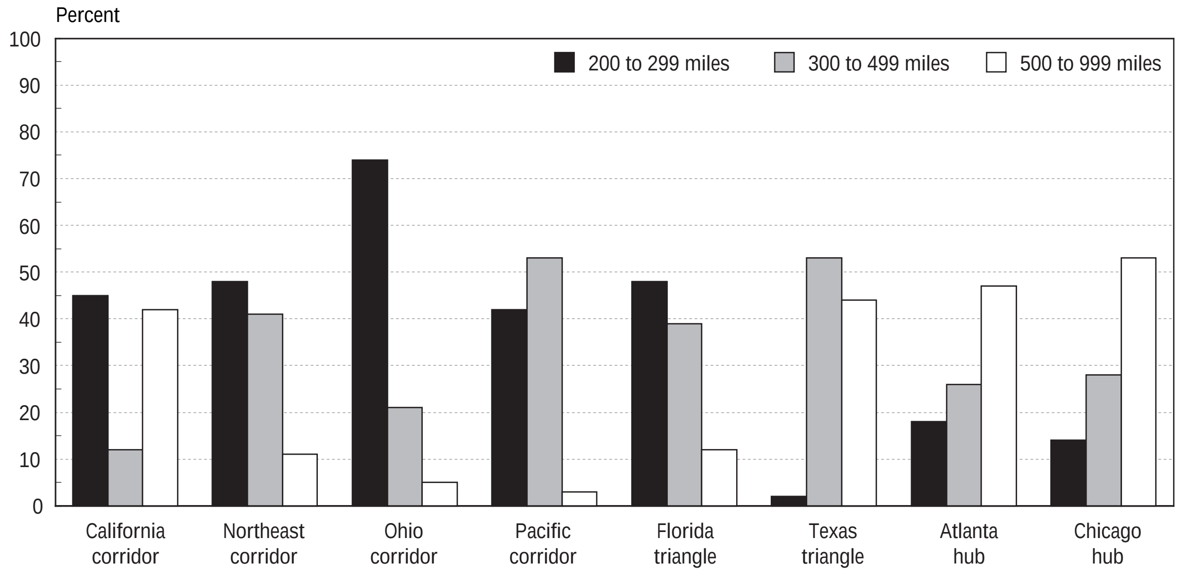
Hub flows are longer than corridor or circular flows because of the convergence of trips on one place. The median one-way distance of hub flows centered on Atlanta was 262 miles and Chicago was 280 miles, compared with a median of 177 in the California corridor and 232 miles in the Texas triangle. Air travel in hub markets is a larger proportion of trips than the other intraregional markets (air trips were 22 percent in the Atlanta hub and 26 percent in the Chicago hub (see figure 6-8)). These markets did not stand out on any of the other dimensions, however.

Interregional

Interregional flows are trips in the range of 500 to 1,500 miles one way. Some of the largest flows are from the Northeast corridor to Florida, Chicago, and Atlanta; from California to the Pacific Northwest; and from Chicago to Texas. Nationally, trips in this mileage range are much more evenly split between air and highway travel, although the longer trips are more likely to be taken by air. Between New York and Miami, a distance of about 1,100 miles, 78 percent of person-trips were by commercial air, and only 21 percent by car. Similarly, between Chicago and Dallas, a distance of 800 miles, only 14 percent of person-trips were made by car, with the rest made by air.

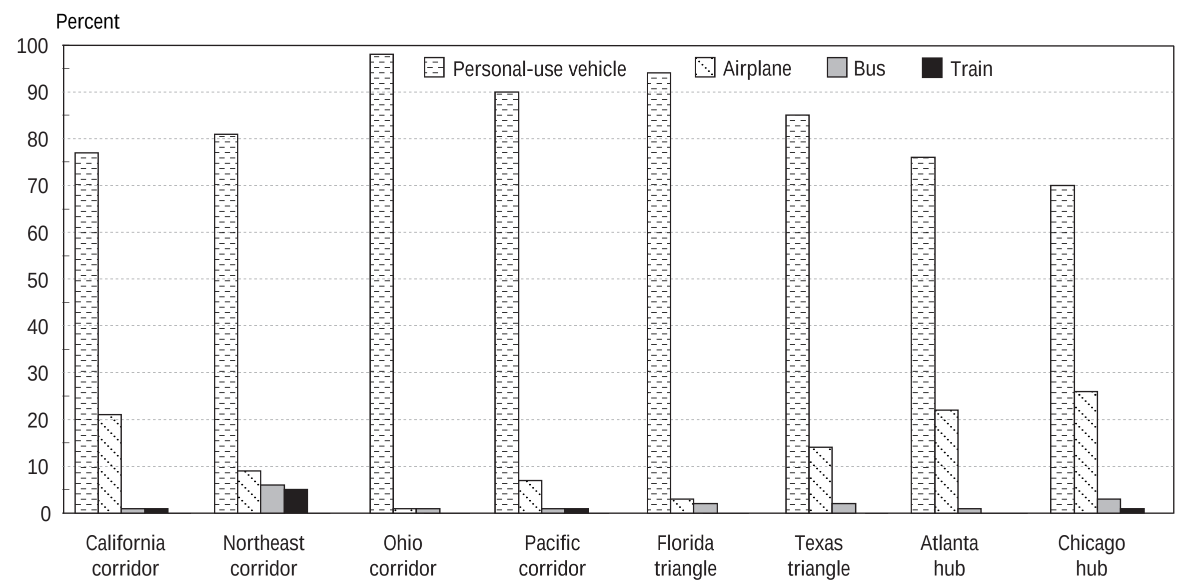
Interregional flows are much more likely to be for business. Between New York and Miami, 41 percent of trips were for business compared with 33 percent of intraregional trips to and from Chicago and 28 percent to and from Atlanta. On interregional trips between Dallas and Chicago, 70 percent were for business.

Figure 6-7.
Roundtrip Distance Distribution by Intraregional Market: 1995



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

Figure 6-8.
Long-Distance Travel Modes in Intraregional Markets: 1995



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

Transcontinental and Transoceanic

There are several transcontinental markets between places that are more than 1,500 miles one way. The largest markets are those between New York and California (Los Angeles and San Francisco), and both Chicago and Washington, DC, to these California metropolitan areas. There is also a good deal of travel between New York and Las Vegas, Chicago and San Diego, and Detroit and San Francisco. The vast majority of trips of this distance are taken by air. For instance, 94 percent of trips between New York and San Francisco in 1995 were taken by commercial air, the rest were taken by car. Moreover, 52 percent of the trips on this route were for business, with 22 percent for leisure, 16 percent to visit friends and relatives, and 10 percent for personal business. The largest domestic transoceanic market is between Los Angeles and Honolulu (over a half million trips in 1995).

International

Only about 4 percent of all long-distance trips by U.S. residents were to foreign destinations (41.3 million person-trips). Nevertheless, the percentage growth of international trips surpassed that of domestic long-distance travel between 1977 and 1995. People also appeared to go farther afield when traveling internationally; 49 percent of foreign trips were to overseas destinations in 1995 compared with only 38 percent in 1977. In 1995, 28 percent of trips were to Canada and 23 percent to Mexico.[9] Europe (18 percent), the Caribbean (11 percent), and Asia (8 percent) were the most popular overseas destinations.

As a whole, Americans traveling internationally are slightly wealthier than domestic travelers. The profile of travelers to Canada and overseas, however, is very different from that of travelers to Mexico. About 60 percent of overseas travelers and travelers to Canada were from households with income over $50,000, while only 48 percent of domestic travelers and 38 percent of those traveling to Mexico earned that much. Not surprisingly, nonwhites and Hispanics are a much higher percentage of travelers to Mexico (59 percent), compared with travelers to Canada (15 percent) or overseas (26 percent). In addition, nonwhites and Hispanics are a much larger proportion of people traveling internationally than those traveling domestically. Only 15 percent of domestic person-trips were taken by nonwhites or Hispanics compared with 30 percent of person-trips taken internationally.

[9] It must be noted that international trips under 100 miles one way, such as Detroit to Windsor, and San Diego to Tijuana, are not included in these data.

TRAVEL BY SOCIOECONOMIC AND DEMOGRAPHIC GROUPS

Access to transportation—whether geographic, financial, or physical—is not uniform, and as a result mobility outcomes vary by social and demographic group (for more discussion of access and mobility see USDOT BTS 1997b). Much of the research on mobility outcomes has focused on local mobility; less is known about long-distance mobility. The following analysis of ATS data on the effects of household income, sex, race, age, and household type on travel indicates that long-distance travel varies greatly among different segments of the population in a manner similar to local mobility, reflecting different needs and different abilities to travel.

Various groups within the population place different demands on the transportation system, demands that have been changing over the past 20 years. Figure 6-9 summarizes long-distance mobility by social and demographic group in 1995. As the following sections note, however, some of these disparities have lessened since 1977.

Income

Level of income affects the demand for travel. People with greater income can afford more transportation and opportunities, such as vacations and other leisure activities, that often require long-distance travel. Furthermore, people in highly paid positions are more likely to be required to travel on business. The ATS revealed that people in households earning more than $50,000 a year (in 1995 dollars) made 6.3 long-distance trips on average in 1995, nearly four times the 1.6 trips made on average by people in households earning less than $25,000. Households with income between $25,000 and $50,000 a year averaged 4.7 trips a year.

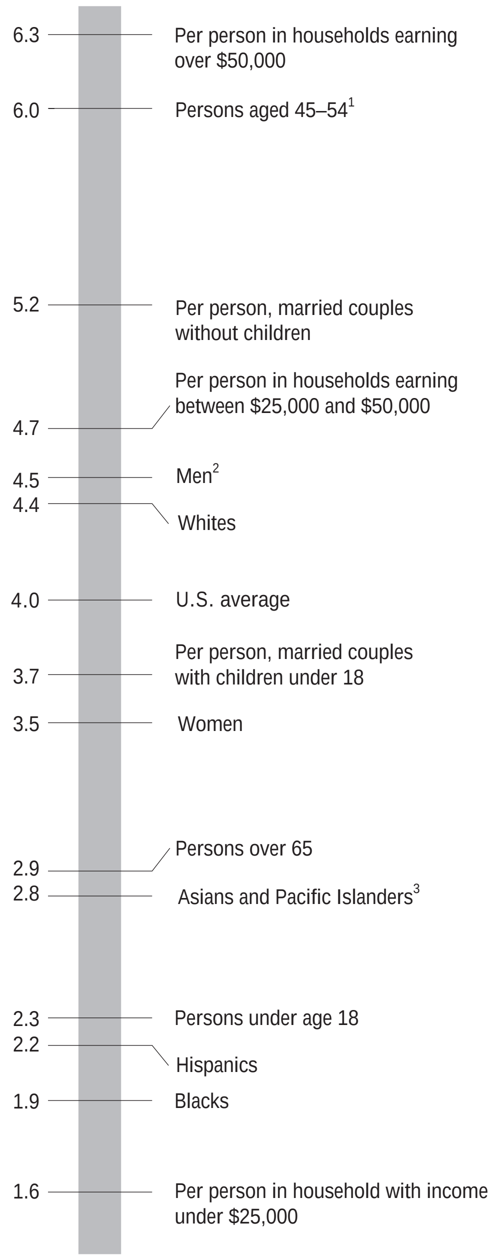
Despite more tripmaking by households with a greater income, the disparity between households earning over $50,000 and those between $25,000 and $50,000 (measured in constant 1995 dollars) decreased between 1977 and 1995[10] (see figure 6-10). The disparity between these two income groups and households earning less than $25,000, however, increased. Trips per person in households earning under $25,000 only increased by 8 percent, from an already low base of 1.4 trips per capita.

In 1995, people in households with a yearly income of $25,000 to $50,000 averaged about 2 more long-distance trips by car and 0.4 more trips by air than in 1977. Although the change in air travel is small (absolutely), this represents a 162 percent increase over 1977, far more than the overall increase of 88 percent for travel in this income group. Bus trips per capita increased slightly for this income group.

People in households earning over $50,000 increased their travel between 1977 and 1995 by 1.6 car trips and 0.9 air trips. Car trips by this income group represented a large percentage change over 1977, but the increase was smaller

[10] The comparisons are based on these broad groupings because of limitations in the 1977 data.

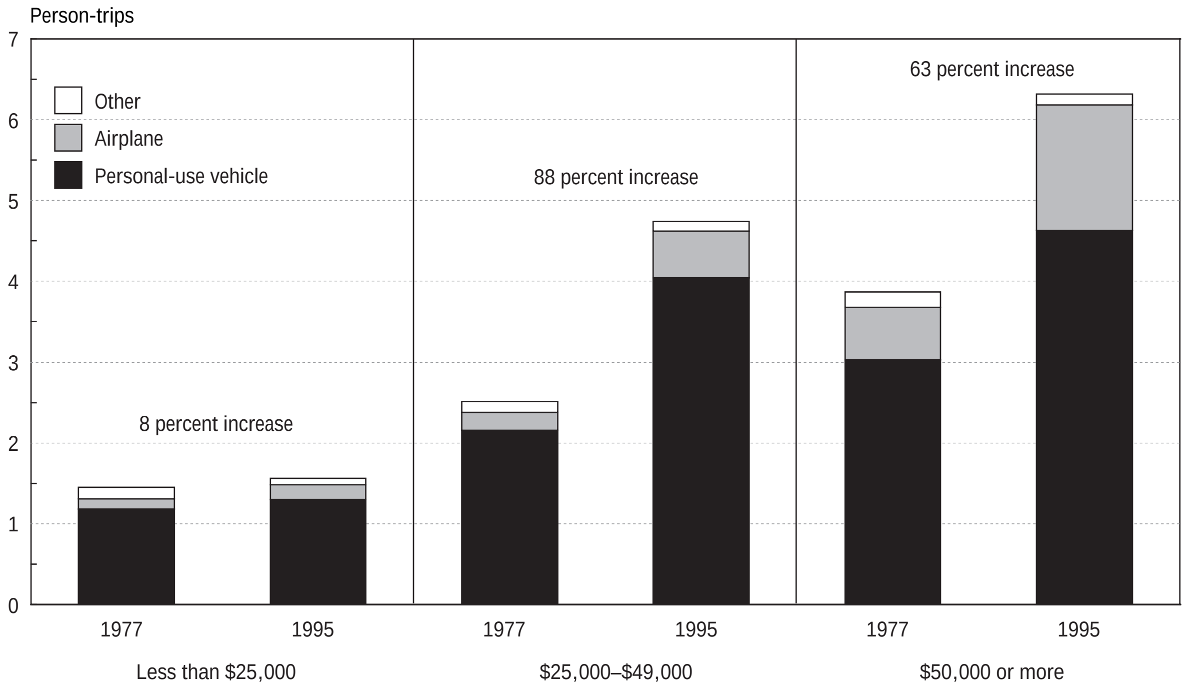
Figure 6-9.
Per Capita Long-Distance Trips: 1995



[1] Not statistically different from per person in households earning over $50,000.
[2] Not statistically different from whites.
[3] Not statistically different from persons over 65.

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

Figure 6-10.
Per Capita Long-Distance Trips by Mode and Income: 1977 and 1995



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997; U.S. Department of Commerce, Bureau of the Census, *National Travel Survey, Travel During 1977* (Washington, DC: 1979).

than the percentage increase made by households in the middle income range. People in households earning less than $25,000 made 0.1 more car trips a year and 0.05 air trips a year.

Higher income households are more likely to use air travel and take longer trips. The median trip length was 462 miles for households earning over $50,000, 395 miles for households in the $25,000 to $50,000 bracket, and 388 miles for households earning less than $25,000.[11] Total annual person-miles by higher income households were 4,400 per person compared with 3,200 miles for middle income households and 1,400 miles for lower income households. Members of higher income households, however, took trips of shorter duration than did persons in lower income households. The average length of stay for households with income over $50,000 per year was 4.1 nights, compared with 4.3 nights for households earning between $25,000 and $50,000, and 4.9 nights for households earning less than $25,000.[12]

Income is directly related to the proportion of long-distance trips made for business and leisure and inversely related to the proportion of trips taken to see friends and relatives and for personal business. Households with lower income made a greater proportion of their trips to see friends and relatives, 43 percent compared with only 28 percent by higher income families. Moderate-income families fell between the two at 34 percent. The higher proportion of trips

[11] These are great circle distances. Great circle distance is the shortest distance between two points on the surface of a sphere.

[12] Does not include trips with no overnight stay.

taken on personal business by lower income households reflects the fact that lower income households take many fewer trips for either business or pleasure. Thus, personal business trips, which tend to be less discretionary, become a much more important share. Nevertheless, when calculated as trips per capita, higher income households still made more personal business trips, even though lower income households may have similar requirements. Both the $25,000 to $50,000 and over $50,000 income groups made 0.8 trips per capita for personal business compared with only 0.3 trips per capita by households earning below $25,000.

Race / Ethnicity

In 1995, whites made more than twice the number of long-distance trips as blacks (4.4 person-trips per capita versus 1.9) and twice as many as Hispanics (2.2 trips per capita). Asians and Pacific Islanders made 2.8 person-trips per capita on average. These differences partly reflect household income, vehicle availability, and geographic location. In 1995, the median income of families by race was $46,400 for Asians and Pacific Islanders, $42,600 for whites, $26,000 for blacks, and $24,600 for Hispanics (USDOC 1997, 469). Only 5 percent of white households were without a car in 1995 compared with 9 percent of Asian, 12 percent of Hispanic, and 24 percent of black households (USDOT FHWA 1998). Whites are more likely to reside in rural locations compared with other racial and ethnic groups, explaining some of the higher trip rates and person-miles (see earlier discussion in the Geography section). Approximately 40 percent of whites live in rural areas compared with 21 percent of Hispanics, 19 percent of blacks, and 16 percent of Asians.

Whites, blacks, and Hispanics used cars and light trucks for about four-fifths of their long-distance trips. Asians and Pacific Islanders, however, made less than two-thirds of their trips by car: they were much more likely to travel by air (33 percent of trips). The large Asian and Pacific Islander population in Hawaii does not explain this transportation mode split; excluding Hawaiians' travel only slightly increases the share of personal-use vehicle trips and slightly decreases the share of air trips among Asians and Pacific Islanders. Blacks' travel by air was only 13 percent compared with 18 percent for whites, and a relatively high proportion of their trips were by intercity and charter and tour bus (4 percent compared with 2 percent for whites) and train (1.5 percent compared with 0.4 percent for whites). Although blacks took only 6 percent of all person-trips, these trips represented 23 percent of all person-trips by intercity bus and 20 percent by train. Hispanics took 6 percent of all trips, but accounted for 28 percent of intercity bus trips and 10 percent of train trips.

The disparity between whites and minorities in long-distance tripmaking appears to have declined. Tripmaking by minority groups, at least by blacks and "other races,"[13] increased faster than that by whites between 1977 and 1995. Blacks and other races increased tripmaking by 84 percent over this period compared with a 61 percent increase by whites. Tripmaking by Hispanics increased at about the same rate as whites (64 percent). The increasing availability of personal vehicles and income growth among some minority groups most likely account for these gains. Nevertheless, in 1995 neither Hispanics nor blacks reached the level of long-distance mobility achieved by whites in 1977.

[13] *Other races* are included here because of the categorization of data in 1977, and include Asians and Pacific Islanders; American Indians, Eskimos, and Aleuts, and other races not elsewhere classified.

Women and Men

The domestic travel of women differed from that of men in 1995, with women, on average, taking 3.5 trips covering 2,900 miles compared with men's 4.5 trips covering 3,700 miles. The disparity between the sexes is virtually unchanged since 1977, because long-distance travel has grown at the same rate for both groups. Women, therefore, continue to account for about 45 percent of all long-distance trips and person-miles. The average distance of trips is about the same for men and women.

Differences in long-distance travel behavior can be explained, to a degree, by lower income, lower employment rates, and a lower driver's licensing rate among women. In 1995, women's labor force participation was 59 percent (up from 52 percent in 1980) compared with men's participation of 75 percent (down from 77 percent in 1980). Women are also more likely to work part time than men, and in occupations that require less travel. As a result, women take fewer business trips—0.5 trips per person for women compared with 1.3 trips per person for men. Therefore, business travel is a much smaller proportion of women's trips—15 percent as compared with 29 percent of men's trips. Nevertheless, the entry of women into the labor force in much larger numbers means they are more likely to travel on business now than they were 20 years ago. The overall increase in business trips by women from 1977 to 1995 was twice as great as the overall increase in trips by women (180 percent increase for business trips compared with 90 percent overall). Business trips by men increased 100 percent.

Another factor accounting for the lower mobility of women is that they tend to live in households with lower income. In 1995, the households with the lowest income ($19,700) were those headed by a female householder with no husband present. This compares with $30,400 for households headed by a single man and $47,000 for married couple households (USDOC 1997, 472). Low-income may account for the greater than average use of buses by women (0.1 trips per capita versus 0.07 for men), and their less frequent use of airplanes (0.6 per capita compared with 0.8 for men). Train trips were the same for men and women (0.02 trips per capita), but were a larger share of all trips for women because of their lower trip rates.

With a lower licensing rate and income, women also made fewer trips by car than men. In 1995, 84 percent of eligible females were licensed compared with 92 percent of men. In that year, women took 2.8 trips per person by personal-use vehicle compared with 3.5 by men, about the same proportion of all long-distance trips. The disparity between the licensing rates of men and women, however, increases with age, particularly for those over 65. This factor, consequently, may diminish in importance with time. A greater proportion of baby boomer women will hold licenses when they reach age 65 than women 65 and over today.

In addition to the factors noted above, lower mobility for some women can also be explained by the different social roles of men and women. Women are still more likely to be the primary caregivers for children and to spend more time doing housework, whether they work outside the home or not (Marini and Shelton 1993). These factors inhibit business travel for many working mothers (as noted above), and may dampen the ability of women to travel for leisure (see table 6-4). Women traveled less overall for leisure, especially for outdoor recreation. Men traveled about the same on personal business as women, but such trips are a greater proportion of women's travel (16 percent versus 13 percent). Women and men traveled about the same amount to visit friends and relatives, although

Table 6-4.
Per Capita Long-Distance Trip Rates
By Sex and Purpose: 1995

Main purpose of trip	Men	Women
Total	4.5	3.5
Business	1.3	0.5
Pleasure	2.6	2.4
Visit friends or relatives	1.3	1.3
Leisure	1.3	1.1
Rest or relaxation	0.5	0.5
Sightseeing	0.2	0.2
Outdoor recreation	0.3	0.2
Entertainment	0.2	0.2
Personal business	0.6	0.5

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

this type of travel was a greater share of women's trips (37 percent compared with 29 percent).

Age

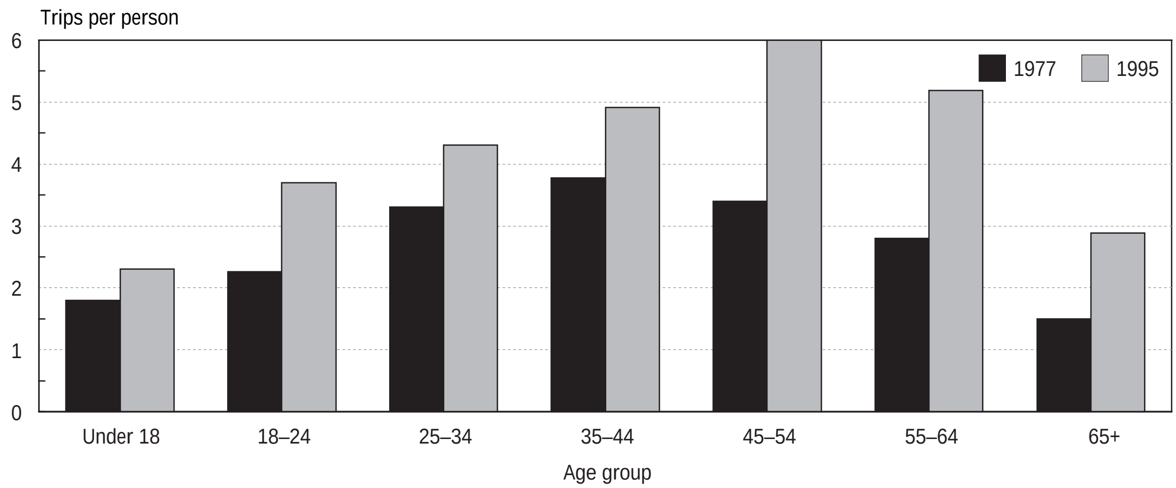
While individuals took four long-distance trips each on average in 1995, there was great variability by age. The highest propensity to travel was found among 45- to 54-year-olds, followed by those 55 to 64, and 35 to 44. The youngest (under 18) and oldest (75 and older) members of the population traveled the least. All age cohorts traveled more in 1995 than in 1977, but the travel behavior of different age cohorts changed quite dramatically over this period. In 1977, those aged 35 to 44 took the most trips per capita, 3.7, but by 1995, this group fell to number three among the age cohorts (4.9 trips per person) compared with the six trips averaged by the next older age group (45 to 54). The age group in 1995 with the second highest number of trips on average was people between 55 and 64 years old. Baby boomers and the generation before them were frequent travelers in their thirties and forties and they have continued that behavior into their fifties and sixties. There are broad implications for the transportation system and the travel and tourism industry should this trend continue.

The two highest traveling cohorts in 1995 (those 45 to 54 and 55 to 64) had larger increases in all types of trips than the highest traveling cohort in 1977, those aged 35 to 44 (see figures 6-11 and 6-12). The older cohorts had especially large increases in leisure and business travel. For instance, the 45 to 54 age cohort had a 98 percent increase in business travel and a 179 percent increase in leisure travel, compared with the 35 to 44 age cohort who had a 46 percent increase in business and 83 percent increase in leisure travel. The over-65 cohort also had large increases in leisure and business travel.

People over 65 took on average 2.9 trips in 1995, fewer than all other age groups except those under 18 and less than half the number of trips of those in the 45 to 54 age bracket. Despite the disparity with other age groups, travel by the elderly increased the most between 1977 and 1995 in percentage terms, with the exception of the 55- to 64-year-olds, who had a comparable increase. Travel by those over 65 is done by the youngest old—those aged 65 to 74—because tripmaking steadily declines with age. Those aged 65 to 69 made on average 4.3 trips per year, more than all age groups except those aged 45 to 54 and 55 to 64. People over 85, however, averaged under one trip yearly. Increases in travel by the elderly reflect income growth, improvements in health, and tourism industry initiatives geared to their special needs.

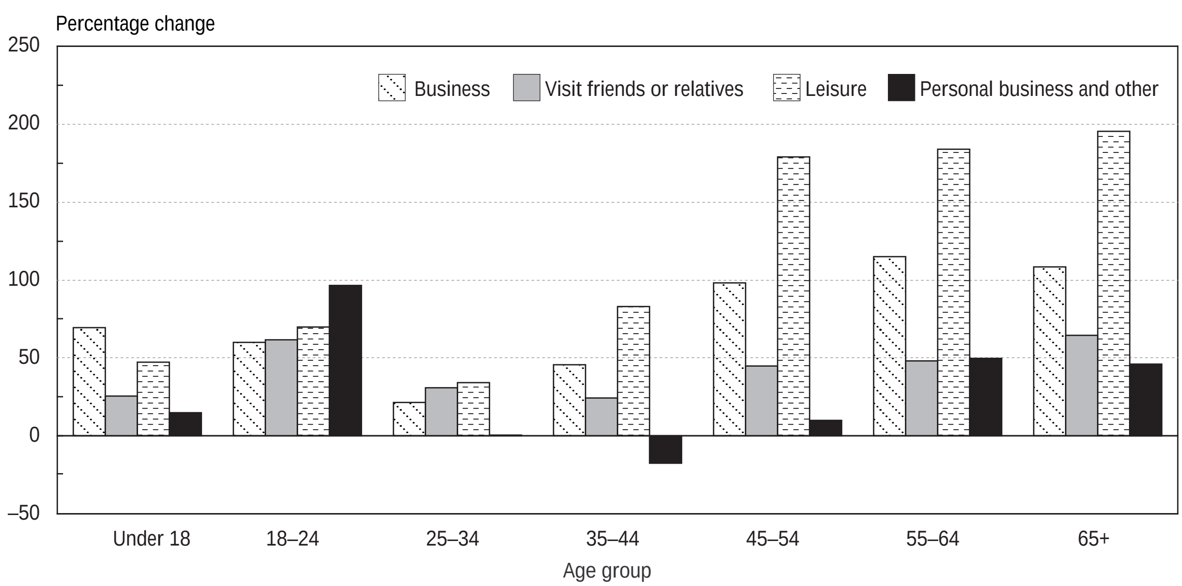
Like the rest of the population, those over 65 take most of their trips by car. The share of car trips declines from 81 percent by the youngest old (65 to 69) to 67 percent for the oldest old (85 and over), however. Although statistical differences cannot be discerned for mode share by age

Figure 6-11.
Per Capita Long-Distance Trips by Age: 1977 and 1995



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997; U.S. Department of Commerce, Bureau of the Census, *National Travel Survey, Travel During 1977* (Washington, DC: 1979).

Figure 6-12.
Change in per Capita Long-Distance Trips by Age and Purpose: 1977–95



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, American Travel Survey data, October 1997; U.S. Department of Commerce, Bureau of the Census, *National Travel Survey, Travel During 1977* (Washington, DC: 1979).

groups over 65, there appears to be a general increase in the percentage of trips by air and bus with age. Most trips taken by bus (85 percent) by those over 65 are taken on charter or tour buses.

Household Type

Different types of households have very different propensities to take long-distance trips. Married couples without children have the highest per capita trip rate (5.2 trips per person) of any household type and single mothers have the lowest (1.8 trips per capita). Much of the difference is due to the level of income and the amount available to spend on travel. Married couples with children under 18 have slightly higher income than married couples without children, but the latter have more disposable income for travel. Married couples have much higher incomes than female-headed households with children; median household income in 1995 for married couples was $47,100 compared with only $19,700 for female-headed households (USDOC 1997, 472).

PERSPECTIVES ON FUTURE TRAVEL

This section considers the influence of demographic and socioeconomic trends on the future of long-distance travel as well as the travel impacts of globalization and technological change.

Demographic Trends

The Census Bureau expects the U.S. population to increase by 32 percent between now and 2030,[14] which would lead to a proportionate increase in travel, all else remaining equal. Of course, all else may not remain equal: if it had, person-miles of long-distance travel would have increased 19 percent between 1977 and 1995, not the 116 percent shown in figure 6-1.

Baby boomers will start reaching the traditional retirement age of 65 in 2010. Until then the elderly population will remain at about 13 percent of the total population. After 2010, however, the population over 65 will grow dramatically, rising to 17 percent of all Americans in 2020 and 21 percent in 2030.

Surprisingly, perhaps, demographic changes seem to have more of an effect on the means of travel than on the amount of travel. (See later section on Modal Changes.) If 1995 trip rates by age cohort remain steady, the Census Bureau's projected numbers of people in each age cohort would increase overall trip rates per capita by only 2 percent between 1995 and 2010. There would be a 2 percent decline if the projection period were 1995 to 2030. Trip rates, particularly of the elderly, are unlikely to remain constant over the next 35 years, however. The income of the elderly has grown faster than for the population as a whole over the past 20 years, and this trend may continue. Moreover, people who are likely to retire over the next 20 years currently have very high trip rates, rates that may be sustained further into old age. How this will be affected by longer life expectancy is unclear.

Future travel growth also will be affected by changes in the proportions of household types. If trip rates by household type remain constant between 1995 and 2010, then changes expected by the Census Bureau in the types of households would lead to a 7 percent increase in trips. This increase would occur because the households with the highest trip rates are projected to increase the fastest—married couples without children (+7.6 million) and nonfamily households (+7.2 million). Households with relatively low trip rates—married couples with children, and females with children and no spouse pre-

[14] The Census Bureau makes high, middle, and low population projections based on various assumptions. These are middle projections.

sent—are projected to decrease (by 2.1 million and 400,000 respectively).

Geography

Population growth is expected to be geographically uneven, according to the Census Bureau.[15] The biggest impact will likely be felt in California, Texas, and Florida. Between 1995 and 2020, more than one in five new residents (on a net basis) are expected to live in California, and another one in five will live in either Texas or Florida. Even though much of this growth will be among racial and ethnic minorities and immigrants (both with relatively low travel rates), the number of long-distance travelers can be expected to grow enormously within Los Angeles, in the California corridor, and from California cities to Las Vegas (currently the fastest growing metropolitan area in the country), Reno, and Phoenix. Travel may also grow in the Texas triangle and Florida. Moreover, these states may see increases in interregional, transcontinental, and international long-distance traffic.

Although there are great uncertainties associated with projecting population change, especially at the state level, the Census Bureau expects only 12 other states to grow by more than 1 million people between 1995 and 2020. They are, in order of magnitude, Georgia, Washington, North Carolina, Arizona, Virginia, Illinois, New Jersey, Tennessee, Colorado, New York, Maryland, and Oregon. This population growth would reinforce travel to and from Atlanta, particularly from several of the surrounding states such as the Carolinas and Tennessee. Although not as dramatic as growth in the California corridor, travel would also increase in the Northeast corridor, and in the Pacific Northwest between Eugene and Seattle. The other 35 states and the District of Columbia are expected to account for only one-quarter of U.S. population growth between 1995 and 2020 (USDOC 1997).

Socioeconomic Trends

If real per capita income continues to grow, trip rates for the population as a whole can be expected to increase, especially if travel costs fall in real terms. Changes in the travel behavior of different income groups, though, is not so straightforward, and may be impacted by future trends in income distribution. Lower income households are likely to have unmet needs for all types of trips, especially visiting friends and relatives and conducting personal business. Such long-distance trips are heavily dependent on the cost of travel. If the cost of travel continues to decline or the real income level of lower income households rises, trip rates should increase. This is especially likely if vehicle availability spreads further within the low-income population, increasing their ability to use the most prevalent means of long-distance travel. Moreover, trends in airfares and, to a lesser extent, the price of charter and intercity bus trips will also have an impact on the ability of low-income households to take long-distance trips.

The propensity of moderate-income households to take trips to visit friends and relatives and conduct personal business is likely to remain stable for a while, but room for growth in sightseeing, outdoor recreation, and other forms of leisure travel is possible. These types of trips are sensitive to not only travel costs but the costs of hotels, restaurants, and other such factors relative to income. Vehicle availability is almost universal among those of moderate income. Assuming the costs of operation (including gasoline, insurance, and highway congestion) do not increase significantly, then the cost of air travel will be a more crucial determinant of the travel behavior of this group.

[15] The data used here are the Census Bureau's Series A projections, the preferred series model.

It is not clear whether high-income households are reaching an upper bound for long-distance travel. Much as there is debate about saturation in local travel, the same question could be asked about long-distance travel. Travel, both local and long distance, is limited by the amount of time and energy people want to allocate to travel versus other activities. Because of these factors, there has been a slight shift from highway vehicles and other slower modes (trains and buses) to air travel, allowing people with more resources to travel much farther and faster than in the past. This is a trend that is likely to continue in the foreseeable future.

Travel by racial minorities has increased relative to the majority white population, and the gap may continue to decrease as vehicle availability rises. Vehicle ownership and driver licensing are currently at very high levels among non-Hispanic whites, but there is room for growth among other races and Hispanics. The impact of future immigration (immigrants are overwhelmingly racial and ethnic minorities), income, and settlement patterns on these trends is difficult to judge, and will undoubtedly vary by racial and ethnic minority.

Women's long-distance travel has not increased relative to men's over the past 20 years, but may do so in the coming years if women's earnings rise, family size declines, women travel more on business, and if the number of single-parent families headed by women decreases.

Modal Changes

If current trip rates by mode remain unchanged between 1995 and 2030, the Census-projected age profile of the population would lead to an overall increase in trips of 30 percent, but there would be uneven effects by mode. The number of trips taken by charter bus would increase by about 50 percent and intercity bus by about 40 percent, reflecting the greater propensity of the elderly to use this mode. For the same reason train and ship travel also would increase by about 40 percent each. Air travel, again assuming there is no change in modal trip rates, would grow at a rate slower than average (under 30 percent) and travel in cars and trucks at about average (30 percent). Most trips, of course, will still be taken by car and plane. Moreover, there could be changes in modal choice. For instance, the baby boomers, when they reach old age, are more likely to continue to travel by air, whereas the elderly today are less used to air travel. Also, the use of new technology, such as collision warning systems and vision enhancement, particularly at night, may encourage more driving by the elderly (see below for a discussion of technology and travel).

The economy may continue to demand high levels of business travel, and leisure travel will also likely grow. Both will increase the importance of air travel, especially if more people travel to overseas destinations. As mentioned above, the proportion of trips by charter buses and cruise ships should also increase with the fast growth of leisure trips taken by the elderly. Intercity buses and trains, on the other hand, will probably continue to decline relative to the other modes, with demographic factors being outweighed by changes, such as the low and declining cost of air travel. This scenario, however, assumes no major supply changes in intercity bus and train travel, such as the development of high-speed trains, which might spur demand.

Globalization

International travel is also expected to increase rapidly between 1995 and 2020, because of economic growth and the continued globalization of production and consumption (WTO 1998). According to one estimate, international tourist arrivals worldwide are expected to nearly triple over this period. Prior to its recent economic crisis in late 1997, arrivals in East Asia were expected by the World Tourism Organization to grow the most between 1995 and 2000. Growth in travel to and from countries such as Japan, South Korea, Taiwan, China (including Hong Kong) would have had an especially large impact on the West Coast. Such growth may occur in the longer term (from 1995 to 2020), and as a result the relative dominance of travel to Europe will wane. A much smaller decline in relative share is also expected for travel to the Americas. Africa, the Middle East, and South Asia are expected to increase their share of tourists very slightly over this period.

Advances in Technology

New technology is another element that could change long-distance travel in the future, although its impacts are difficult to predict (see USDOT BTS 1997b, chapter 11 for a more detailed discussion). Several innovations may ease travel and, therefore, spur greater demand. Global positioning systems (GPS), for instance, an innovation that is now becoming widely available, have a myriad of potential uses in transportation. Some analysts believe that GPS will increase the capacity of the aviation system. In the next few years GPS will also become widely available for use in highway vehicles, as one component of the "smart car" of the future. As part of an onboard computer system, such technology might help people navigate in unfamiliar places, provide location assistance in the case of breakdowns or emergencies, and assist with the location of services such as hotels and restaurants. These and other improvements could help elderly people maintain higher rates of vehicle travel.

Finally, technology may spur long-distance travel via information flow and changes in the travel industry itself. Individuals increasingly use the Internet to make travel plans and get information on potential destinations; for example, they can download a map of a faraway city with ease, view a hotel room in virtual reality, and track the times and prices of flights. Aircraft and hotel capacity are managed so that fare and room prices can be adjusted to maximize utilization, and potential travelers can be alerted via the Internet to short-term travel opportunities. Travel agents, hotels, and other tourist businesses are also using the technology to provide seamless services for international travelers. All of these innovations are likely to push travel and tourism in the next century to new heights.

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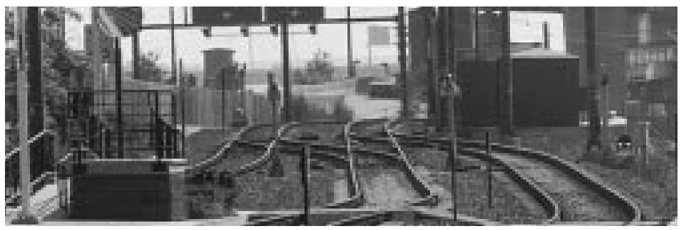
Long-Distance Freight Transportation



This chapter examines nonlocal freight shipments of over 100 miles, which account for 61 percent of the value, 33 percent of the weight, and 91 percent of the ton-miles of commodities moved in the United States[1] (USDOC Census 1996). The magnitude of these nonlocal shipments is a reflection of the importance of interstate and interregional trade in the nation's economy.

In *Transportation Statistics Annual Report 1997,* the Bureau of Transportation Statistics (BTS) used information from the 1993 Commodity Flow Survey (CFS) and other data sources to describe freight movements at the *national* level by mode of transportation, major commodity moved, and major origin and destination. (See box 7-1 for a discussion of the CFS.) This year, the discussion examines how commodity shipments and freight mode activity differ by *region*. Using CFS data, the chapter identifies regions and states having the largest origins and destinations of freight, and the major nonlocal freight flows in each region. In addition, the chapter highlights forces of stability and change in the freight transportation system that might affect future trends.

[1] Nonlocal shipments fall into two categories: short-haul (beyond 100 miles, but within a 250-mile radius of its origin), and long-haul (beyond a 250-mile radius). Due to data limitations, the broad category of nonlocal shipments is generally used in this chapter.

Box 7-1.
Commodity Flow Survey: 1993 and 1997

The Commodity Flow Survey (CFS) is cosponsored by the Bureau of Transportation Statistics (BTS) and the Bureau of the Census. The Bureau of the Census conducts the CFS as part of the economic census, which is undertaken in years ending in 2 and in 7. Because BTS was not established until 1992, data for the initial CFS were collected throughout calendar year 1993 instead of 1992.[1] The Census Bureau is currently processing 1997 CFS data, and data products are expected to become available for distribution in late 1998 and throughout 1999.

The CFS collects data on the transportation modes American businesses use to move commodities in the United States. It provides information on the types of commodities shipped, their value, weight, and mode of transportation, and the origin and destination of shipments by manufacturing, mining, wholesale, and selected retail and service industries. The CFS is the only source of nationwide data on the flows of goods by all modes of transportation, on the geography of commodity movements, and the distance of shipments. The survey excludes shipments by establishments classified in the Standard Industrial Classification as farms, forestry, fishing, governments, construction, transportation, and most retail and service businesses. The CFS covers exports but not imports, because the survey samples only domestic businesses.

For the 1997 CFS, BTS and the Census Bureau took steps to improve upon the 1993 CFS and reduce the overall reporting burden on respondents. To get better data, the Census Bureau reduced the number of establishments sampled by half, reduced the amount of information collected in the survey, shortened the number of weeks covered by the survey, and changed the commodity classification code from the Standard Transportation Commodity Classification (STCC) to the Standard Classification of Transported Goods (SCTG).[2] The SCTG has fewer than half the commodity codes in the STCC and is more useful for multimodal analysis than the STCC, which was designed in the 1960s to capture rail freight information.

As the CFS does not cover all freight movement in the United States, BTS supplemented 1993 CFS data with additional estimates from Oak Ridge National Laboratory (noted in this chapter where appropriate). These estimates are valid at the national level only. BTS will use similar estimates from Oak Ridge and other sources to supplement the 1997 CFS data.

[1] The Federal Highway Administration was a major financial contributor to the 1993 CFS.

[2] A detailed description of the SCTG may be found under statistical policy and research at http://www.bts.gov.

To provide a context for the regional analyses, the introductory section that follows highlights overall freight movement in the United States as measured by the CFS.

FREIGHT MOVEMENT IN THE UNITED STATES

In 1993, domestic establishments in the United States shipped raw materials and finished goods weighing 12.2 billion tons, generating 3.6 trillion ton-miles of output of the transportation system. The goods and materials, which include internal domestic movements and export shipments, were valued at $6.1 trillion.[2] These figures translate into about 33 million tons of freight shipped on a typical day in 1993, yet do not fully reflect all the freight moved in the United States. The survey excluded most shipments by service industries, agricultural movements from farms to off-farm storage and processing facilities,

[2] BTS calculated these figures using data from the 1993 CFS together with additional data on waterborne and pipeline shipments not fully covered in the CFS. The ton and value totals in the CFS represent the sum of separate shipments of a commodity as it moves through the production and consumption chain. Hence, the CFS totals are much larger than the value-added and final weight of materials used in products purchased by consumers and other end-users.

shipments by government agencies, and imports shipped to the United States. There is no simple way to be certain how much these unsampled shipments would add to the total, but BTS separately estimated that one-tenth of the ton-miles moved by trucks on the nation's highways are made up of U.S. exports and import trade.[3]

In 1993, food and kindred products[4] accounted for the highest dollar sum of CFS shipments, followed by transportation equipment,[5] and then by chemicals and allied products. These three commodity groups accounted for over one-third of the value of shipments. When measured by tonnage rather than value, the major commodities were petroleum and coal products, nonmetallic minerals, and coal, making up about half the tonnage of CFS shipments.

Trucking was the most used commodity shipment mode in 1993, measured both by shipment value—about 72 percent—and by tonnage—about 53 percent (USDOT BTS 1996a, table 9-5). Trucking also accounted for 24 percent of ton-miles. Waterborne shipments accounted for about 4 percent of the value, 18 percent of the tons, and 24 percent of the ton-miles. Railroads hauled 4 percent by value, 13 percent by tonnage, and led other modes in ton-miles with 26 percent of the total. Intermodal combinations (which include parcel, postal, and courier services; truck and rail; truck and water; and others) accounted for about 11 percent of the value of shipments. Pipelines transported about 3 percent by value, 11 percent by tonnage, and 16 percent by ton-miles.

Rail plays a key role in transporting bulk and time-sensitive commodities over long distances. In 1993, rail accounted for 42 percent of the ton-miles of freight shipments of 100 miles or more. Truck transportation was second in ton-miles, accounting for 32 percent. Trucking's share of ton-miles, however, represented 70 percent of the value of these shipments, as commodities moved by truck have higher average values per ton. (Rail's share of the value was 6 percent, reflecting the low per ton value of most bulk commodities.) For shipments over 1,000 miles, rail accounted for 40 percent of the ton-miles. Pipelines play a critical role in the domestic movement of petroleum, petroleum products, and natural gas—accounting for most natural gas movement and over half of crude oil and refined petroleum products movement.

Over one-third of the shipments by value originated in states with large populations and manufacturing sectors, such as California, New York, Michigan, Texas, and Illinois. These five states were also the destination for over one-third of the shipments measured by value. Hence, freight activity is quite concentrated.

Nationally, about 62 percent of shipments by value and 35 percent by weight moved across state boundaries in 1993, with the rest moving within states. The interstate proportion of shipments varied by state, commodity, and mode. For example, about 55 percent of the value of truck shipments crossed state boundaries, lower than the national average of 62 percent for all modes in 1993 (USDOT BTS 1997b). Freight transportation in the United States is truly an interstate activity and most states have traffic that simply passes through their borders—en route from and to other states. In 25 states, such through shipments accounted for more than half of the value of the commodities

[3] BTS calculated this estimate by combining CFS data on exports with data on surface imports by trucks and data for a portion of waterborne imports leaving U.S. ports of entry by truck to domestic destinations. The estimate of surface and water imports plus all exports was divided by ton-miles of total shipments to derive the proportion of highway shipments of exports and imports.

[4] Includes meat and dairy products, fruits and vegetables, grain mill products, bakery and confectionery goods, beverages, and other food products.

[5] Includes motor vehicles and parts, aircraft and parts, railroad equipment, and motorcycles and bicycles.

moved by truck. In 19 states, through shipments accounted for more than half of the state's ton-miles by truck.

FREIGHT TRANSPORTATION AMONG U.S. REGIONS

Freight transportation is the vital link that allows firms and households to purchase goods produced in all parts of the United States and throughout the world. By providing access to geographically dispersed markets, freight transportation allows regions to specialize in producing those goods for which they have comparative advantage. At the same time, by providing access to a broad range of inputs, freight transportation allows regions the flexibility to engage in a diverse range of economic activities, hence increasing returns to scale in production.[6]

The United States is vast in expanse, with 3.7 million square miles of land area, and diverse in industrial composition and geography. It comprises regions that differ in their endowments of natural resources, labor skills, and transportation infrastructure, but are connected by flows of trade and movement of people. Differences in the supply of resources and transportation infrastructure lead to concentrations of production activities, which in turn generate demand for freight services. Transportation can help compensate for regional differences in the supply of natural resources and labor. The American economy is a *multiregional* economy—that is, an economy made up of distinctive regions (both multistate and substate) that are both diverse and highly interconnected. These interconnected economies are reflected in part by intraregional, interregional, and international freight flows.

[6] Comparative advantage implies that trade among regions occurs to take advantage of inherent differences. Increasing returns to scale holds that trade occurs to take advantage of economies of scale and gains from specialization (Krugman 1991).

Multistate Regions

In 1993, the top five states of origin accounted for 35 percent of the value and 31 percent of the tonnage of total CFS shipments. The origins of some commodities were more concentrated than others, however. For instance, the top five origin states for metallic ores[7] accounted for 81 percent of the value, while the top five origins for farm products[8] accounted for only 37 percent of the value (see table 7-1). The most concentrated origins for commodity groups include metallic ores, coal, forest products, and fresh fish.

States can be grouped into different multistate regions to describe the degree of concentration of shipment origins by commodity. The Bureau of the Census created U.S. census divisions, which are one type of multistate region that can be used to describe freight origins.[9] (see figure 7-1). The nine census divisions are multistate regions with different resources, climates, populations, and histories. Using information from the CFS, it is possible to separate shipments from each division into 26 Standard Transportation Commodity Classification (STCC) groups.[10] By looking at how shipments originating in the regions are distributed across commodity groups, differences and similarities between the regions emerge. For example, the Pacific, East South Central, and South Atlantic divisions produce a large proportion of the nation's lumber and wood products, which are then distributed broadly to the other seven regions.

Table 7-2 lists the five major commodity groups by value and share of shipments originat-

[7] Nevada, Arizona, Minnesota, Missouri, and Tennessee.
[8] California, Illinois, Texas, Ohio, and Iowa.
[9] Other types of regions could be delineated based on either commodity or mode of transportation.
[10] The CFS includes data on 31 commodity groups, including waste or scrap material, hazardous materials, miscellaneous freight, containers returned empty, and unknown commodities. Some groups were not considered because of large proportions of missing values at the state level.

Table 7-1.
Share of Commodity Shipments by Top Five and Top Ten Origin States: 1993

STCC	Commodity group	Top 5 states as percentage of value of shipments	Top 10 states as percentage of value of shipments	Value per ton (dollars)
10	Metallic ores	81.2	92.5	136
11	Coal	71.1	92.9	21
8	Forest products	69.7	100.0	56
9	Fresh fish or other marine products	68.2	88.2	3,693
22	Textile mill products	65.3	83.3	4,128
19	Ordnance or accessories	63.7	81.7	25,903
31	Leather or leather products	63.2	79.3	21,093
21	Tobacco products	55.7	77.4	18,803
38	Instruments, photographic, and optical goods	53.3	70.6	23,080
29	Petroleum or coal products	50.2	65.8	191
23	Apparel or other finished textile products	46.5	69.3	19,249
37	Transportation equipment	45.1	66.4	7,447
36	Electrical machinery, equipment, or supplies	43.0	61.4	13,630
35	Machinery, excluding electrical	42.3	60.3	12,954
39	Miscellaneous products of manufacturers	42.0	61.3	9,686
33	Primary metal products	40.9	62.8	858
28	Chemical or allied products	40.6	61.0	977
14	Nonmetallic minerals	40.0	58.5	12
34	Fabricated metal products	39.8	60.6	2,795
32	Clay, concrete, glass, or stone products	39.5	59.8	114
25	Furniture or fixtures	38.7	59.1	4,193
1	Farm products	36.8	57.3	224
30	Rubber or miscellaneous plastic products	35.1	56.3	3,348
24	Lumber or wood products, excluding furniture	34.0	50.9	191
20	Food or kindred products	33.2	53.0	997
26	Pulp, paper, or allied products	30.8	50.9	898

KEY: STCC = Standard Transportation Commodity Classification.

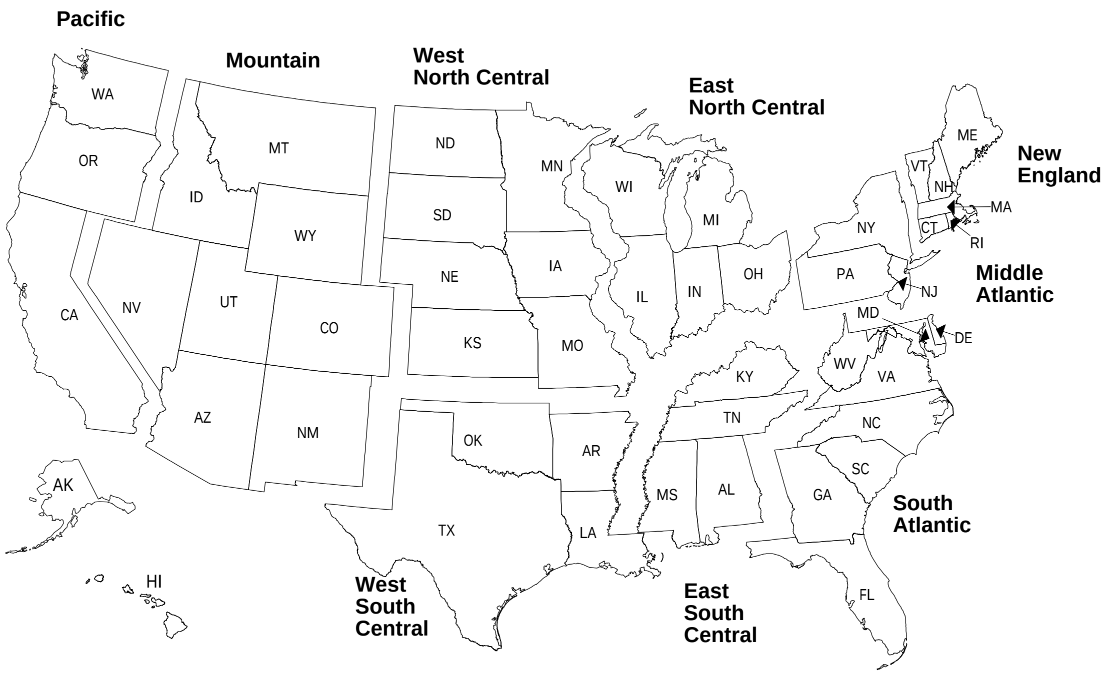
SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey, NTAR CD-ROM* (Washington, DC: 1996).

ing in each of the nine census divisions.[11] In all nine regions, the top five commodity groups account for 50 percent or more of total shipment values. For the purpose of comparison, national shipments (from all regions combined) for each group as a percent of national shipments of all commodities are also listed. For example, the data indicate that electrical machinery (STCC 36) accounts for 11.6 percent of the value of all shipments originating in New England, but only 7.4 percent of the value of shipments originating in all groups nationwide.

The data indicate both striking similarities and differences among regions. Evidence of similarity is the repeated presence of just a few commodity groups in most regions. The five commodity groups with the highest values of national shipments are food and kindred products, transportation equipment, chemical or allied products, machinery excluding electrical, and electrical machinery. At least four of these

[11] The CFS data summarized in this table exclude additional Oak Ridge National Laboratory data on waterborne and pipeline shipments not fully captured in the CFS.

Figure 7-1.
Multistate Census Regions



SOURCE: U.S. Department of the Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1997* (Washington, DC: 1997).

Table 7-2.
Value and Share of Top Five Commodity Groups by Region of Origin: 1993

STCC	Commodity group	Value of shipments originating in region (million $)	Regional shipments as a share of region's shipments (percent)	U.S. shipments as a share of all U.S. shipments (percent)
New England (4.0% of U.S. shipments)				
36:	Electrical machinery	25,634	11.6	7.4
35:	Machinery, excluding electrical	24,575	11.1	8.0
20:	Food or kindred products	24,163	10.9	15.5
37:	Transportation equipment	18,293	8.3	11.8
28:	Chemical or allied products	18,227	8.2	9.7
All other commodities		110,783	50.0	47.5
Middle Atlantic (13.0% of U.S. shipments)				
20:	Food or kindred products	116,457	16.3	15.5
28:	Chemical or allied products	81,078	11.3	9.7
38:	Instruments, photographic, and opticals	66,621	9.3	3.6
36:	Electrical machinery	59,308	8.3	7.4
37:	Transportation equipment	55,021	7.7	11.8
All other commodities		337,827	47.2	52.0
South Atlantic (15.3% of U.S. shipments)				
20:	Food or kindred products	133,916	15.9	15.5
28:	Chemical or allied products	90,687	10.8	9.7
37:	Transportation equipment	90,669	10.8	11.8
22:	Textile mill products	63,744	7.6	1.9
23:	Apparel or other finished textile products	61,406	7.3	5.3
All other commodities		402,746	47.8	55.9

(continued on next page)

Table 7-2.
Value and Share of Top Five Commodity Groups by Region of Origin: 1993 *(continued)*

STCC	Commodity group	Value of shipments originating in region (million $)	Regional shipments as a share of region's shipments (percent)	U.S. shipments as a share of all U.S. shipments (percent)
East North Central (21.2% of U.S. shipments)				
37:	Transportation equipment	222,396	19.0	11.8
20:	Food or kindred products	173,912	14.9	15.5
28:	Chemical or allied products	110,236	9.4	9.7
35:	Machinery, excluding electrical	100,784	8.6	8.0
33:	Primary metals	80,001	6.8	4.1
All other commodities		480,669	41.2	50.8
East South Central (7.3% of U.S. shipments)				
20:	Food or kindred products	50,494	12.6	15.5
37:	Transportation equipment	48,507	12.1	11.8
23:	Apparel or other finished textile products	48,179	12.0	5.3
28:	Chemical or allied products	40,336	10.1	9.7
36:	Electrical machinery	27,392	6.8	7.4
All other commodities		186,198	46.4	50.3
West North Central (7.6% of U.S. shipments)				
20:	Food or kindred products	112,909	26.8	15.5
37:	Transportation equipment	43,722	10.4	11.8
28:	Chemical or allied products	34,631	8.2	9.7
35:	Machinery, excluding electrical	34,534	8.2	8.0
1:	Farm products	33,546	8.0	2.6
All other commodities		161,389	38.4	52.4
West South Central (10.5% of U.S. shipments)				
29:	Petroleum or coal products	106,241	18.4	6.5
28:	Chemical or allied products	88,667	15.4	9.7
20:	Food or kindred products	86,772	15.0	15.5
35:	Machinery, excluding electrical	57,411	9.9	8.0
37:	Transportation equipment	35,661	6.2	11.8
All other commodities		202,720	35.1	48.5
Mountain (3.7% of U.S. shipments)				
20:	Food or kindred products	35,286	17.2	15.5
35:	Machinery, excluding electrical	20,231	9.9	8.0
23:	Apparel or other finished textile products	18,420	9.0	5.3
36:	Electrical machinery	16,832	8.2	7.4
28:	Chemical or allied products	12,972	6.3	9.7
All other commodities		101,552	49.5	54.1
Pacific (14.4% of U.S. shipments)				
20:	Food or kindred products	122,699	15.4	15.5
37:	Transportation equipment	102,429	12.9	11.8
36:	Electrical machinery	89,700	11.3	7.4
35:	Machinery, excluding electrical	72,626	9.1	8.0
29:	Petroleum or coal products	62,806	7.9	6.5
All other commodities		344,499	43.3	50.7

KEY: STCC = Standard Transportation Commodity Classification.

NOTE: Regions are based on nine Census Divisions (see figure 7-3). The numbers for region's share of shipments do not sum to 100% because some data are excluded for statistical or disclosure reasons.

SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey, NTAR CD-ROM* (Washington, DC:1997).

groups appear in the top five groups for all but one census division, and food and kindred products are in the top three for all nine divisions.

Some commodity groups, however, rank higher in particular regions than they do at the national level. For example, apparel and other finished textiles rank only 7th nationally, but rank 3rd in both the East South Central and Mountain divisions; petroleum or coal products rank 6th nationally, but 1st (with over 18 percent of all shipments) in the West South Central division; instruments rank 11th nationally, but 3rd in the Middle Atlantic Division; textile mills rank only 16th nationally, but 4th in the South Atlantic Division; and farm products rank only 14th nationally, but 5th in the West North Central division.

Even for those commodity groups that are important in all regions, there are notable variations in their contribution to total shipments. Food and kindred products accounts for 15.5 percent of national shipments, but varies from a high of 26.8 percent of regional shipments in the West North Central divisions to a low of 10.9 percent in New England. Transportation equipment accounts for 19 percent of shipments in the East North Central division, but only 5.2 percent of shipments in the Mountain division.

The distribution of production of individual commodities across the nine census divisions also shows differences in concentration of freight origins. Table 7-3 lists the distribution for four selected commodity groups: farm products, food and kindred products, lumber or

Table 7-3.
Distribution of Shipments by Region of Origin for Four Selected Commodity Groups: 1993

Region	Farm products	Food or kindred products	Lumber or wood products	Transportation equipment
	Value of region's shipments (million $)			
United States	142,442	856,884	126,662	652,474
New England	361	24,163	5,571	18,293
Middle Atlantic	7,738	116,457	9,084	55,021
South Atlantic	11,849	133,916	21,944	90,669
East North Central	29,323	173,912	16,545	222,396
East South Central	6,034	50,494	11,509	48,507
West North Central	33,546	112,909	8,461	43,722
West South Central	20,142	86,772	10,850	35,661
Mountain	6,982	35,286	7,851	10,581
Pacific	24,596	122,699	33,189	102,429
	Region's share of all national shipments[1] (percent)			
United States	100.0	100.0	100.0	100.0
New England	0.3	2.8	4.4	2.8
Middle Atlantic	5.4	13.6	7.2	8.4
South Atlantic	8.3	15.6	17.3	13.9
East North Central	20.6	20.3	13.1	34.1
East South Central	4.2	5.9	9.1	7.4
West North Central	23.6	13.2	6.7	6.7
West South Central	14.1	10.1	8.6	5.5
Mountain	4.9	4.1	6.2	1.6
Pacific	17.3	14.3	26.2	15.7

[1] The figures do not sum to 100% for all commodity groups because some data are excluded for statistical or disclosure reasons.

NOTE: Regions are based on nine Census Divisions (see figure 7-3).

SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey, NTAR CD-ROM* (Washington, DC: 1997).

Box 7-2.
National Transportation Analysis Regions

This chapter presents data at two levels of geographic detail—for states and for National Transportation Analysis Regions (NTARs). NTARs are aggregations of Bureau of Economic Analysis' Economic Areas[1] and reflect the functional geography of markets and their economic spheres of influence. For the 1993 Commodity Flow Survey, the Bureau of Transportation Statistics (BTS) defined NTARs to complement states, because state borders do not necessarily reflect important elements of economic geography. States often encompass more than one distinct economic region. Also, many economic regions (such as the New York City and Chicago metropolitan areas) straddle state borders. State borders also fail in some instances to account for important economic barriers such as mountain ranges and lakes.

BTS drew the NTAR borders with a number of considerations in mind. NTARs were to cover the entire United States. Each NTAR is a distinctive economic unit with one or more urban cores and surrounding communities and outlying areas. NTARs are smaller than states in order to provide superior geographic detail, but are few enough in number to make it possible to provide reliable estimates of a manageable number of interregional commodity flows. These criteria are the basis for defining the 89 NTARs.

[1] NTARs are based on the 1987 delineation of Economic Areas. The Bureau of Economic Analysis has since modified its definitions and boundaries of Economic Areas.

wood products, and transportation equipment. Here regional differences in the structure of production are more clearly visible. Only the East North Central division is among the largest sources of all four categories of shipment. Despite the direct economic linkage between farm products and processed food, the distribution of farm products and food and kindred products across the nine regions is quite different. Grain-producing states of the East North Central and West North Central divisions account for much larger shares of farm production than food production, while the reverse is true for the Middle and South Atlantic states.[12]

Lumber and wood production is highly concentrated in the Pacific division and southeastern states, and tends otherwise to be relatively low in major farm regions. While transportation equipment is among the top five groups for all but one of the nine census divisions, its aggregate production is highly concentrated, with two divisions—the East North Central and Pacific—accounting for half the value of national production.

Substate Regions

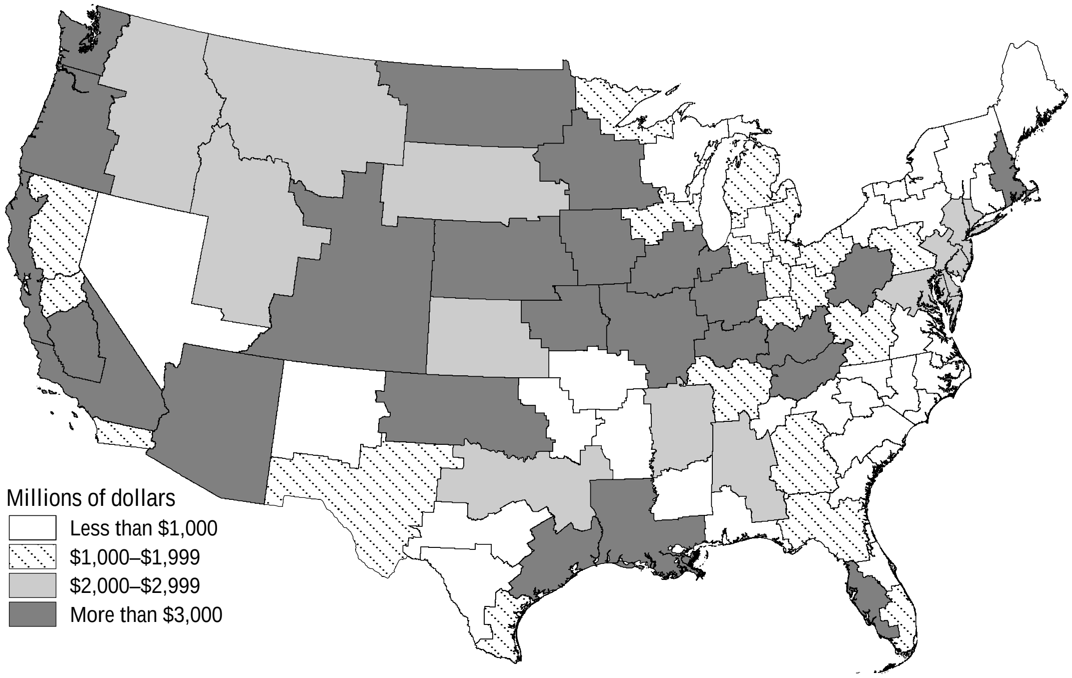
BTS analyzed CFS data based on National Transportation Analysis Regions (NTARs), a nationwide set of 89 regions designed to encompass distinct production areas (see box 7-2). Figure 7-2 provides details on the spatial distribution at the NTAR level of two types of production. The figure clearly shows a spatial separation of goods production and demand that leads to a massive volume of goods movement. These broad-scale maps, however, conceal tremendous spatial differences within the categories of primary and secondary production and simplify a complex picture.

Primary production refers to the raw materials produced by activities such as farming, mining, and forestry, the spatial patterns of which reflect the natural resource endowments of the regions. Concentrations of production in the Midwest and Great Plains reflect climate and soil conducive to agriculture; concentrations in the

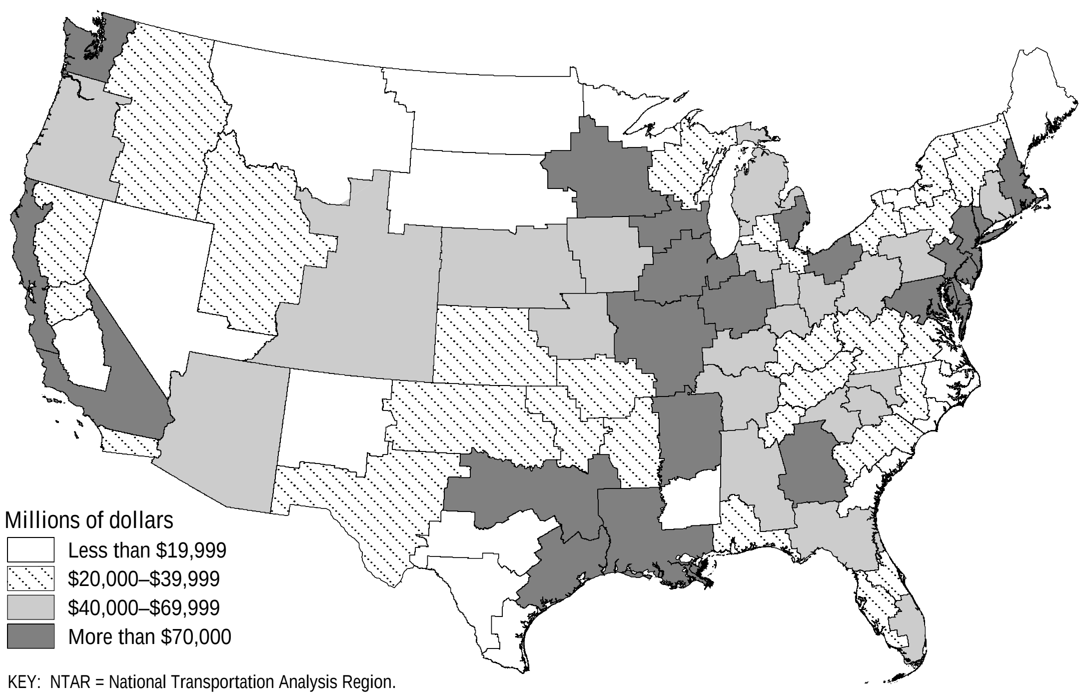
[12] The relative distribution of farm and processed food products among regions may vary, because the CFS excludes shipments from farms to off-farm storage and processing plants.

Figure 7-2.
Value of Commodity Shipments by NTAR of Origin: 1993

Shipments of primary products



Shipments of secondary products



KEY: NTAR = National Transportation Analysis Region.
NOTES: Primary products include shipments of farm and agricultural products; forest and lumber products; and mining, mineral, and petroleum products. Secondary products include shipments of machinery, equipment, metal products, furniture, textiles, apparel, paper products, and others.
SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey, NTAR CD-ROM* (Washington, DC: 1997).

Gulf Coast, Rocky Mountain, and Appalachian regions reflect the distribution of mineral resources; and concentrations in the Southeast, North Central, and Pacific Northwest regions reflect the distribution of forest resources. Primary products are seldom consumed directly, but are shipped as input to *secondary production* (manufacturing) for transformation into goods of greater value to the final consumer. Figure 7-2 shows that many NTARs have substantial amounts of primary production, but secondary production is far more spatially concentrated.

Manufacturing industries generally benefit from urban infrastructure and large pools of labor, and tend to cluster around population centers. This partly explains why the highest concentrations of secondary production coincide with the three largest metropolitan areas: New York, Los Angeles, and Chicago. This is not to say, however, that the distribution of secondary production coincides precisely with the distribution of population. Many important population clusters have economies based on service industries, and therefore do not appear as major areas of goods shipment. Manufacturing also takes place in more rural areas, as evidenced by such industries as furniture production and the processing of agricultural products. With the extension of improved transportation infrastructure such as the Interstate Highway System, many rural communities have attracted parts suppliers, assembly plants, and other manufacturing facilities in diverse industries. Major population clusters represent large consumer markets, however, and are the ultimate destinations for most goods shipments.

Even though regional diversity in production and demand produces greater demand for transportation, this is not usually an economic disadvantage. In general, regional specialization combined with a lack of internal trade barriers has allowed the U.S. economy to achieve levels of efficiency that most other parts of the world have not been able to match. Such high levels of efficiency would not be possible without low-cost, reliable freight transportation connecting all parts of the country. This is one way in which the domestic freight transportation system contributes to economic performance, but there are others. Freight transportation makes it possible for producers in every region to sell to international markets by providing access to international terminals and ports.

While inexpensive freight transportation promotes regional specialization, it also helps regional economies branch out into new areas of production. For example, were it not for efficient delivery of components, it would not have been possible for General Motors to establish a Saturn automotive assembly plant in rural Tennessee. Thus, over time freight transportation can help narrow regional disparities in economic performance.

There are differences in the degree of concentration of freight shipments among NTARs by commodity groups. Table 7-4 provides information on the top five commodity groups by value of shipments originating in 10 selected NTARs. The table includes 8 of the top 10 NTARs by shipment value, plus 2 others chosen to provide broad regional and sectoral coverage. In each case, the top commodity group accounts for 12 percent or more of total shipments and the top five groups account for 46 percent or more.

Some of the NTARs shown in table 7-4, however, exhibit much higher concentrations. Notable are the transportation equipment centers of Detroit and Seattle, where transportation equipment alone accounts for 42.5 percent and 35.7 percent, respectively, of total shipment value.

The food and kindred products category ranks in the top five commodities for all 10 NTARs. It is evident that production in this

Table 7-4.
Top Five Commodity Groups by Value of Shipment for 10 Selected NTARs: 1993

NTAR	Commodity group	Value (million $)	Cumulative share of NTAR's shipments (percent)	Value per ton (dollars)	Average distance per ton (miles)
12 New York, NY					
	38: Instruments, photographic, optical, etc.	46,632	12.5	38,828	465
	20: Food or kindred products	43,427	24.1	1,318	291
	28: Chemical or allied products	43,224	35.7	2,604	265
	36: Electrical machinery, equipment, supplies	39,279	46.2	24,352	679
	37: Transportation equipment	31,752	54.7	17,640	600
29 Charlotte, NC					
	23: Apparel or other finished textile products	12,153	16.7	20,357	757
	22: Textile mill products	10,334	30.9	4,366	494
	20: Food or kindred products	6,735	40.2	999	156
	35: Machinery, excluding electrical	5,701	48.0	15,162	519
	28: Chemical or allied products	4,898	54.8	1,356	250
36 Atlanta-Columbus-Macon, GA					
	37: Transportation equipment	29,833	18.3	17,559	602
	20: Food or kindred products	18,752	29.8	967	233
	23: Apparel or other finished textile products	15,959	39.6	18,622	559
	28: Chemical or allied products	13,585	47.9	2,209	360
	36: Electrical machinery, equipment, supplies	10,646	54.5	11,534	661
71 Detroit, MI					
	37: Transportation equipment	65,468	42.5	7,220	551
	20: Food or kindred products	18,419	54.5	1,433	122
	35: Machinery, excluding electrical	10,825	61.5	11,241	556
	33: Primary metal products	9,979	68.0	590	153
	34: Fabricated metal products	9,900	74.4	1,345	203
83 Chicago-Rockford-Peoria, IL-Davenport, IA					
	20: Food or kindred products	52,354	15.3	1,188	406
	28: Chemical or allied products	44,917	28.4	1,759	360
	35: Machinery, excluding electrical	32,864	38.0	10,722	531
	37: Transportation equipment	30,457	46.9	8,536	542
	36: Electrical machinery, equipment, supplies	27,212	54.8	12,728	601
122 Houston-Beaumont, TX					
	29: Petroleum or coal products	52,604	26.8	184	163
	28: Chemical or allied products	41,335	47.8	533	519
	20: Food or kindred products	12,054	53.9	1,109	253
	35: Machinery, excluding electrical	11,133	59.6	12,991	515
	33: Primary metal products	5,930	62.6	906	395
125 Dallas-Fort Worth-Abilene, TX					
	20: Food or kindred products	22,801	14.1	968	254
	37: Transportation equipment	17,131	24.7	13,457	561
	36: Electrical machinery, equipment, supplies	13,627	33.1	20,868	531
	28: Chemical or allied products	11,266	40.0	1,520	473
	23: Apparel or other finished textile products	10,353	46.4	20,142	605

Continued on next page

Table 7-4.
Top Five Commodity Groups by Value of Shipment for 10 Selected NTARs: 1993 *(continued)*

NTAR	Commodity group	Value (million $)	Cumulative share of NTAR's shipments (percent)	Value per ton (dollars)	Average distance per ton (miles)
176 San Francisco-Oakland-Eureka, CA					
	36: Electrical machinery, equipment, supplies	32,797	18.7	65,725	1,130
	35: Machinery, excluding electrical	25,665	33.3	54,260	973
	20: Food or kindred products	18,119	43.7	1,171	428
	29: Petroleum or coal products	15,024	52.2	196	221
	37: Transportation equipment	13,684	60.1	14,269	1,292
171 Seattle, WA					
	37: Transportation equipment	33,942	35.7	18,609	784
	20: Food or kindred products	12,755	49.0	1,291	361
	24: Lumber or wood products (excludingfurniture)	6,545	55.9	120	110
	29: Petroleum or coal products	5,938	62.2	187	NA
	35: Machinery, excluding electrical	4,057	66.4	8,877	818
180 Los Angeles, CA					
	37: Transportation equipment	49,064	13.9	8,623	290
	36: Electrical machinery, equipment, supplies	40,630	25.4	24,242	893
	20: Food or kindred products	40,169	36.8	1,337	334
	35: Machinery, excluding electrical	28,926	45.0	23,926	1,079
	23: Apparel or other finished textile products	27,274	52.7	23,172	1,063

KEY: NA = data not available; NTAR = National Transportation Analysis Region; STCC = Standard Transportation Commodity Classification.

SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey, NTAR CD-ROM* (Washington, DC: 1997).

commodity group is oriented to local markets because of the low average distance of shipments (ranging from 122 miles for Detroit to 428 miles for San Francisco-Oakland.) Contrast this with the more nationally oriented apparel group whose average distances range from 768 miles for Charlotte to 1,570 miles for Los Angeles.

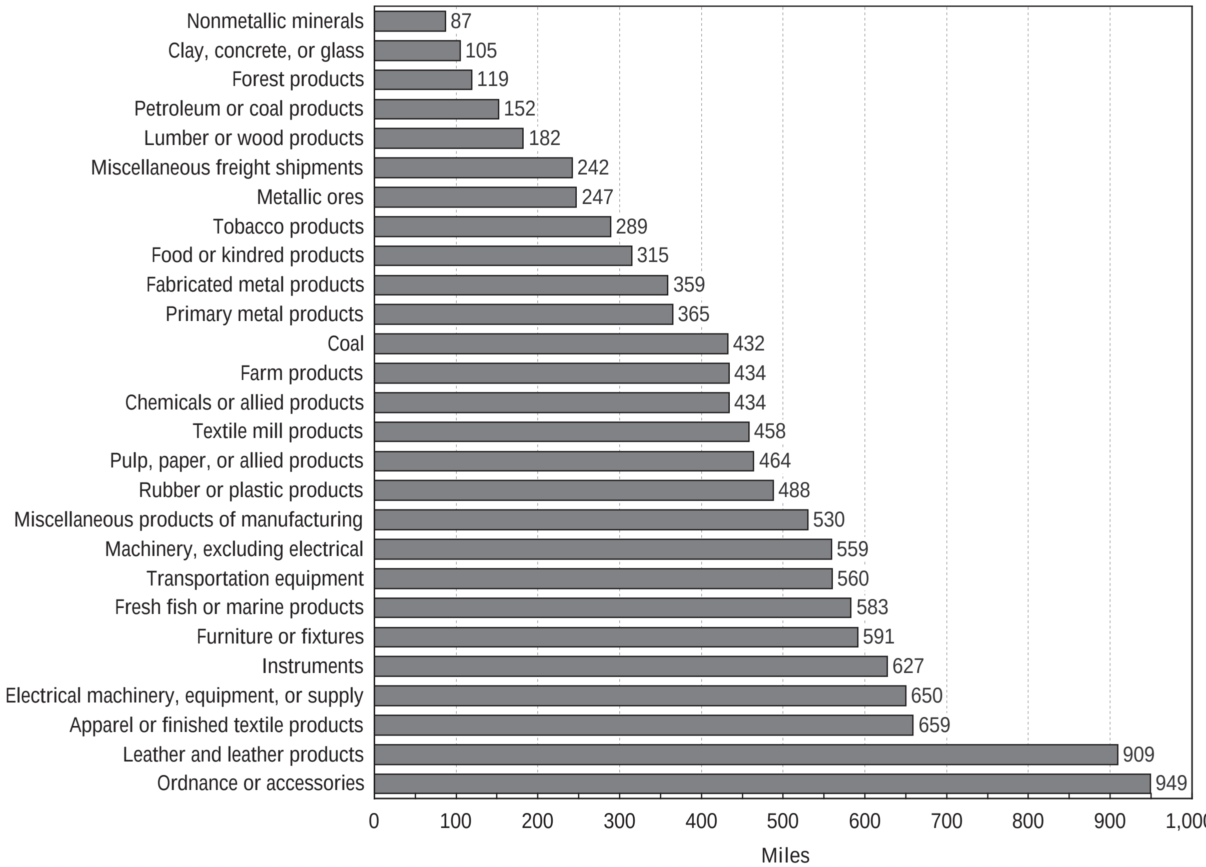
LONG-HAUL FREIGHT SHIPMENTS

Long-haul freight moves goods and materials produced in one region to other regions for manufacturing or consumer use. The distance hauled per ton varies greatly by commodity type. As shown in Figure 7-3, the average haul for two groups—leather and leather products, and ordinance or accessories—exceeded 900 miles, compared with an average distance of about 250 miles for all commodity groups.[13] Commodity groups with the shortest hauls were nonmetallic minerals (87 miles), concrete, clay, or glass products (105 miles), and forest products (119 miles). In general, primary or intermediate products—those used as input for further production—moved shorter distances, while the final products of manufacturing moved longer distances.

The average distance moved by shipments within any particular commodity group varied by region. For example, chemicals and allied products moved on average only 265 miles when transported from the New York NTAR. The shipment distance for chemicals transported from the Houston-Beaumont NTAR was much further—

[13] Average miles are based on the estimated distance traveled per ton shipped.

Figure 7-3.
Average Miles per Ton of Shipments by Commodity Group: 1993

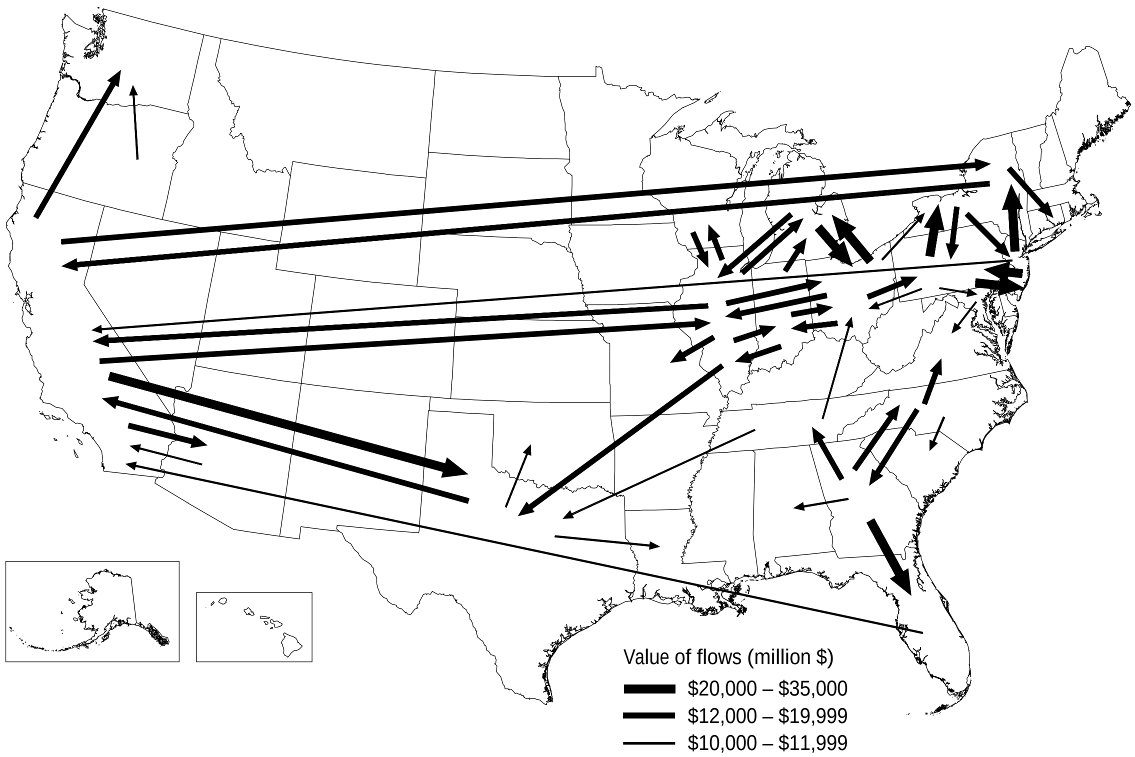


SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey, United States,* TC92-CF-52 (Washington, DC: 1997).

519 miles. In the former case, production is sent mostly to nearby markets, while Houston-Beaumont's sales are more spatially dispersed. The broad range of end-products encompassed by the general category of chemicals and allied products masks the distinct differences that exist between the products. For example, New York's chemical production may well be more highly specialized end-products, serving a regional market. Houston-Beaumont's chemicals shipments, on average, are less valuable per ton and may be primary or intermediate products transported longer distances as input for further manufacturing (see table 7-4).

Origin and destination (O&D) freight flow information from the CFS suggests heavy trade among states. In 1993, interstate flows accounted for about 62 percent of the value of shipments, worth about $3.6 trillion. Interstate freight movements among the regions are often concentrated along certain corridors between states. Figure 7-4 shows the O&D states for the largest 50 interstate flows for all modes by value of shipment in 1993. The 50 largest O&D freight flows shown in the figure sum to over $470 billion and accounted for 13 percent of the $3.6 trillion worth of good moved across state borders. The distribution of these 50 largest

Figure 7-4.
Origins and Destinations of the Top 50 Interstate Commodity Flows for All Modes by Value: 1993



SOURCE: U.S. Department of Commerce, Bureau of the Census, Commodity Flow Survey data,1996.

flows shows *intraregional* trade among states and NTARs within the same region and *interregional* trade between states and NTARs of different regions.

Intraregional Freight Flows

Intraregional flows are heavily concentrated in major corridors within the Midwest, Northeast, South Atlantic, and West (see figure 7-4). The most concentrated of intraregional freight corridors stretch from Illinois to New York and North Carolina to Florida, in part a reflection of these states' large populations, demand for products, and importance for manufacturing. The three largest O&D flows, which are also intraregional, are New Jersey to New York, Ohio to Michigan, and Georgia to Florida. While many of the largest flows are to neighboring states, the shipments along these corridors often exceed 100 miles from origin to destination. The average distances of such shipments vary by commodity and region, particularly at the NTAR level.

Information from the CFS about average distances shipped by region sheds some light on the characteristics of intraregional freight markets within some NTARs. For example, the category of food and kindred products accounts for a high proportion of total shipments made for the Minneapolis-St. Paul-Rochester, Minnesota/La Crosse, Wisconsin, NTAR. Farm products are also among the top five commodity groups shipped for that region. The CFS found that the region's food and kindred products are shipped a very short distance on average, suggesting these products are sold primarily as input to local food processors. Those local processors make up a sizable part of the economic base of the area, and export their final products to other regions.

Another NTAR where the presence of intraregional freight movement can be inferred from the data on average shipment distance is Detroit. The production categories of transportation equipment and of primary metals are both among Detroit's top five commodity groups transported. A short average distance of movement of 159 miles for primary metals suggests a strong local linkage of metals production with the area's automotive plants and suppliers.

Unfortunately, the level of commodity aggregation that is necessary to provide accurate estimates based on the CFS obscures much of the detail that would illuminate regional analysis. For example, transportation equipment is an important commodity for both the Detroit and the Seattle NTAR. But the two regions specialize in very different types of transportation equipment. Detroit is the largest producer of passenger vehicles, while Seattle is the largest producer of commercial aircraft and is important in railcar and truck production. The CFS data can be used to show many such differences and the summary information presented in this section reveals the broad geographic patterns of the goods-producing economy.

Interregional and Interstate Freight Flows

The extent of regional economic interdependence in the United States is suggested by the magnitude of interstate freight flows. As figure 7-4 shows, several of the largest O&D flows are interregional and some are transcontinental. In 1993, the largest interregional flows by value of shipments were between California and its major manufacturing trading partners: Texas, New York, and Illinois. The major commodities transported between each pair of trading partners vary and show some degree of regional specialization. For example, electrical machinery, apparel and textile products, and machinery (excluding electricals) were the major commodities traded between California and Texas. By comparison, transportation equipment, electrical machinery, and food and kindred products were the major commodities shipped between California and Illinois.

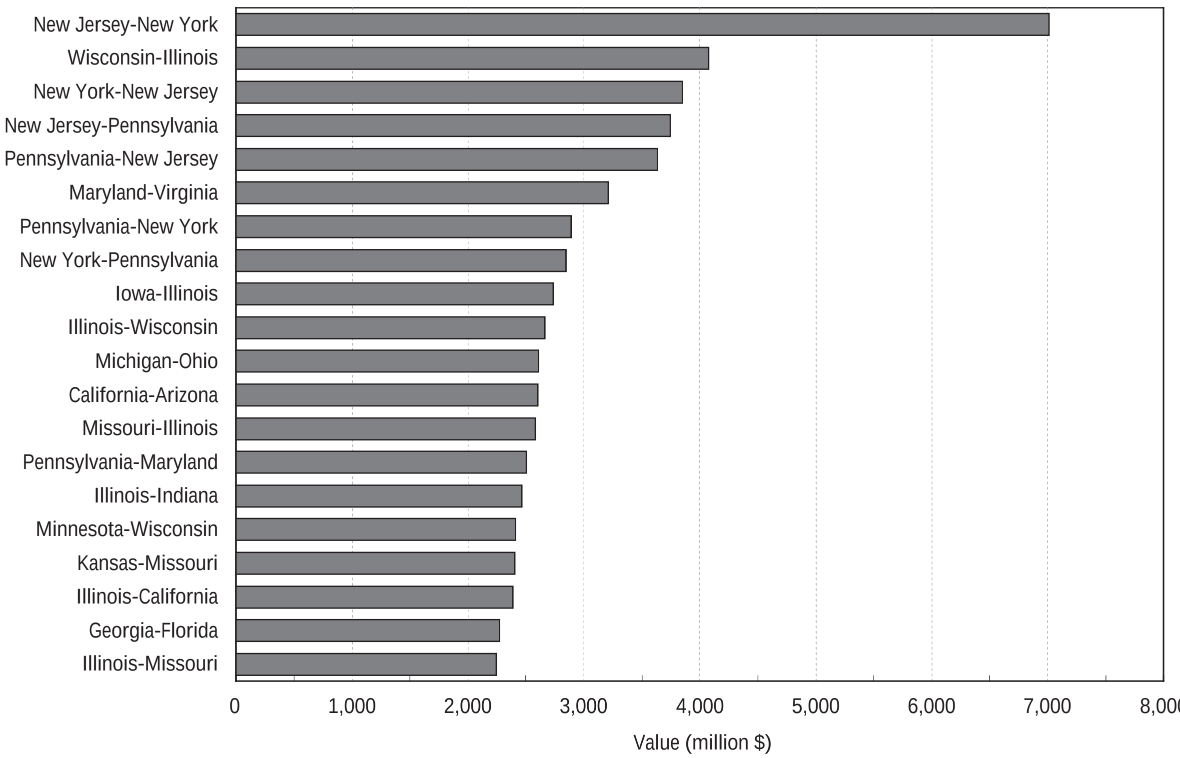
The country's regional specialization implies significant interregional demand for raw materials and goods, and the export of produced goods to other regions. Movement of a variety of commodities reflects different types of linkages among regions. Some flows represent the movement of intermediate goods among industries, while others reflect the movement of specialized final goods to consumers. Other flows involve international trade.

The extent of interstate freight shipments varies by commodity group. While nationally, 62 percent of the value of all shipments were interstate, 45 percent of food and kindred products, and 67 percent of electrical machinery were sent out-of-state in 1993. Figures 7-5 and 7-6 show the top 20 interstate O&D flows by value of shipments for these two commodity groups.

The food and kindred products commodity group shows an interesting interregional shipment pattern (see figure 7-5). Nineteen of the top 20 O&Ds of shipments of processed foods and kindred products were between contiguous states.[14] Despite the fact that some food products are shipped long distances, most go to nearby local markets. Food products include perishables, such as meat, poultry, dairy, and eggs, which are relatively expensive to ship and there-

[14] The figure does not show large O&D flows from Florida and California in part because these states' shipments of food and kindred products are sent to many states and therefore individual flows are not relatively large in comparison.

Figure 7-5.
Major Origin and Destination Flows of Food and Kindred Products by Value of Shipments: 1993



SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey, NTAR CD-ROM* (Washington, DC: 1997).

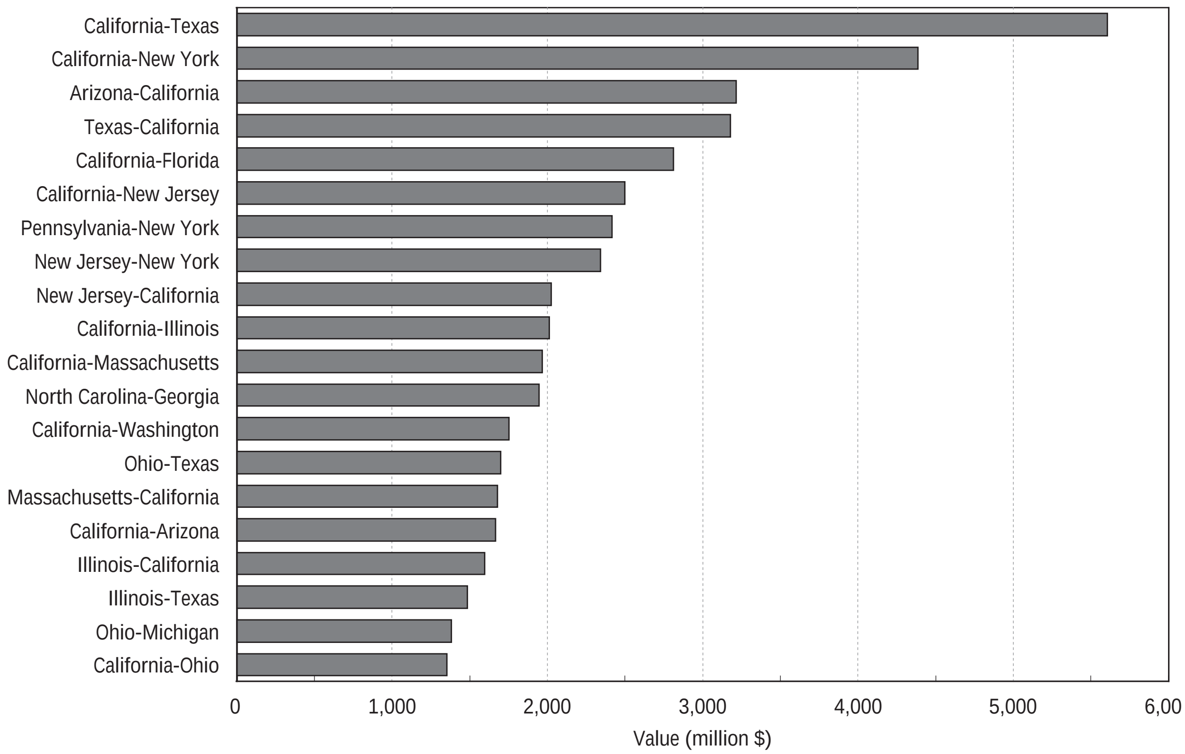
fore are often marketed close to the point of production. Also, beverages, which make up about 21 percent of this commodity group by weight, consist mostly of water. Because in general it is not economical to ship water long distance, bottling plants are usually located close to markets.[15]

Many of the large state-to-state shipments of food products shown in figure 7-5 occur where major metropolitan areas straddle state lines. These include the New York City area, which spreads across New York, New Jersey, and Connecticut; metropolitan Washington, which includes parts of Virginia and Maryland; and metropolitan Chicago, which straddles the Illinois-Indiana border. In each of these cases, shipments that were reported as state-level movements are in large part flows within a large urbanized region. There are also major bi-directional shipments within these regions, that is, goods from the same commodity group moving in both directions between a pair of states. This is due to the high density of food product shipments within metropolitan areas and to the diversity of goods encompassed by this commodity group.

The electrical machinery commodity group provides an interesting contrast to food and kindred products. Shipments of electrical machinery travel on average, 650 miles per ton compared to just 315 miles for food products (see figure 7-3). Electrical machinery's average value per ton

[15] Detailed data indicate that meat and poultry, dairy products, bakery products, and beverages have average shipment distances less than the food or kindred products commodity group as a whole (USDOC Census 1996, table 5b).

Figure 7-6.
Major Origin and Destination Flows of Electrical Machinery by Value of Shipments: 1993



SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey, NTAR CD-ROM* (Washington, DC: 1997).

($13,630) is almost 14 times that of food and kindred products ($997). As such, transportation costs make up a rather small share of the delivered cost of the products. This type of manufacturing is less dependent on bulky inputs than food products, with a high proportion originating in California. Among the top 20 O&D electrical machinery flows, there are five cases where significant shipments between a pair of states occur in both directions (see figure 7-6).

Shipment patterns reflect both the product mix and the diversity of demands and tastes across regions. Evidence of bi-directional shipment for interregional freight is more the rule than the exception. Some commodity groups, however, like apparel and textile products, show dispersed rather than bi-directional flows. Apparel and finished textile products provide a contrast to food products and electrical machinery. Apparel and finished textile products have a much higher value-to-weight ratio ($19,249 per ton) and average more miles per shipment (925 miles) than the food and electrical products commodity groups. Apparel manufacturers tend to use marketing strategies involving product differentiation, and the pattern of apparel demand across regions varies greatly due to regional diversity in climate and lifestyle. These factors are conducive to a highly dispersed pattern of shipments with many regions serving as both origin and destination.

An example of dispersed shipment flows of apparel is given in figure 7-7, which shows the value of shipments from two leading production

Figure 7-7.
Value of Origin and Destination Flows of Apparel and Textile Products: 1993

From New York NTAR

From Los Angeles NTAR

KEY: NTAR = National Transportation Analysis Region.

SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey NTAR CD-ROM* (Washington, DC: 1997).

regions, New York and Los Angeles.[16] Apparel moves from each of these production or transshipment points to every other NTAR in the country. Indeed, two of the largest flows of freight are bi-directional, from New York to Los Angeles and from Los Angeles to New York.[17]

Freight Movements by Mode

Many factors influence the choice of mode for long-haul freight transportation, including access of the shipper and receiver to the mode, transportation and logistics costs, type of commodities, and service characteristics of the modes. The interplay of these factors leads to the modal choices in the freight market presented in table 7-5, which shows the value of commodities shipped by mode in 1993. In that year, trucking was the dominant mode of freight transportation in the United States. Although the proportion varied by state, nationally trucks moved 72 percent by value of all freight covered in the CFS, and 53 percent by tonnage. In terms of value, trucking was followed by intermodal transportation, which includes various combinations of modes, with about 11 percent of shipments.

Rail, which accounted for about 4 percent of the value and 13 percent of the tonnage, is more spatially concentrated than truck, with only small shares along the eastern seaboard but with very large shares of total shipments in some states, especially the Great Plains and Rocky Mountains states. Rail's share by weight reflects the movement of low value-per-ton commodities like coal, ores, and grains. The east-west orientation of the nation's major railways, and the availability of few commercial inland waterways west of the Mississippi River Basin, influence the rail and water shares for some states.

Transportation costs make up a proportionally larger share of total costs for commodities with a lower value-to-weight ratio and often influence the price of the product. In order to be competitive in the widest possible market, producers will seek the modes that will keep costs as low as possible. In addition, many low-value commodities have relatively few origins and destinations. An example is coal, which is shipped from a limited number of mines or processing facilities to a limited number of powerplants, heavy industrial sites, and ports for export. For coal, the limited availability of fixed-route rail and water systems is less of a problem than for a product such as apparel, which has many highly dispersed origins and destinations.

The tendency for traffic to move by rail instead of truck as distance increases is due to the cost structure of the two modes. Rail, with its heavy capital requirements and high terminal costs, has higher per-trip fixed costs than road freight.[18] Rail's high capacity and low operating costs, however, lead to lower total costs per ton-mile than trucking for many long hauls. Therefore, the cost advantages of rail transportation are realized over fairly long trips.

These shipper tendencies are reflected by the mode shares shown in table 7-5. States with the highest rail shares of freight are, for the most part, located in the interior West where average distances to shipment destinations or origins are relatively long. For example, only 27 percent of shipments (by value) in Idaho and Wyoming

[16] Not all shipments from New York and Los Angeles are of apparel produced in those NTARs. Both are major gateway ports for both air and water, so a large proportion of the shipments are of imported apparel that was reshipped by local wholesalers.

[17] Bi-directional flows of this type could be observed for other commodity groups as well. Apparel was chosen as an extreme case because of its high average shipment distance and the existence of two dominant centers in New York and Los Angeles.

[18] Much of road freight's capital cost is for user fees for infrastructure.

Table 7-5.

Value of Commodity Shipments by State of Origin and Transportation Mode: 1993

States	Total all modes (million $)	Truck	Rail	Intermodal[1]	Air (including air and truck)	Other and unknown
		(percent share of state's total)				
Alabama	88,845	82.6	7.3	5.1	1.4	3.6
Alaska	8,120	44.7	4.8	4.0	1.6	44.9
Arizona	68,569	72.2	4.8	7.4	8.7	6.9
Arkansas	66,954	87.6	5.2	4.1	0.6	2.5
California	638,523	67.5	1.7	15.1	4.7	11.1
Colorado	58,765	74.6	2.7	14.0	4.5	4.2
Connecticut	71,357	73.0	0.2	19.4	4.1	3.3
Delaware	16,140	70.3	2.5	15.7	1.7	9.8
Florida	172,045	77.6	2.9	11.0	3.2	5.2
Georgia	210,143	84.7	3.1	9.3	0.8	2.2
Hawaii	11,462	61.4	NA	9.1	3.4	26.1
Idaho	16,518	70.5	16.8	6.4	1.7	4.6
Illinois	346,604	74.5	5.0	12.8	1.9	5.7
Indiana	178,704	77.3	6.9	7.6	1.9	6.3
Iowa	79,900	80.3	6.5	7.5	NA	5.7
Kansas	70,519	75.0	9.3	8.8	1.8	5.0
Kentucky	112,047	77.2	5.1	8.5	2.5	6.6
Louisiana	96,194	48.5	14.2	3.7	0.3	33.4
Maine	20,233	74.6	7.0	12.4	2.5	3.6
Maryland	98,508	80.8	3.5	11.7	0.8	3.3
Massachusetts	111,722	72.0	0.3	19.2	3.6	4.8
Michigan	256,289	76.9	6.6	11.1	0.8	4.5
Minnesota	110,180	70.7	5.0	15.7	2.7	5.9
Mississippi	56,268	82.2	5.1	3.5	0.3	8.8
Missouri	136,929	72.5	3.0	13.8	0.0	10.6
Montana	10,167	61.7	22.1	7.6	NA	8.6
Nebraska	42,534	80.3	9.9	7.4	0.4	2.0
Nevada	19,597	80.5	0.9	11.8	4.0	2.8
New Hampshire	16,465	66.8	0.3	21.9	6.1	4.9
New Jersey	252,790	78.2	0.6	14.0	1.6	5.5
New Mexico	11,794	65.5	9.0	13.3	2.9	9.4
New York	261,894	76.0	1.6	13.3	4.0	5.1
North Carolina	209,398	87.1	1.6	5.8	1.2	4.3
North Dakota	10,528	63.2	19.5	5.7	0.1	11.4
Ohio	325,626	76.9	3.9	12.2	1.1	5.8
Oklahoma	48,702	68.2	4.3	12.5	3.7	11.4
Oregon	81,939	64.3	5.3	7.1	1.3	22.0
Pennsylvania	248,758	80.6	2.9	11.7	1.1	3.7
Rhode Island	19,475	72.8	NA	18.2	1.3	7.7
South Carolina	83,621	86.7	4.9	5.5	0.7	2.1
South Dakota	9,585	80.1	3.3	11.2	2.2	3.2
Tennessee	170,056	84.0	3.2	7.0	1.3	4.5
Texas	451,847	68.3	6.7	7.8	1.9	15.3
Utah	35,599	69.7	7.7	10.6	1.4	10.5
Vermont	8,599	75.0	0.8	13.0	8.6	2.6
Virginia	114,590	81.3	3.6	9.7	1.6	3.9
Washington	123,245	64.7	3.6	9.3	4.5	17.9
West Virginia	34,924	64.9	14.0	1.3	2.0	17.9
Wisconsin	143,318	83.8	2.5	9.3	1.1	3.2
Wyoming	9,012	29.8	56.8	4.0	NA	9.3

[1] Intermodal = parcel, postal, or courier + truck and rail + truck and water + rail and water + other intermodal.

KEY: NA = data are not available for statistical or disclosure reasons.

NOTE: The data presented in this table sum to $5.8 trillion and differ from the larger total of $6.1 trillion cited in this chapter and other BTS publications, because they do not include additional estimates for waterborne and pipeline shipments not fully covered in the Commodity Flow Survey.

SOURCE: U.S. Department of Commerce, Bureau of the Census, *1993 Commodity Flow Survey*, *NTAR CD-ROM* (Washington, DC:1997).

travel less than 100 miles, as compared with 44 percent in New York and 47 percent in California. Also, the states with the highest rail share tend to produce more of the nation's low value-per-ton commodities. For Wyoming, which has the highest rail share, coal is the number one commodity shipped in terms of both value and weight. The leading commodities shipped in West Virginia are coal and chemicals, and West Virginia has a much higher rail share than the other eastern states (USDOT BTS 1996b).

The extent of rail activity in the industrial heartland is reflected more in the significant share of multimodal shipments than by the rail share alone. Rail and truck combinations dominate multimodal shipments for states like Ohio, Michigan, Indiana, and Illinois.

International Freight

Commodities that are traded internationally have been a major source of growth in U.S. domestic freight activity, placing demands on the transportation system for access between ports of entry or exit and the interior. International trade has shifted some transportation activity within the United States. The west coast has increased its share of oceanborne international trade, and Canadian and Mexican surface traffic is adding significantly to freight volumes in several states.

Globalization—the integration of the U.S. economy with other economies around the world—also affects freight transportation patterns. One measure of globalization of the U.S. economy is the ratio of the value of international trade in goods to the U.S. GDP. This ratio has more than doubled from 8.1 percent in 1970 to 23.2 percent by 1997. During this period, the value of total U.S. goods exports plus imports more than quadrupled from $276 billion in 1970 to $1.7 trillion in 1997 (in chained 1992 dollars) (USDOC BEA 1998).

Other globalization measures include the level of direct investments by American firms in foreign operations of affiliates, direct foreign investment from abroad in domestic U.S. businesses, and the penetration of foreign markets by American firms. Each of these activities influences the domestic movement of international trade and may increase the demand for freight services. Information from the Department of Commerce's Bureau of Economic Analysis shows a rise in the level of international direct investments. For example, U.S. direct investment abroad in foreign business enterprises was $712 billion in 1995, up 65 percent from $431 billion in 1990 (in current dollars). Comparatively, foreign direct investment in U.S. businesses amounted to $504 billion in 1994, up 28 percent from $395 billion in 1990 (in current dollars)[19] (USDOC Census 1997a, tables 1302 and 1297).

While exports grew, the United States continued to have a merchandise trade deficit, importing large quantities of goods, especially from Asia. Increased trade with Asia has affected U.S. domestic freight patterns, especially west to east flows.[20]

Although the United States trades with many countries, a few countries account for a large share of total U.S. trade. In 1997, Canada and Mexico accounted for nearly one-third (31 percent) of U.S. trade in goods globally[21] (USDOC ITA 1998). In 1997, Canada was the United States' largest trading partner, followed by Japan, Mexico, China, and the United Kingdom. These five largest trading partners accounted for over half of the U.S. imports plus exports in goods.

[19] 1995 and 1994 are the most recent years for which data on direct investments are available.

[20] Late 1997 financial crises in several Asian markets may affect trade patterns with the United States, but the impact was unclear when this report was written. Some Asian countries view increased exports to the United States as central to their recovery strategies.

[21] Preliminary 1997 data.

Five of the largest 10 trading partners in 1997 were in Asia.

Trade among countries with high per capita incomes often involves high-value manufactured and processed products, with relatively high transportation costs. The combination of economic growth and geography (the vast expanse of Asia and the long distance from the United States) may continue to make air freight transportation more important in meeting the changing needs of shippers.

International trade in high-value manufactured goods also reflects sectoral changes in the economies of the United States and its trading partners. As manufacturing and services become more important economic sectors in developing and newly industrialized countries, and as agriculture, mining, and forestry decline in relative importance, trade in high-value goods represents a growing proportion of the value of imports and exports. The combined effect of this structural change and the growth in personal income partly explains the trend in manufactured products' share in U.S. imports and exports. In 1996, manufactured goods accounted for 84 percent of the value of total U.S. goods exports, up from 72 percent in 1970. Comparatively, agriculture accounted for 10 percent in 1996, down from 17 percent in 1970. The story is similar for manufacturing's share of imports. In 1996, manufactured products accounted for 83 percent of imports, a significant increase from 67 percent in 1970. Agricultural products represented only 4 percent of the value of imports to the United States, down from 14 percent in 1970 (USDOC ITA 1998). The extent to which such structural changes continue is key to the future of freight transportation services in the United States.

Changes in global manufacturing and product distribution strategies are impacting freight transportation patterns. Today, it is common to produce component parts of manufactured goods in several countries, transport the components to a different country for assembly, and market the end-products to many other countries. A large proportion of the goods traded internationally is transported to many trading partners. For example, the United States buys and sells processed foods and beverages in nearly every country of the world. From 1994 to 1995, the United States averaged about 190 export trade partners and 170 import trade partners for processed foods and beverages (USDA ERS 1997). These new global trading patterns generate enormous international freight, resulting in more ton-miles carried on the U.S. transportation network than ever before.

► NAFTA Trade

The North American Free Trade Agreement (NAFTA), put in place in 1994, seeks to reduce trade barriers and liberalize trade policies among the United States, Mexico, and Canada. U.S. total trade in goods with Canada and Mexico increased 39 percent from $343 billion in 1994 to over $476 billion in 1997 (USDOC ITA 1998). Information from the BTS Transborder Surface Freight Data shows land freight movement between the United States, Canada, and Mexico has increased since 1994.

In 1996, goods valued at over $295 billion moved by land between the United States and Canada, up 19 percent from 1994.[22] The distribution of trade with Canada was fairly concentrated. Not surprisingly, in 1996 the top five U.S. destinations for land imports from Canada were neighboring states: Michigan, New York, Ohio,

[22] The BTS Transborder Surface Freight Data, collected by the Census Bureau, include transshipments. Transshipments are shipments that enter or exit the United States by way of Customs ports on the northern or southern border even when the actual origin or destination is other than Canada or Mexico.

Illinois, and Minnesota.[23] These states accounted for over half of the value of imports by all surface modes. U.S. exports to Canada accounted for 47 percent of U.S.-Canada land trade in 1996, down slightly from 50 percent in 1994. The top five U.S. states for land exports to Canada in 1996, were Michigan, Washington, Ohio, New York, and Illinois, accounting for 43 percent by value.

Bilateral land trade between the United States and Mexico, $115 billion in 1996, was far less than U.S. trade with Canada, but still increased 28 percent from 1994. The rapid increase in overland trade with Mexico partly reflects the strong growth of the U.S. economy and the liberalized trade policies during the same period. By value, the major destinations for imports from Mexico in 1996 were Texas, Michigan, California, Arizona, and Tennessee. U.S. exports to Mexico accounted for 45 percent of U.S.-Mexico land trade in 1996, down from 52 percent in 1994. The major origins for U.S. exports to Mexico in 1996 were Texas, California, Michigan, Arizona, and Illinois.

The trade growth among the United States, Canada, and Mexico highlights the importance of north-south land freight movement and has the potential to alter major freight corridors in the United States.

► Oceanborne and Air Cargo Trade

Although transborder land freight with Canada and Mexico are important, about two-thirds of the value of U.S. international trade is with other countries and moves in and out of the United States by seaports and airports. In 1996, U.S. seaports handled international freight valued at $594 billion (current dollars), a large increase from $49 billion in 1970. During the past two decades, regional shares of international oceanborne trade shifted from east coast ports to west coast ports, changing transportation activity within the United States. In 1995, west coast seaports more than doubled their share to 45 percent of the total value of trade, from 20 percent in 1970. By contrast, the share handled by east coast ports declined to 38 percent in 1995, from 55 percent in 1970 (see table 7-6). Major factors accounting for the shift in regional shares are the growing Pacific Rim trade and the increase in containerization. Four of the top five U.S. container ports, located along the Pacific coast, handled containerized cargo valued at $200 billion in 1996.[24] The port of New York and New Jersey led east coast ports in containerized trade with $49 billion. The four largest east coast ports combined handled containerized cargo valued at $104 billion[25] (USDOC Census 1997b, table 6).

Table 7-6.
Regional Share of Total Annual Value of Oceanborne International Trade: 1970–95
(In percent)

Year	East Coast	Gulf Coast	West Coast	Great Lakes
1970	54.9	20.0	19.6	5.5
1980	41.2	33.0	23.6	2.2
1985	39.1	21.1	38.0	1.7
1990	37.5	17.8	42.7	2.0
1991	37.1	17.5	43.4	2.1
1992	37.6	16.4	43.8	2.2
1993	37.7	15.3	44.7	2.3
1994	37.7	15.0	45.7	1.6
1995	38.3	16.1	44.8	0.8

SOURCE: U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1997* (Washington, DC:1997), table 1069.

[23] Top origin and destination states are based on foreign trade data collected from administrative records. Due to filing requirements and procedures, border-state activity may be overrepresented. In addition, trade data do not always reflect physical transportation flows.

[24] In 1996, the top five container ports by value were Long Beach, Los Angeles, New York-New Jersey, Seattle, and Oakland.

[25] The largest east coast container ports were New York-New Jersey, Charleston, Norfolk, and Miami.

Between 1970 and 1996, international freight moved by air transportation grew rapidly. In 1996, U.S. airports handled over $380 billion worth of international freight, up from $10 billion in 1970 (current dollars). The air cargo share of the value of U.S. exports plus imports increased from 11 percent in 1970 to 27 percent in 1996 (USDOC Census 1990 and 1997a). Growth in Pacific Rim trade has had a major influence on air cargo trends. The recent economic crises in several Asian countries, however, could affect air cargo trends. A stronger U.S. dollar means American businesses can import more foreign goods but export less to Asian markets. In 1996, the nation's top air cargo airport was New York's Kennedy International Airport, handling over $80 billion of air freight. Two of the top five U.S. air cargo airports[26] are located on the west coast: San Francisco International Airport with $71 billion and Los Angeles International Airport with $62 billion[27] (USDOC Census FTD 1998).

As the U.S. economy globalizes and production and distribution systems become more agile, the movement of high-value goods and the ton-miles carried on the transportation system are expected to grow. Because most air cargo and oceanborne shipments begin and end their journey by truck or rail, freight ton-miles moved by truck, rail, and intermodal combinations are expected to increase as international trade grows.

[26] The top five cargo airports in 1996 by value were: New York Kennedy International Airport, San Francisco International Airport, Los Angeles International Airport, Chicago O'Hare International Airport, and Miami International Airport.

[27] Data on major air cargo gateways in earlier years were not readily available for comparison.

FACTORS AFFECTING FREIGHT MOVEMENT

In recent years, higher value shipments have accounted for a growing proportion of freight, and a further decline in the relative contribution of bulk commodities to GDP is likely. The U.S. economy, however, will always use enormous quantities of low-value bulk commodities, and the movement of such commodities may continue to grow.

International trade is a major factor affecting the demand for freight transportation. Moreover, global and regional economic conditions appear favorable for long-term trade. While future expansion of trade is likely, short-term conditions can be difficult to anticipate. Trade in agricultural products, timber, coal, and petroleum, for example, may fluctuate, as markets adjust to factors such as changes in the weather and commodity policies that influence localized demand. Unanticipated events, such as the Asian financial crisis that started in 1997, can cloud the horizon.

International agreements, especially with Canada and Mexico, may lead to fewer obstacles to the movement of freight across borders. Agreements that allow freight operators licensed in one country to operate in another reduce costly transshipments at borders. This may make it more economical for producers located at a distance from international frontiers to export and import.

Outsourcing of manufactured components and services has increased, implying a greater demand for transportation services, as items that were formerly produced onsite must be shipped in from subcontractors (Venkatraman 1997). As the number of subcontracting relationships rises, the quality of transportation services often goes up. For example, just-in-time (JIT) inventory systems require more carefully timed shipments, which may, on average, be smaller. Thus, even if the volume of freight in tons does not go up, the cost of freight services may rise, as may the total number of ton-miles.

Changes in business practices can have complex implications for freight movement. For example, developments in logistics management, warehousing, and distribution systems could result in a gradual shift to direct delivery of goods from manufacturers to consumers, bypassing distribution centers and retail stores (Fisher 1997).

Information technology (IT) has wide ranging ramifications for freight movement. Facsimile copying, electronic mail, and electronic publishing may displace a small volume of freight, especially printed material moved by postal and courier services. The more important role of IT is its potential for streamlining freight operations. For example, global positioning systems, geographic information systems, and intelligent transportation systems provide information about the location of freight, optimal routes, and network conditions, which may lead to more efficient and reliable shipping.[28]

Innovations such as JIT, which place a premium on speed and reliability and ship smaller quantities of goods, generally favor the use of trucks. Air freight, the fastest growing freight mode, also is gaining in favor as a way to ship high-valued goods. Commodities with low value to weight ratios, which have traditionally made up the bulk of rail business, are a declining proportion of freight. Yet, there are a number of reasons to expect the rail share of freight to stabilize or even grow.

A combination of factors such as deregulation and application of new technologies has improved the economic performance of railroads. In recent years, Class I railroads have abandoned less profitable lines and have concentrated on those freight corridors where demand is sufficient to justify major capital investments that embody new technologies for freight handling, management, and tracking. Other lines have been transferred to short line and regional railroads whose different cost structure offers the prospect of profitable operations. The institutional, infrastructural, and technological changes to achieve fuller integration of road and rail into an intermodal system are progressing. In a truly intermodal system, shippers will be able to exploit the cost advantages of rail and the flexibility advantages of road.

Intermodal links among ocean shipping, rail, and trucks have become key for international trade. The expectation for continued growth in containerization will increase the need for intermodal facilities to handle landside traffic. The largest oceangoing containerships, some able to carry over 5,000 20-foot-equivalent container units, offer a means to improve the economic performance of the shipping industry (Wood et al 1995). To optimize the efficiency of these larger vessels, however, the ships may call at fewer ports; such changes will influence patterns of domestic movement of internationally traded goods.

As overall freight transportation increases, traditional commodity flow patterns will remain and new flow patterns may emerge. Continued monitoring of freight flow patterns and freight trends is important for understanding and improving the performance of the U.S. transportation system.

[28] For a discussion of the impacts of IT on transportation, see USDOT BTS 1997a, chapter 11.

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List of Acronyms

ASOS	Automated Surface Observation Systems
ATS	American Travel Survey
AWIPS	Advanced Weather Interactive Processing System
BART	Bay Area Rapid Transit
BLS	Bureau of Labor Statistics
BNSF	Burlington Northern Santa Fe
BOD	biological oxygen demand
BTS	Bureau of Transportation Statistics
CAA	Clean Air Act
CBD	central business district
CFCs	chlorofluorocarbons
CFC-12	dichlorofluoromethane
CFS	Commodity Flow Survey
CMSA	Consolidated Metropolitan Statistical Area
CO	carbon monoxide
CO_2	carbon dioxide
CODES	Crash Outcome Data Evaluation System
DOE	U.S. Department of Energy
DNL	day-night noise level
DOT	U.S. Department of Transportation
DWT	deadweight tons
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FAHP	Federal-Aid Highway Program
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FY	fiscal year

GDD	Gross Domestic Demand
GDP	Gross Domestic Product
GES	General Estimates System
GGE	gallons of gasoline equivalent
GHG	greenhouse gas
GOES	Geospatial Operational Environmental Satellite
GPRA	Government Performance and Results Act
GPS	Global Positioning System
HP/LB	horesepower per pound
HP/CID	ratio of horsepower to engine size
ICST	International Classification of Ships by Type
INS	Immigration and Naturalization Service
IRI	International Roughness Index
ISTEA	Intermodal Surface Transportation Efficiency Act
IT	information technologies
ITDB	Intermodal Transportation Data Base
ITS	intelligent transportation system
JIT	just-in-time
LOS	level of service
LPG	liquefied petroleum gas
MARAD	Maritime Administration
MCMIS	Motor Carrier Management Information System
mmbd	million barrels per day
mpg	miles per gallon
mph	miles per hour
MPO	metropolitan planning organization
MSA	metropolitan statistical area
MSMS	Marine Safety Management Information System
MTBE	methyl-tertiary-butyl-ether
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAFTA	North American Free Trade Agreement
NAS	National Academy of Sciences
NGA	National Governors' Association
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration

NMSL National Maximum Speed Limit
NO_2 nitrogen dioxide
NO_X nitrogen oxides
NPTS Nationwide Personal Transportation Survey
NTAR National Transportation Analysis Region
NTD National Transit Database
NTL National Transportation Library
NTS National Travel Survey
NTSB National Transportation Safety Board

OECD Organization for Economic Cooperation and Development
O&D origin and destination
OMC Office of Motor Carriers
OPEC Organization of Petroleum Exporting Countries
OPS Office of Pipeline Safety

PAR police accident report
PM-2.5 particulate matter of 2.5 microns in diameter or smaller
PM-10 particulate matter of 10 microns in diameter or smaller
pmt person-miles traveled
ppm parts per million
PSR Present Serviceability Rating

RFG reformulated gasoline
RSPA Research and Special Programs Administration
RTECS Residential Transportation Energy Consumption Survey
RWIS Road Weather Information System

SAMIS Safety Management Information Statistics
SCDD supercooled drizzle drops
SCTG Standardized Classification of Transported Goods
SIC Standard Industrial Classification
SLSS St. Lawrence Seaway System
SO_2 sulfur dioxide
SP Southern Pacific
STAA Surface Transportation Assistance Act of 1982
STB Surface Transportation Board
STCC Standard Transportation Commodity Classification

TEA-21	Transportation Equity Act for the 21st Century
TEU	20-foot equivalent container unit
TIUS	Truck Inventory and Use Survey
TSA	Transportation Satellite Accounts
TSAR	*Transportation Statistics Annual Report*
TSAR97	*Transportation Statistics Annual Report 1997*
TTI	Texas Transportation Institute
UA	Urbanized Area
UP	Union Pacific
UPS	United Parcel Service
USCG	U.S. Coast Guard
UST	underground storage tank
vmt	vehicle-miles traveled
VOC	volatile organic compounds
V/SF	volume-service flow
YPLL	years of potential life lost

U.S./Metric Conversions and Energy Unit Equivalents

U.S. TO METRIC

Length (approximate)

1 yard (yd) = 0.9 meters (m)
1 mile (mi) = 1.6 kilometers (km)

Area (approximate)

1 square mile (sq mi, mi^2) = 2.6 kilometers (km^2)
1 acre = 0.4 hectares (ha) = 4,000 square meters (m^2)

Mass/Weight (approximate)

1 pound (lb) = 0.45 kilograms (kg)
1 short ton = 2,000 pounds (lbs) = 0.9 metric tons (t)

Volume (approximate)

1 quart (qt) = 0.96 liters (l)
1 gallon (gal) = 3.8 liters (l)

Energy Units (approximate)

1 British thermal unit (Btu) = 250 calories = 1,055 joules
1 calorie (cal) = 4.186 joules (exactly)
1 barrel of oil = 42 U.S. gallons (gal) = 0.16 cubic meters (m^3)
1 quadrillion Btu (quad) = about 170 million barrels of crude oil

METRIC TO U.S.

Length (approximate)

1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 miles (mi)

Area (approximate)

1 square kilometer (km^2) = 0.4 square miles (sq mi, mi^2)
10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres

Mass/Weight (approximate)

1 gram (gm) = 0.036 ounces (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 metric ton (t) = 1,000 kilograms (kg) = 1.1 short tons

Volume (approximate)

1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallons (gal)

Energy

1 joule = 0.24 calories (cal)
1 exajoule = 10^{18} joules

SOURCE: U.S. Department of Commerce, National Institute of Standards and Technology.

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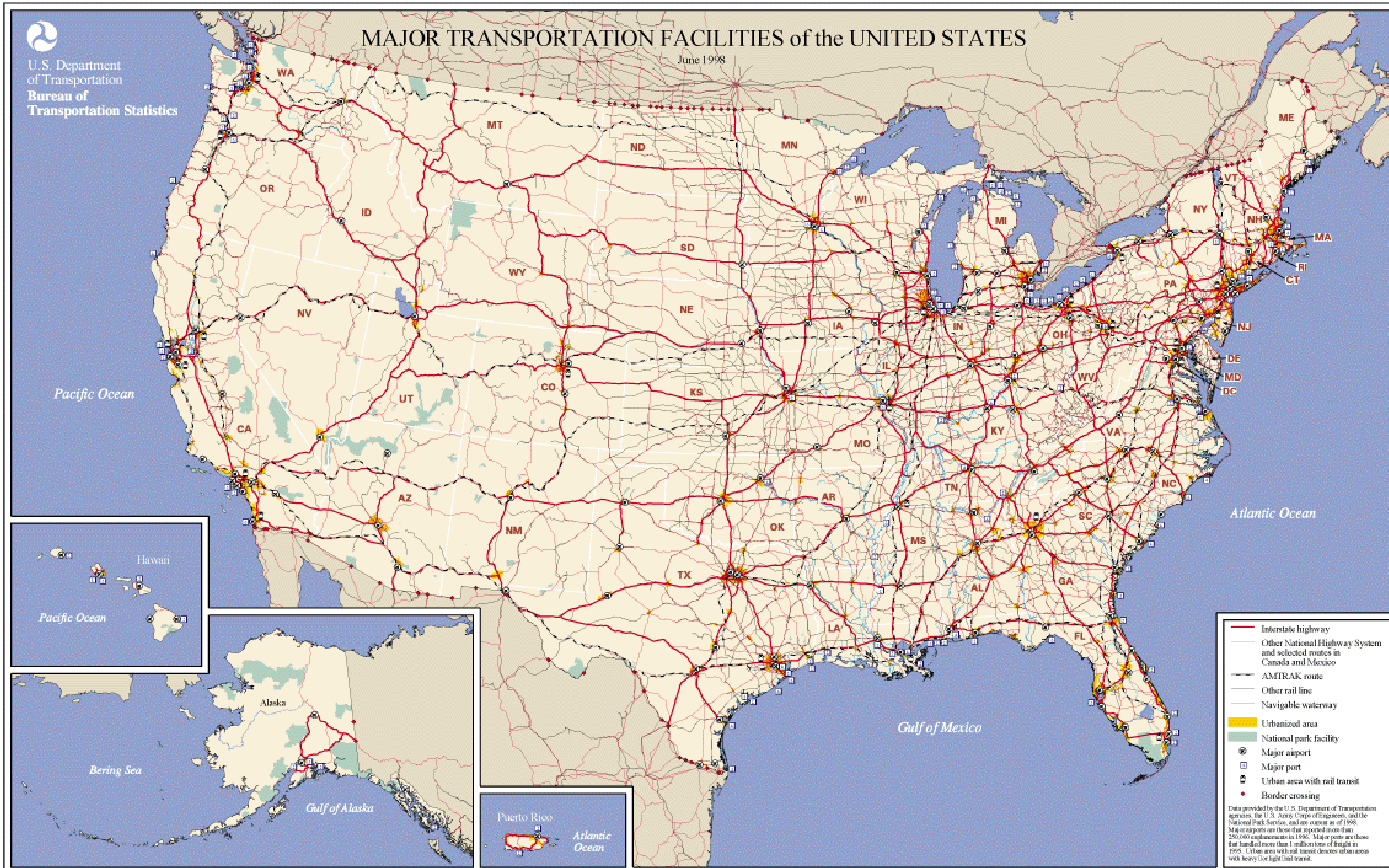

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June 1998
U.S. Department
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DE
MD
DC
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Atlantic Ocean
Gulf of Mexico
Hawaii
Pacific Ocean
Alaska
Bering Sea
Gulf of Alaska
Puerto Rico
Atlantic Ocean
Interstate highway
Other National Highway System and selected routes in Canada and Mexico
AMTRAK route
Other rail line
Navigable waterway
Urbanized area
National park facility
Major airport
Major port
Urban area with rail transit
Border crossing

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