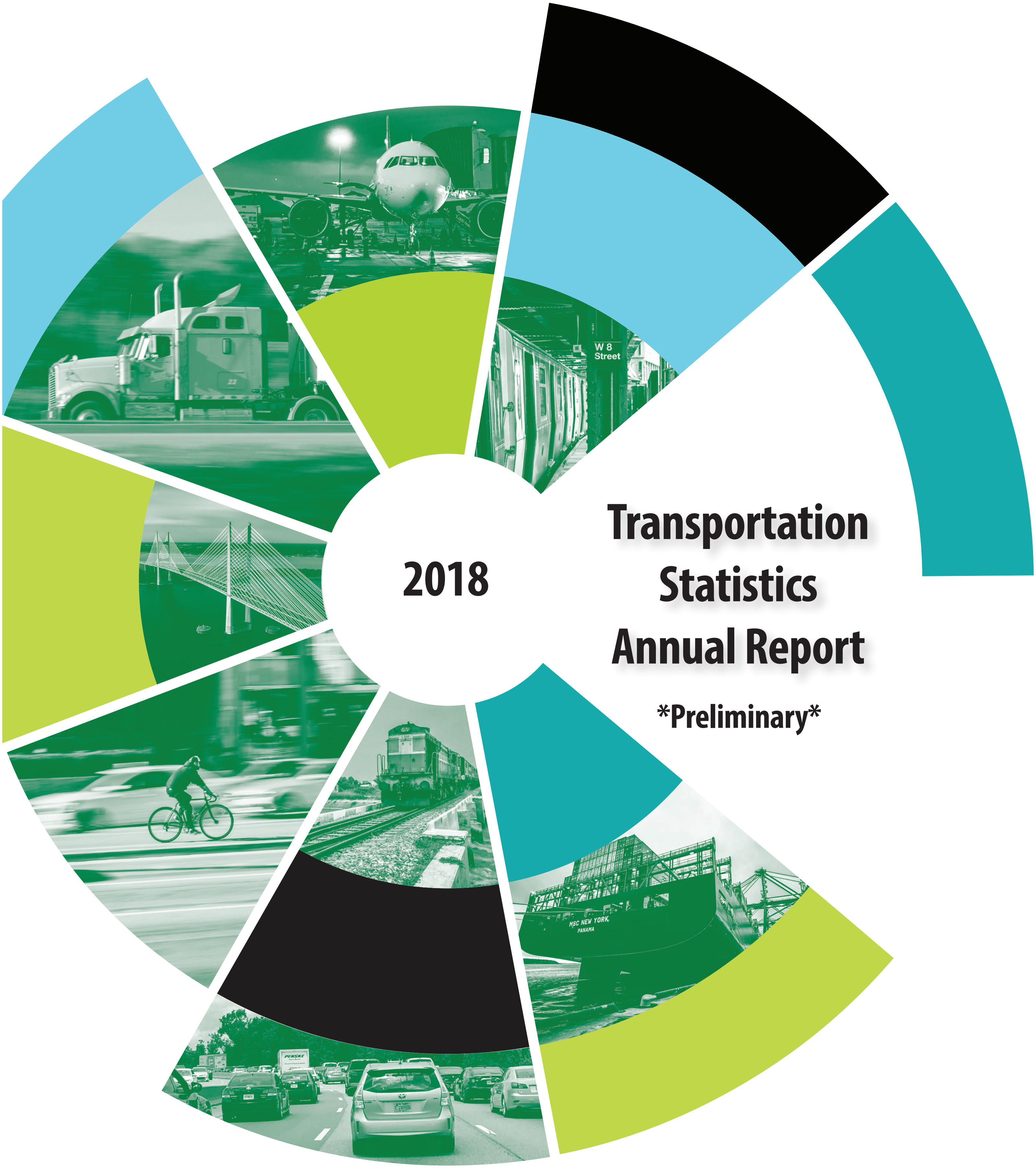

2018 Transportation Statistics Annual Report

Preliminary

U.S. Department of Transportation
Office of the Secretary of Transportation
Bureau of Transportation Statistics

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Transportation Statistics Annual Report 2018

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Introduction

Congress requires the Director of the Bureau of Transportation Statistics (BTS) to prepare and submit the *Transportation Statistics Annual Report* each year to Congress and the President.[1] Using data collected or compiled by BTS, this 23rd edition of the report describes the Nation's transportation system, the system's performance, its contributions to the economy, and its effects on people and the environment, presenting the latest available annual data to examine national trends for all modes of transportation.

Congress calls on BTS to collect, compile analyze and publish data on 11 topics (see the box below), which are examined in the first 7 chapters of the annual report. The eighth and final chapter, on the state of transportation statistics, responds to Congress's requirement that the BTS Director provide any recommendations on improving transportation statistical information. For the reader's convenience, each chapter begins with summary highlights.

Notable emphases in this year's report include:

- more treatment of automated transportation systems, e-commerce and other information technology interactions affecting transportation;
- transportation system resilience in addressing natural disasters and human caused disruptions such as cyber-attacks;
- the first national update on local travel since 2009 due to the release of the 2017 National Household Travel Survey (NHTS) by the Federal Highway Administration;
- national data from the Freight Analysis Framework, with projections to 2045, and a discussion of e-commerce;
- an updated and more comprehensive treatment of the economics of transportation;
- the latest safety statistics for all modes of transportation updated through 2017; and
- energy usage and environmental impacts of transportation.

The report's final chapter examines the state of transportation statistics, identifies long standing

[1] 49 U.S. Code § 6302

and recent data shortcomings, and highlights challenges in responding to those challenges. The chapter articulates the need for updating decades-old surveys of long distance travel and of vehicles and their use. The chapter also identifies the need for data to better understand the rapid emergence and pervasive effects of transformational technology and services such as autonomous vehicles, new forms of ride-hailing, and e-commerce on the transportation system.

A companion resource to this report is National Transportation Statistics (NTS), a comprehensive online data source maintained by BTS. The more than 260 data tables and source and accuracy statements in NTS cover transportation's physical components, safety record, economic performance, energy usage, impact on the human and natural environment, and national security, with some data series going back to 1960.

BTS welcomes comment on its products. Comments should be sent to answers@dot.gov or to Bureau of Transportation Statistics, U.S. Department of Transportation, 1200 New Jersey Avenue SE, Washington DC, 20590.

Legislatively Mandated Topics and Chapter Guide

Topics addressed in this report specified by Congress in 49 U.S. Code § 6302(b)(3B)(vi). The topics and the chapters in which they are addressed herein are as follows:

- transportation safety across all modes and intermodally—Chapter 6;
- the state of good repair of U.S. transportation infrastructure—Chapters 1 and 2;
- the extent, connectivity, and condition of the transportation system, building on the BTS National Transportation Atlas Database—Chapters 1, 2, 3, and 4;
- economic efficiency across the entire transportation sector—Chapters 2, 4 and 5;
- the effects of the transportation system on global and domestic economic competitiveness—Chapters 3, 4, and 5;
- demographic, economic, and other variables influencing travel behavior, including choice of transportation mode and goods movement—Chapters 1, 3, and 4;
- transportation-related variables that influence the domestic economy and global competitiveness—Chapters 3, 4, and 5;
- economic costs and impacts for passenger travel and freight movement—Chapters 3, 4, and 5;
- intermodal and multimodal passenger movement—Chapters 1 and 3;
- intermodal and multimodal freight movement—Chapters 1 and 4; and
- consequences of transportation for the human and natural environment—Chapter 7.

A detailed checklist of which legislatively mandated topics are addressed in each table and figure in the report is provided in Appendix A.

Table of Contents

Chapter 5—Transportation Economics

Chapter 6—Transportation Safety

CHAPTER 1

Extent and Use

Highlights

- The net value of U.S. transportation capital stock was estimated at $7.7 trillion in 2016. The public sector owned $4.2 trillion of transportation capital stock, while the private sector owned $3.5 trillion
- The number of vehicles using the system and vehicle-miles traveled continues to increase, while the mileage of the highway system is largely flat, contributing to congestion in many urban areas.
- In 2017 transit riders made 10.1 billion trips, a decline of 600 million from the recent high in 2014. Ride-hailing companies, such as Uber and Lyft, provide connectivity to transit but sometimes also compete with transit.
- National Rail Passenger Corp. (Amtrak) ridership reached a record 31.7 million trips in fiscal year 2017, a slight increase over Amtrak's 31.3 million trips in fiscal year 2016. When included with U.S. airlines, in fiscal year 2017 Amtrak ranked Number 6th in passengers carried— behind Southwest Airlines, Delta Air Lines, American Airlines, United Airlines, and JetBlue Airways.
- The top 50 U.S. commercial air carrier airports (out of the more than 5,000 public use airports) account for 85 percent (about 726 million) of passenger enplanements.
- Over the past 50 years, Class I railroads and connecting facilities have developed increasingly efficient ways to carry and transfer cargo. The system mileage of Class I railroads in 2016 was less than one-half the mileage in 1960, while freight rail ton-miles tripled.
- The TEU, tonnage, and size of containerships calling at U.S. ports continue to increase, with an average capacity of 4,856 TEU in 2016, an increase of 37 percent since 2013. U.S. ports are increasingly equipped with Super Post Panamax cranes to serve Neo-Panamax (also known as New Panamax) ships.
- Automated vehicle development is advancing in all modes of transportation, ranging from 38 jurisdictions permitting testing of driverless highway vehicles, to autonomous ports systems and ships, to the adoption of Positive Train Control systems.

In 2017 the U.S. transportation system served 326 million Americans—including those who may not own a vehicle or rarely travel. Transportation is used to commute to work, obtain goods and services, call on family and friends, and visit distant places. It also drives the economy, connecting over 7.6 million business establishments with customers, suppliers, and workers [USDOC CENSUS QF 2017]. The transportation system allows over 75 million foreign visitors to travel to the United States (see Chapter 3 *Moving People*), resulting in a sizable contribution to the U.S. economy.

This chapter examines the extent and usage of the principal transportation modes, including associated infrastructure, vehicles, control systems, and intermodal connections. The following section looks at transportation capital stock, followed by sections on highway systems, public transit, aviation, railroads, ports and waterways, pipelines, and intermodal connectors.

Capital Stock and Investments

Transportation capital stock is the value of transportation infrastructure (e.g., roadways, bridges, and stations) and equipment (e.g., automobiles, aircraft, and ships) in existence as of a specific date. The net value of U.S. transportation capital stock was estimated at $7.7 trillion in 2016 (figure 1-1).

Transportation capital stock is owned by both the public and private sectors. Freight railroad facilities and equipment are almost entirely owned by the private sector, while highways, bridges, airports, seaports, and transit structures are owned by state and local governments.

In 2016 the public sector owned $4.2 trillion (54.7 percent of transportation capital stock), while the private sector owned $3.5 trillion (45.3 percent) (figure 1-1). Public highways and streets accounted for the largest share of publicly owned transportation capital stock ($3.5 of $4.2 trillion), while other publicly owned transportation, such as airports, seaports, and transit structures, accounted for the remaining share ($737 billion).

In 2016 personal motor vehicles and parts owned by households, some of which are used for business purposes, accounted for the largest amount of privately owned transportation capital stock ($1.6 of $3.5 trillion) (figure 1-1). In-house transportation accounted for the second largest amount ($1.1 trillion) of private transportation capital stock, most of which was highway related, such as truck fleets owned by grocery chains. For-hire rail owned the next largest amount, accounting for $397 billion of transportation capital stock, followed by for-hire air at $218 billion.

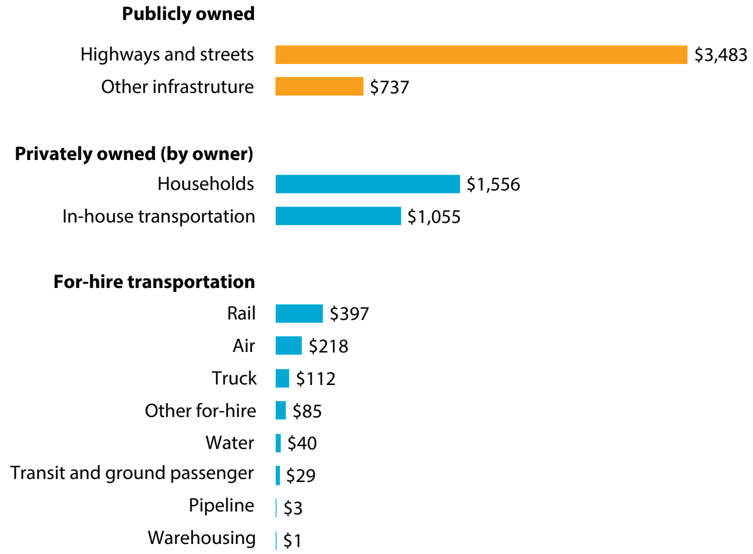
Roads, Bridges, Vehicles, Parking, and Traffic Control Systems

Roads

Following a period of rapid road building after World War II, the physical growth of the infrastructure of the U.S. highway system slowed. Highway mileage, lane-miles, and the number of bridges have grown less than one-half percent per year since 2000, plateauing at their present values (table 1-1) of about 4.1 million centerline miles,[1] 8.7 million lane-

[1] A centerline mile has a total length of one mile as measured along the highway centerline.

FIGURE 1-1 Net Value of Transportation Capital Stock: 2016 (billions of dollars)



NOTES: Data include only privately owned capital stock except for those otherwise noted. Capital stock data are reported after deducting depreciation. *Other publicly owned transportation* includes publicly owned airway, waterway, and transit structures but does not include associated equipment. *Locks and dams* may be included under *Other publicly owned transportation*. *Household* includes personal vehicles, which are considered consumer durable goods. *In-house transportation* is capital stock owned by non-transportation companies. For example, grocery companies often use their own truck fleets to move goods from their warehouses to their retail outlets. *In-house transportation and for-hire transportation* figures cover the the current cost net capital stock for fixed assets (transportation-related equipment including light trucks; other trucks, buses and truck trailers; autos; aircraft; ships and boats; and railroad equipment as well as transportation-related structures including air, rail, transit, and other transportation structures and track replacement) owned by a firm. Details may not add to totals due to rounding. Data may differ from those published in the 2016 TSAR due to revisions in the source data. Please see cited source for additional information.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, *Fixed Asset Tables*, tables 3.1ESI, 7.1B, 8.1; and *Nonresidential Detailed Estimates*, net stocks, current cost table. Available at http://www.bea.gov/ as of August 2018.

miles,[2] and 615 thousand bridges in 2016 [USDOT FHWA 2017]. Today, road building consists primarily of widening projects that increase lane-miles,[3] new or upgraded local streets to serve new commercial and residential developments, and rehabilitation and maintenance projects to maintain the serviceability of existing highways.

Local roads are by far the most extensive, amounting to 2.9 million miles (69.1 percent of total centerline-miles) in 2016 (table 1-1). However, interstate highways, which accounted for about 48,000 miles (1.2 percent of total system-miles), handled the highest volumes of traffic as measured by vehicle-miles traveled (vmt)—25.4 percent in 2016. Similarly, interstate highway bridges represent about 9.3 percent of all bridges while carrying

[2] A lane-mile is where the product of the centerline length (in miles) multiplied by the number of lanes equals one. For example, a half mile centerline length of a two-lane road is one lane-mile.

[3] Both centerline miles and lane miles appear to have decreased slightly since 2016, but this is likely due to some recent refinements in the way that the States collect and report highway mileage data.

TABLE 1-1 Public Roads, Streets, and Bridges: 2000, 2010, and 2016

	2000	2010	2016
Public Road and Street Mileage by Functional Type (miles)	**3,936,222**	**4,067,076**	**4,140,108**
Interstate	46,427	46,900	48,192
Other freeways and expressways	9,140	14,619	18,633
Other principal arterial	152,233	157,194	155,865
Minor arterial	227,364	242,815	246,193
Collectors	793,124	799,226	812,261
Local	2,707,934	2,806,322	2,858,964
Total lane-miles	**8,224,245**	**8,581,158**	**8,711,076**
Total bridges	**587,135**	**604,460**	**614,386**
Total registered vehicles	**225,821,241**	**250,070,048**	**268,799,083**
Vehicle-miles of travel (millions)	**2,746,925**	**2,967,266**	**3,174,408**

NOTE: Lane-miles are the centerline length in miles multipled by the number of lanes.

SOURCE: U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA), *Highway Statistics* (multiple years), as cited in the USDOT. Bureau of Transportation Statistics (BTS). *National Transportation Statistics* (NTS). Tables 1-5, 1-6, 1-28, and 1-35. Available at http://www.bts.gov/ as of August 2018.

the highest volumes of motor vehicle traffic [USDOT FHWA 2017].

Figure 1-2 shows the National Highway System and other principal arterials and intermodal connectors, portraying an extensive system of highways built around large population centers. It includes interstate highways as well as other roads important to the Nation's economy, defense, and mobility. The National Highway System and other connectors and arterials serve people in densely populated urban centers, such as along the Northeast and east coast, to rural areas in the West. Since initial development of the interstate highway system in the 1950s, the growth of the interstates has followed the U.S. population growth in the metropolitan areas in the south and along the Pacific coast [FHWA 2018].

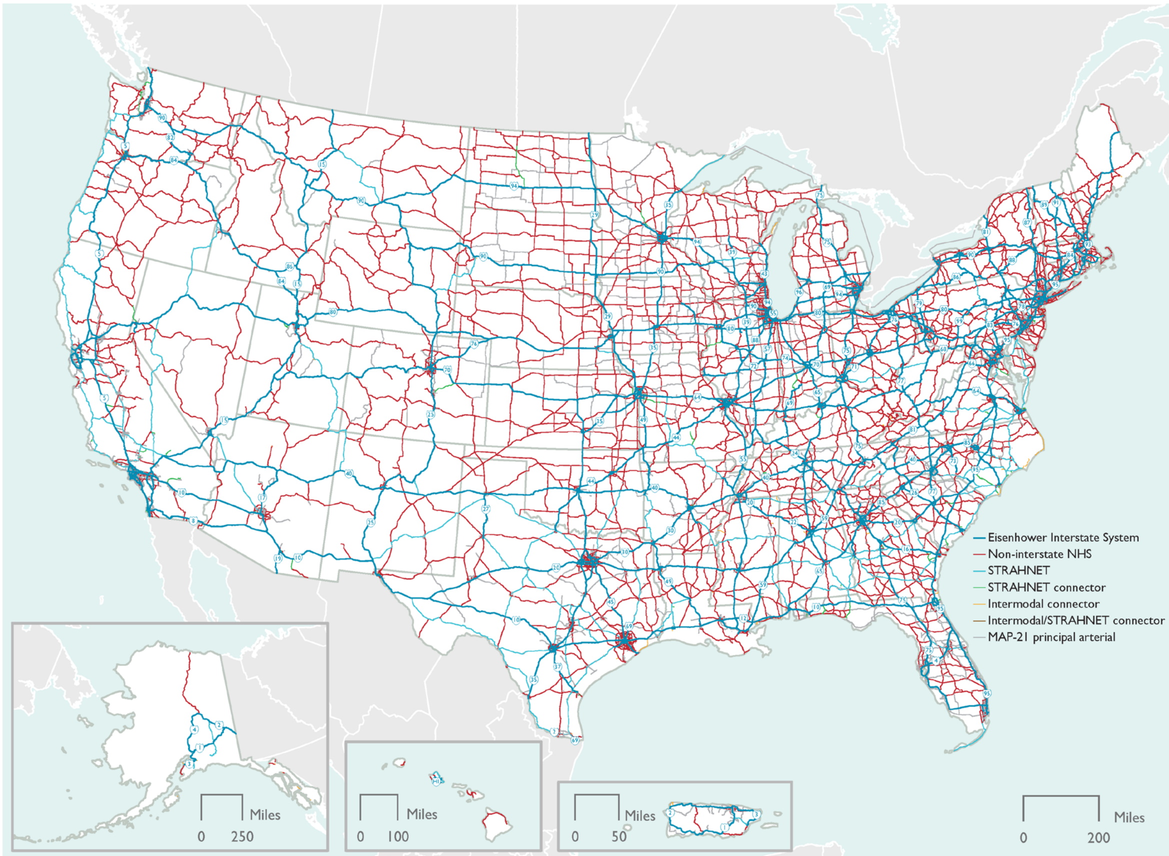
Bridges

A total of 614,386 highway bridges were in use in 2017, ranging in size from rural one lane bridges crossing creeks to urban multilane and multilevel interstate bridges and major river crossings. Rural bridges, including rural interstate, accounted for just under three-quarters of the total bridge network. While rural and urban interstate bridges accounted for 9.4 percent of all bridges, they carried the highest volumes of motor vehicle traffic. Texas had the most bridges, accounting for 8.8 percent of the entire U.S. bridge network, followed by Ohio (4.4 percent) and Illinois (4.4 percent) [USDOT FHWA 2018].

Vehicles

Government, businesses, private individuals, and nongovernmental organizations owned and

FIGURE 1-2 National Highway System, Intermodal Connectors, and Principal Arterials: 2018

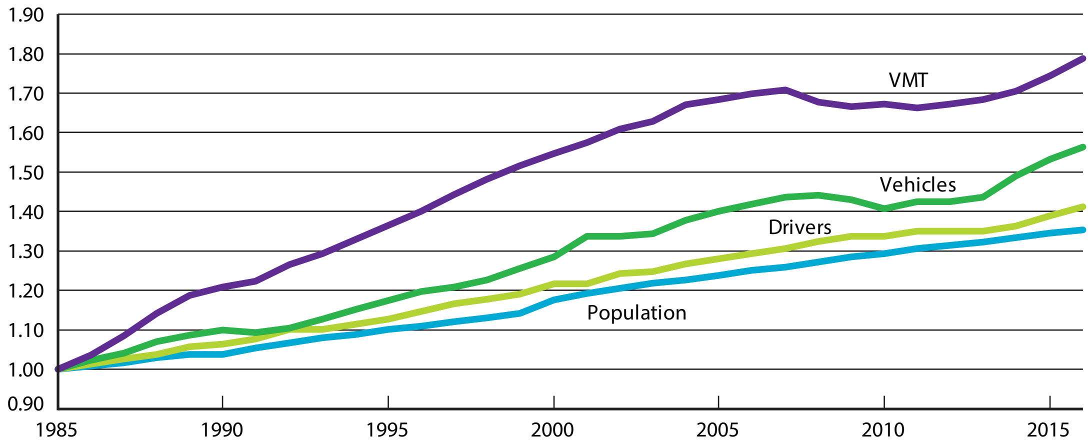


SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Atlas Database*, available at www.bts.gov as of September 2018.

operated about 269 million motor vehicles in 2016, driven a total of more than 3 trillion miles (table 1-1). Many new vehicles offer advanced technologies, such as forward collision warning, automatic emergency braking, lane departure warning, lane keeping assist, blind spot monitoring, rear cross-traffic alert, and adaptive cruise control, which assist drivers and help improve highway safety. Over 194 makes and models offered these technologies as standard or optional features for model years 2016 and 2017 [AAA 2018]. Although commercial vehicles (trucks and buses) comprised about 4.6 percent of registered vehicles, their use accounted for about 10 percent of vmt [USDOT FHWA 2017].

While highway system growth may be relatively stagnant, quite the opposite is true for the number of highway vehicles and the miles they are driven, both of which have grown at a faster rate than licensed drivers and the population since 1985 (figure 1-3). This growth produced an increase in the average number of motor vehicles owned by households, growing from an average of 1.86 vehicles per household in 2009 to 1.88 vehicles

FIGURE 1-3 Licensed Drivers, Vehicle Registrations, Vehicle-Miles Traveled, and Resident Population: 1985–2016



KEY: VMT = Vehicle-miles traveled

SOURCE: Vehicles and Drivers: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2016*. Tables DL-1C and MV-1. Available at http://www.fhwa.dot.gov/policyinformation/statistics/2016 as of August 2018. **Population**: U.S. Census Bureau, Quickfacts, available online at www.census.gov/quickfacts/ as of August 2018. **VMT**: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 1-35, available at www.bts.gov as of August 2018.

per household in 2017 [USDOT FHWA NHTS]. Increasing traffic on a relatively fixed stock of highways leads to increases in traffic congestion, traffic delays, and the degradation of system performance and the environment, as discussed further in the following chapters.

Most daily travel, particularly a work commute, is in a privately owned vehicle. According to the National Household Travel Survey, the average vehicle was driven slightly more than 10,000 miles a year in 2017, which is about the same as in 2009. However, the average miles per vehicle are down from their peak in the 1990s [USDOT FHWA NHTS].

Parking

The parking infrastructure in the United States is both vast and largely unmeasured at the national level. While there is no official estimate of the number of parking spaces in the United States, a recent research study measured in detail the evolution of parking supply in Los Angeles County from 1900 to 2010 [CHESTER 2015]. The researchers found that the number of parking spaces in Los Angeles increased from about 6 million to 18.6 million spots between 1950 and 2010, and that parking consumes 14 percent of the county's incorporated land. Local zoning and building codes usually dictate parking supply, which is one reason for the substantial growth in number of parking spaces in urban areas (as development increases, so does parking supply).

One reason that national estimates are lacking is that parking is inherently a local, mostly private-sector enterprise that is within the purview of land developers, businesses, and individual drivers. There are, however, some national or state transportation issues, which require data on parking supply. For example, while parking spaces for commercial trucks are but a small portion of the total parking supply, adequate truck parking along major freight corridors to help commercial vehicle operators obtain adequate rest while adhering to Federal hours of service regulations is a major highway safety concern. In a recent Federal Highway Administration (FHWA) parking survey, more than 75 percent of truck drivers reported having difficulty finding safe and legal parking during mandatory rest periods, and that number increased to 90 percent at night as drivers wait for their destination to open and accept deliveries [USDOT FHWA 2015]. The top five interstate corridors cited by drivers and staff as having shortages are I-95, I-40, I-80, I-10 and I-81. Most states also reported problems with truck parking shortages, with higher levels of shortages in public parking facilities than in private truck stops.

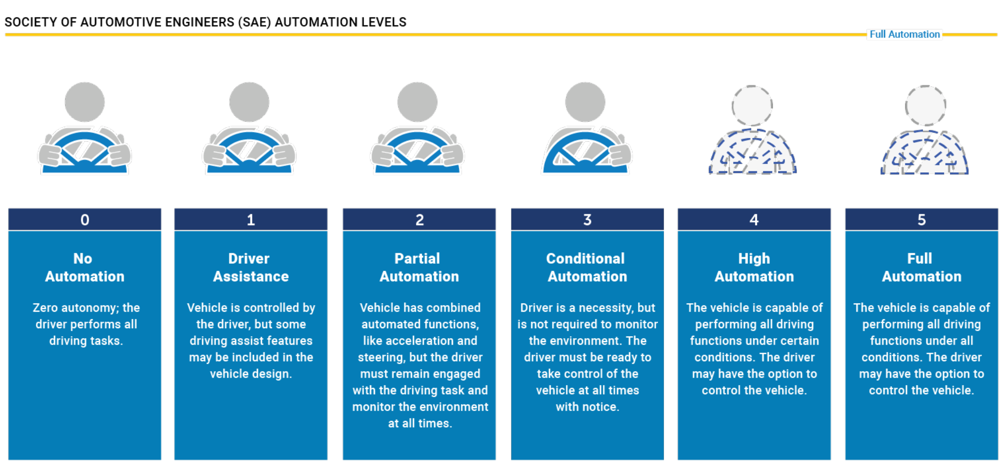
Traffic Control Systems

Traffic control features, such as traffic signs, signals and pavement markings, are an important element of the highway system, but there is no national database on traffic control systems and their condition. There are an estimated 325,000 signalized intersection in the United States. However, there are no comparable estimates of the numbers of other types of traffic control devices.

Automated Transportation Systems

Research and testing to develop automated vehicles as a means of increasing mobility and safety are proceeding at a rapid pace. The Society of Automotive Engineers classify an automated vehicle's complexity using six levels of automation, which range from zero to full automation (figure 1-4). There currently is no timeline in the United States for requiring some level of automation, but these technologies are rapidly being adopted.

FIGURE 1-4 Levels of Automation



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Automated Vehicles for Safety*, available at https://www.nhtsa.gov/ as of August 2018.

Automated vehicles (AVs), also known as automated, self-driving, driverless, or robotic vehicles, are those in which some aspects of vehicle control are automated by the car (AV Levels 1-5). Level 0 means the vehicle has no automation, thus the driver is performing all functions. At AV level 5, the highest level of automation, hands-off driving of the AV on all types of roads in a full range of traffic and weather conditions would be possible.

In 2018 the U.S. Department of Transportation (USDOT) released *Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0)*. AV 3.0 provides a strategy to address existing barriers to safety innovation, clarifies USDOT policy toward automated vehicles (AV), and outlines a process for federal, state, local and tribal governments, as well as the private sector working with USDOT.

Hundreds of companies worldwide, ranging from well-known automobile manufacturers and electronics firms to start-up companies, are working on some aspect of AV technology development, including sensors, on-board computers, controllers, software, and even completely new vehicle platforms.

As of 2018 virtually every company that is developing complete AVs (as opposed to components) is conducting or plans to conduct on-the-road testing in real world conditions. The San Francisco Bay area in California is host to the most AV test sites, followed by the Phoenix area. Other U.S. urban areas with significant field testing of AVs include Ann Arbor, MI; Atlanta; Austin, TX; Boston; Detroit; Frisco, TX; Kirkland ,WA; Las Vegas; and Pittsburgh [BLOOMBERG 2018].

Waymo, Alphabet Inc.'s (Google's parent company) self-driving cars have driven more than 8 million on-road AV miles, primarily on city streets between 2009 through July 2018 [WAYMO 2018]. Uber's self-driving cars have driven over 2 million miles in four different cities as of December 2017 [UBER 2018]. Thus far, virtually all test rides are overseen by an on-board operator who is trained to take over manual control of the vehicle when necessary, and to otherwise assist the test subject riders in proper operation of the AV.

Demonstrating the safety of AVs is one of the objectives of the on-road testing programs. A recent study [FAVARÒ 2017] analyzed in detail 26 crashes involving AVs in California between September 2014 and March 2017. Most of the crashes were of the low-speed "fender bender" variety, with 2 of the 26 crashes reporting injuries. The other vehicle operator was at fault in 22 of the crashes, and AV system control failure was implicated in 1 crash. However, since 2016 there have been three fatalities (in CA, AZ, and FL) [NTSB 2018a, b 2017] at least partially attributable to test car AV system control failure, indicating that considerable work is still needed to bring system safety to an acceptable level.

As automated vehicle on-the-road testing has become more widespread, many states have considered enacting regulations to address the potential impacts of these vehicles on their roads, particularly when AVs are operating in traffic mixed with non-equipped vehicles. As of August 2018, the District of Columbia and 26 states have enacted AV legislation, the governors of 8 states have issued executive orders, and 3 states have done both, for a total of 38 jurisdictions that have acted (figure 1-5). This is up from 27 state-level governments that had acted by 2017.[4]

Automated Transit Systems

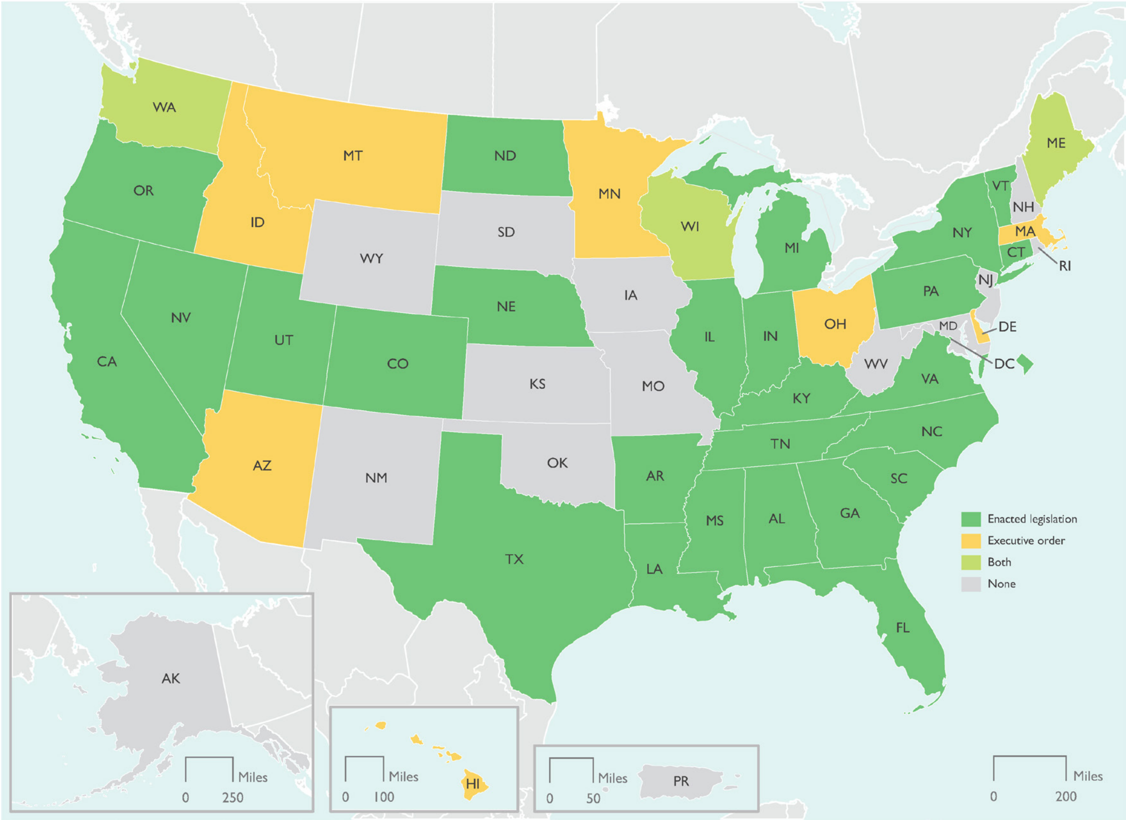
Other transportation modes are also advancing automation. The Federal Transit Administration (FTA) has a Transit Automation Research Program, which is looking toward a future where transit buses operate increasingly towards higher levels of automation as shown in the above figure. FTA has also created a Mobility on Demand Sandbox Program, which promotes for the use of on-demand information, real-time data, and predictive analysis to provide travelers with transportation choices that best serve their needs and circumstances [USDOT AV 3.0 2018].

[4] See TSAR 2017, figure 1-5 for last year's breakdown.

Automated Port Systems

The maritime transportation industry is working on autonomous ports systems and ships. Autonomous port systems use robots to automate port operation, such as the loading and unloading of ships, the inspection and stacking of containers, and gate operation. Autonomous ships operate either entirely

FIGURE 1-5 Automated Vehicle Legislation by State: 2018



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, based upon the National Conference of State Legislators, Autonomous Vehicles Legislative Database, available at http://www.ncsl.org/ as of August 2018.

unmanned or with a small crew. They navigate by computer software and utilize computers to monitor and manage the vessels' systems [USDOT AV 3.0 2018].

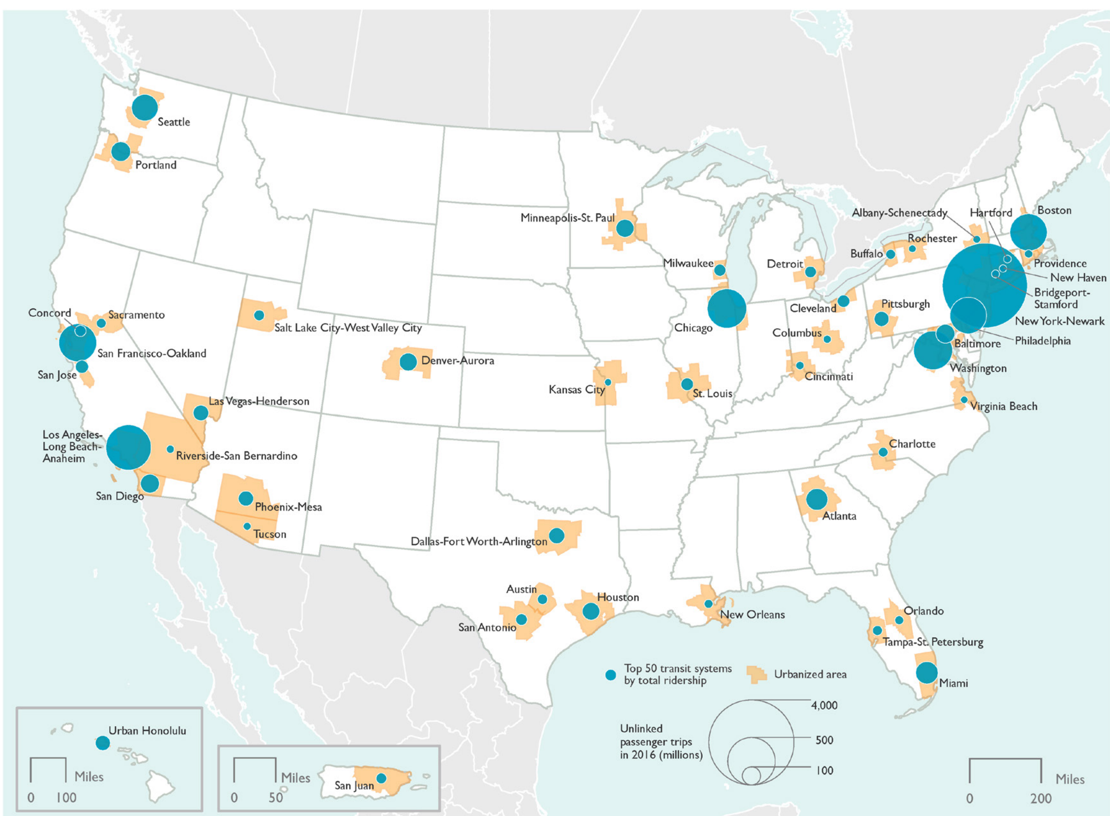
Automated Rail Systems

Automation is also happening in the rail industry. The Federal Railroad Administration has mandated the development of Positive Train Control (PTC) systems. These systems are composed of many different technologies, including on-board computers, event recorders, global positioning systems, wayside interface units, switch monitoring systems, fiber backbones, and radio or cellular towers [USDOT AV 3.0 2018].

Public Transit

About 950 urban transit agencies and more than 1,400 rural and tribal government transit agencies offer a range of travel options, including commuter rail, subway, and light-rail; transit and trolley bus; and ferryboat. Figure 1-6 shows the extent of these services. In 2016 these transit agencies operated over 5,300 stations, 81 percent of which comply with the *Americans with Disabilities Act* (Pub.L.101-336), a slight improvement from 2015. [USDOT FTA 2017]

FIGURE 1-6 Top 50 Transit Systems by Total Ridership: 2016



SOURCE: U.S. Department of Transportation, Federal Transit Administration, *National Transit Database*, available at www.fta.dot.gov as of September 2018.

Transit agencies vary widely in size, ranging from social service agencies operating a single vehicle to the 12,800 vehicles[5] operated by the New York City Metropolitan Transportation Authority. Nationwide, buses accounted for nearly half (about 47 percent) of the 135,000 transit vehicles in 2016 (table 1-2).

Transit ridership surpassed 10 billion beginning in 2006, reaching a high of 10.7 billion in 2014. Ridership declined in subsequent years, falling to 10.1 billion in 2017—a decline of over 600 million, slightly below the 2010 level shown in table 1-2.

[5] Including Commuter Bus, Demand Response, Heavy Rail, Bus, and Bus Rapid Transit

Rail transit (heavy, commuter, and light rail) comprised only 15 percent of the transit vehicles, but accounted for 47.8 percent of transit trips and 62.0 percent of person-miles traveled. Buses recorded the highest share of transit trips at 50.0 percent but only 36.2 percent of person-miles. Bus passengers generally take shorter trips, and buses operate at lower speeds compared to other modes. Conversely, due to longer trips and higher speeds, rail carries over three-fifths of all person-miles traveled on transit. Demand-response systems, which are largely social service agency trip providers, operated 24.3 percent of transit vehicles in 2017.

TABLE 1-2 Transit Vehicles and Ridership: Revenue Years 2000, 2010, and 2017

	2000	2010	2017
TOTAL, transit vehicles	**106,136**	**135,674**	**135,805**
TOTAL, rail transit vehicles	**17,114**	**20,374**	**20,391**
Heavy rail cars	10,311	11,510	10,705
Commuter rail cars and locomotives	5,497	6,768	7,129
Light rail cars	1,306	2,096	2,557
TOTAL, non-rail transit vehicles	**89,022**	**115,300**	**115,414**
Motor bus	59,230	63,679	64,298
Demand response	22,087	33,555	33,012
Ferry boat	98	134	147
Other	7,607	17,932	17,957
Rail Transit Stations	**2,595**	**3,124**	**3,399**
Person-Miles (millions)	**45,100**	**52,627**	**54,826**
Unlinked Passenger Trips (billions)	**8.72**	**10.08**	**10.06**
Rail Transit UPT	3.36	3.41	3.45
Non-Rail Transit UPT	5.36	6.67	6.62

NOTES: *Motor bus* includes Bus, Commuter Bus, Bus Rapid Transit, and Trolley Bus. *Light Rail* includes Light Rail, Streetcar Rail, and Hybrid Rail. *Demand response* includes Demand Response and Demand Response Taxi. *Other* includes Alaska railroad, automated guideway transit, cable car, inclined plane, monorail, and vanpool. *Unlinked passenger trips* is the number of passengers who board public transportation vehicles. Passengers are counted each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination.

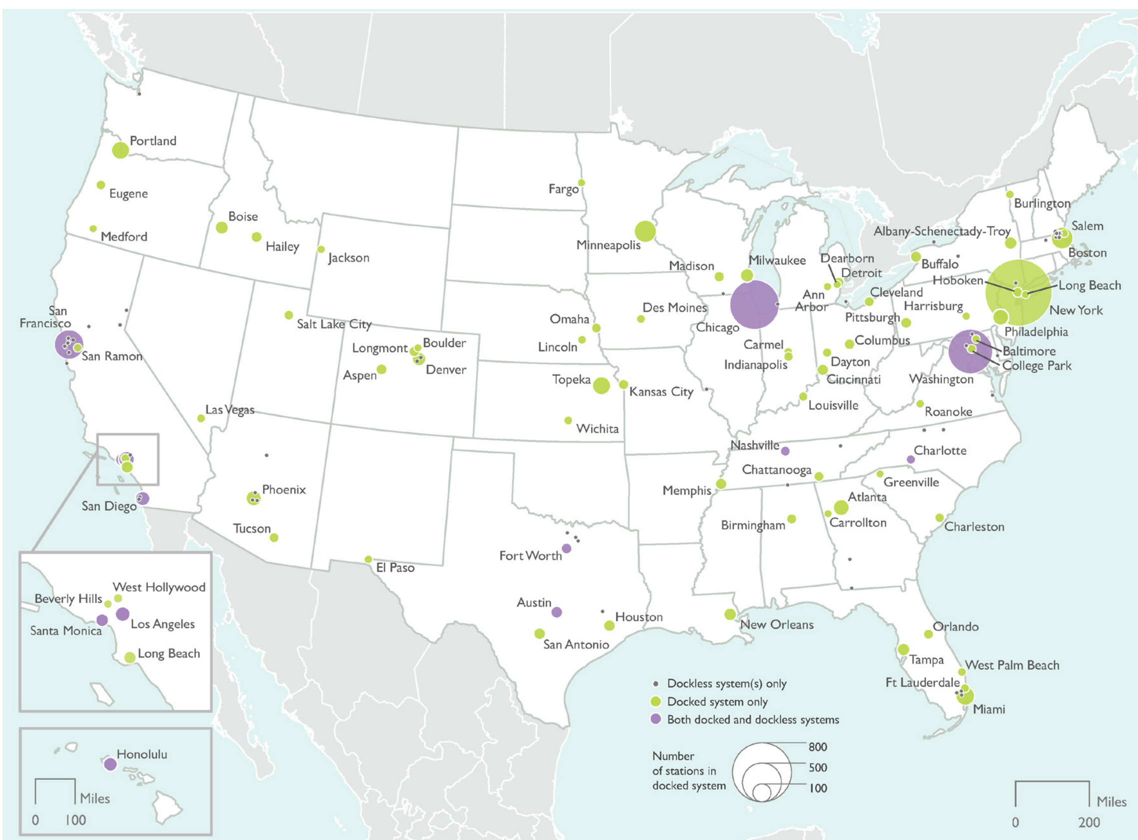
SOURCES: *Transit vehicles*: U.S. Department of Transportation (USDOT). Federal Transit Administration (FTA). National Transit Database (NTD) as cited in USDOT. Bureau of Transportation Statistics (BTS). National Transportation Statistics (NTS). Tables 1-11. Available at http://www.bts.gov/ as of October 2018. *Person-miles travelled*: USDOT/FTA/NTD as cited in USDOT/BTS/NTS. Table 1-40. Available at http://www.bts.gov/ as of October 2018. *Transit Stations and Unlinked passenger trips*: USDOT/FTA/NTD. Available at https://www.transit.dot.gov/ntd/ntd-data as of October 2018.

Bikeshare systems have emerged in recent years as one solution to the problem faced by potential transit riders who do not live near a transit stop, or are going to a location that is not close enough to transit to make it a viable option. As shown in figure 1-7, bikeshare systems are available in urban areas throughout the United States. From May 2017 through May 2018, 18 new systems launched. These systems and existing systems added a net of 1,197 new docking stations, bringing the total number of docking stations to 6,133. About 70 percent of all bikeshare docking stations are within one block of another public, passenger transportation mode. As of July 2018, there were 85 cities with active or pilot dockless bikeshare systems. Bikeshare ridership increased from 320,000 in 2010 to 35 million in 2017 [NACTO]. Box 1-A discusses ride-hailing services, which connect with other transportation modes and increase modal options.

Aviation

The main elements of aviation system infrastructure include airport runways and terminals, aircraft, and air traffic control systems. In 2017 the United States had about

FIGURE 1-7 U.S. Cities with More than 10 Bike-Share Stations: 2018



SOURCES: Docked systems: U.S. Department of Transportation, Bureau of Transportation Statistics, *Intermodal Passenger Connectivity Database*, available at www.bts.gov as of September 2018. **Dockless systems**: U.S. Department of Transportation, Bureau of Transportation Statistics, special tabulation, July 2018.

Box 1-A Ride-Hailing Services

A ride-hailing service uses an online platform to connect riders to drivers, typically using an application (app) on a mobile phone. The largest ride-hailing companies currently providing service in the United States are Uber and Lyft with most ride-hail drivers using their personal vehicles.

Two recent Transit Cooperative Research Program reports [FEIGON 2018, 2016] suggest that most trips are relatively short within urban core areas, and occur during the evening hours and on weekends when transit is less available. A recent estimate [SCHALLER 2018] indicates that in 2000 there were 1.1 billion combined ride-hailing and taxi trips, nearly all of which were by taxi. However, the combined number had grown to 4.8 billion trips by 2018, with 88 percent by ride-hailing, which is about the same as the number of bus trips. Ride-hailing services also provide connectivity to public transit for many transit riders. Concerning urban traffic, ride-hailing drivers waiting for a service call tend to cruise around an area, adding to the traffic on city streets. However, these ride-hailing drivers potentially displace some single occupant vehicle driving, relieve parking, and replace some taxi trips that might otherwise occur. Consequently, the net impact of ride-hailing services on traffic has yet to be determined.

Ride-hailing services are a subset of a broader array of shared mobility services. Included within the latter are car-sharing services, such as Zipcar and Car2Go; bikesharing services, such as Motivate (Citi Bike, GoBike, and others) and Lime; and electric scooter sharing services, such as Lime and Bird. These services have evolved to dockless operation, wherein vehicles may be picked up and dropped off virtually anywhere within the service area, which has increased mobility while raising safety concerns in some cities (particularly for scooters).

19,500 airports (table 1-3), ranging from rural grass landing strips to large paved multiple-runway airports. About a quarter of the airports are public-use facilities, most of which are general aviation airports that serve a wide range of users. The remaining three-quarters are private airports, which are relatively small.

The number of U.S. airports with nonstop international service increased from 81 in 1993 to 351 in 2016 and 381 in 2017, offering more locations throughout the country with commercial air service to the world. While 74 airports lost international service (e.g., Huntsville International Airport), 104 airports gained international service in that time, such as Jackson–Medgar Wiley Evers International Airport and Brown Field Municipal Airport. The number of air passengers traveling between the United States and foreign points reached a new high in 2017 [USDOT BTS 2018].

Global air travel has increased over the past 16 years, with a record amount occurring at U.S. airports in 2015, 2016, and 2017 (as measured by total boardings—as discussed in chapter 3, there were 965 million enplanements in 2017, up about 140 million in 5 years). Figure 1-8 shows the airports with the most passenger enplanements, including Hartsfield-Jackson Atlanta International (50.3 million), Los Angeles International (41.2 million), and Chicago O’Hare (38.6 million). The top 50 airports accounted for 85.2 percent (about 726 million) of the U.S. passenger enplanements in 2017.

TABLE 1-3 U.S. Air Transportation System: 2000, 2010, and 2017

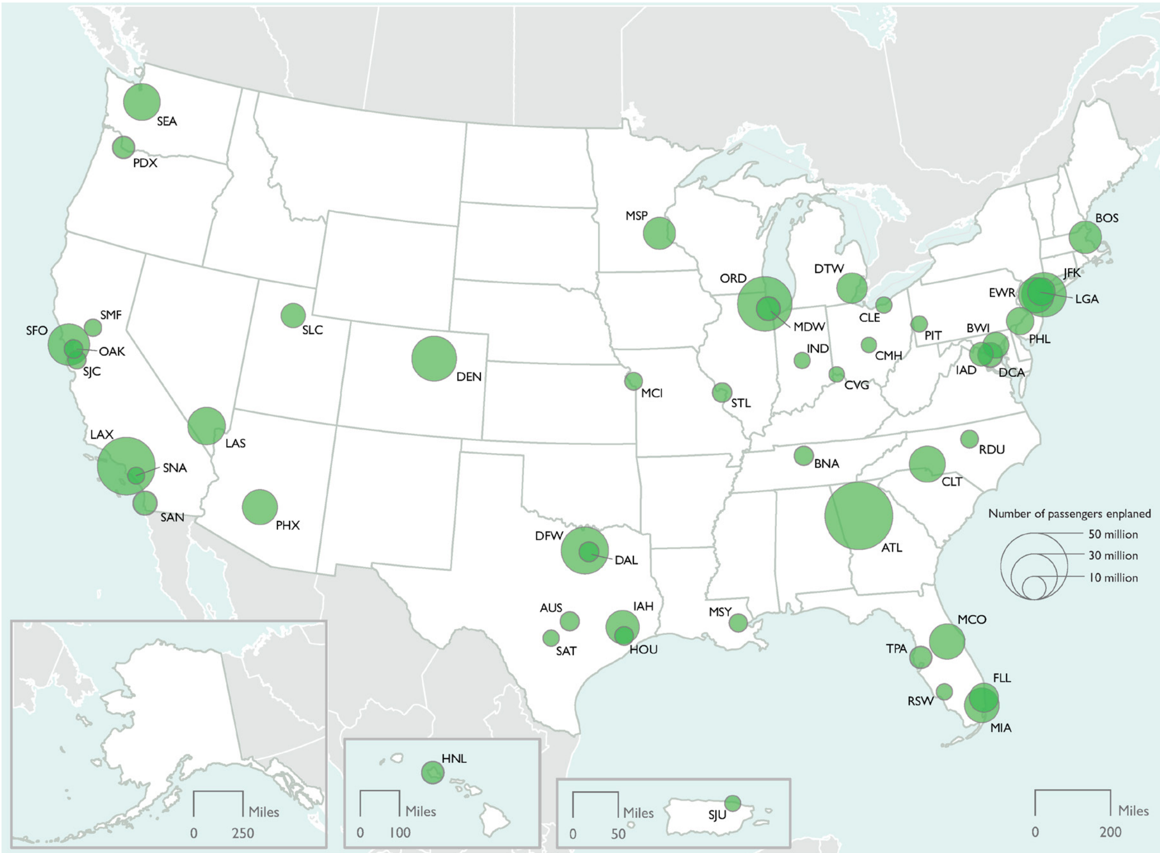
	2000	2010	2017
TOTAL, U.S. airports	**19,281**	**19,802**	**19,570**
Public use	5,317	5,175	5,119
Private use	13,964	14,353	14,168
Military	U	274	283
TOTAL, aircraft	**225,359**	**230,555**	**220,368**
General aviation aircraft	217,533	223,370	213,050
Commercial aircraft	7,826	7,185	7,318
Pilots	**625,581**	**627,588**	**585,783**
TOTAL, load factor	**U**	**81.90**	**82.46**
Domestic flights	U	82.18	84.57
International flights	U	81.59	80.64
TOTAL, passenger enplanements (thousands)	**U**	**723,490**	**865,712**
Enplanements on domestic flights	U	644,761	754,534
Enplanements on international flights of U.S. carriers	U	44,008	53,496
Enplanements on international flights of foreign carriers, orginated from the U.S.	U	34,721	57,682
TOTAL, revenue passenger-miles, U.S. carriers (millions)	**U**	**792,208**	**962,950**
Domestic, revenue passenger-miles (RPM) (millions)	U	552,854	683,750
International on U.S. carriers,revenue passenger-miles (RPM) (millions)	U	239,355	279,200
TOTAL, revenue ton-miles on U.S. carriers (millions)	**U**	**117,422**	**138,099**
Domestic, revenue ton-miles (RTM) (millions)	U	68,402	83,651
International on U.S. carriers, revenue ton-miles (RTM) (millions)	U	49,020	54,447

KEY: U: unavailable.

NOTES: *General aviation* includes air taxis. Major U.S. carriers have annual operating revenue exceeding $1 billion. National carriers have annual operating revenues between $100 million and $1 billion. These carrier categories differ from the more commonly used business model categories. Total includes both scheduled and non-scheduled passenger enplanements. *Revenue passenger-miles* (RPM) are calculated by multiplying the number of revenue passengers by the distance traveled. *Revenue ton-miles* (RTM) is one ton of revenue traffic transported one mile. RTM includes passenger, freight, express, and mail ton-miles using 5,280 feet to calculate mileage distance. Passengers and their baggage are estimated at 200 pounds. *Load factor* is a measure of the use of aircraft capacity that compares the system use, measured in RPMs as a proportion of system capacity, measured by available seat miles.

SOURCES: *Airports*: U.S. Department of Transportation (USDOT). Federal Aviation Administration (FAA) Administrator's Fact Book (September 2018). Available at www.faa.gov/ as of September 2018. *General aviation aircraft and Pilots*: USDOT/FAA. FAA Aerospace Forecast, Fiscal Years (multiple issues). Available at www.faa.gov as of September 2018. *Passenger enplanements*: USDOT, Bureau of Transportation Statistics (BTS), Office of Airline Information (OAI), T1/DB20 (Green Book). Available at http://www.transtats.bts.gov/ as of October 2018. *RPM and RTM*: USDOT, BTS, OAI, T-100 Segment data. Available at http://www.transtats.bts.gov/ as of October 2018.

FIGURE 1-8 Enplanements at the Top 50 U.S. Airports: 2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Office Airline Information, available at www.bts.gov as of September 2018.

U.S. airports handled about 9.8 million[6] commercial airline flights in 2017. Total commercial flights have varied between 9.5 and 10.0 million since 2010, but remain below the pre-Great Recession (December 2007 to June 2009) levels that exceeded 11 million [USDOT BTS 2018c]. At least some of this reduction is due to the trend for airlines to use larger aircraft and reduce the number of flights.

The list of U.S. airlines since airline deregulation in 1978 has constantly changed with two somewhat contradictory trends emerging. Through a steady wave of acquisitions, mergers, and shut downs, the industry has seen considerable consolidation. On the other hand, a group of new low-cost carriers have entered the market. The net result is that the number of passenger airlines designated as "major" decreased from 17 in 2000 to 12 in 2018.[7] In 2018 five of the major

[6] Previous editions of this report have reported total commercial fights for all major U.S. airports only, rather than for all U.S. airports.

[7] A "major" airline is defined as an airline that has at least $1 billion in annual revenue. The current major airlines are Alaska, Allegiant, American, Delta, Frontier, Hawaiian, JetBlue, SkyWest, Southwest, Spirit, and United. In 2018 there was a merger between Alaska and Virgin America, reducing the number of major airlines from 12 to 11.

airlines market themselves as low-cost carriers (Alaska, Frontier, JetBlue, SkyWest, and Spirit).

The Federal Aviation Administration (FAA) is amid a major effort to upgrade the U.S. air traffic control system to increase its capacity. Current efforts are focused on developing the Next Generation Air Transportation System (NextGen), which will utilize global positioning system (GPS) satellite technology and related communications and information technology improvements.

New approach procedures using the Wide Area Augmentation System (WAAS) will increase access to general aviation airports, especially during low visibility. The WAAS provides augmentation information to GPS receivers to enhance the accuracy and reliability of position estimates. With WAAS, aircraft can use these runways in poor weather conditions with ceiling and visibility as low as 200 feet. Specifically, the FAA has published 3,922 WAAS-enabled approach procedures at 1,906 airports as of July 2018 [USDOT FAA 2018].

GPS is used by all transportation modes to navigate position and timing. The lessening of the power of the signal coming from the satellite towards Earth makes it vulnerable to interference, of either natural or human origin, as discussed further in box 1-B.

Freight Railroads

The United States had about 138,500 railroad route-miles in 2017 [AAR 2018], including roughly 93,000 miles owned and operated by the seven Class I railroads.[8] About 570 local and regional railroads operated the remaining 45,500 miles. Class I railroads provided freight transportation using over 26,700 locomotives and 1.63 million railcars (table 1-4). Average freight car capacity was about 93 tons in 2000, and reached 105 tons in 2016 due to construction of larger cars, particularly new hopper and tank cars.

Over the past 50 years, Class I railroads and connecting facilities have developed increasingly efficient ways to carry and transfer cargo (e.g., larger cars as noted above, double-stack container railcars, and on-dock rail), allowing more cargo to be carried with fewer railcars. Figure 1-9 shows that the system mileage of Class I railroads in 2016 was less than one-half the mileage in 1960. However, freight rail ton-miles tripled to 1.8 trillion during the same period (despite a decline during the last recession). The railroads, which are private companies, invested $13.8 billion in 2016 to improve their facilities (table 1-4), which is comparable to the average investment over the past 6 years [AAR 2018].

Passenger Rail

The National Rail Passenger Corp. (Amtrak) is the primary operator of intercity passenger rail service in the United States. Amtrak operated 21,400 route-miles in 2017 and more than 500 stations that served 46 states and Washington, DC (table 1-5). On an average day, Amtrak operates more than 300 trains, using a fleet of 1,400 passenger cars and over 400 locomotives. During fiscal year (FY) 2017,

[8] Includes BNSF Railway, CSX Transportation, Grand Trunk Corp. (Canadian National operations in the United States), Kansas City Southern, Norfolk Southern, Soo Line (Canadian Pacific operations in the United States), and Union Pacific.

Box 1-B Global Positioning System (GPS) Interference

GPS provides geolocation and time information to receivers anywhere on or near Earth where there is an unobstructed line of sight to four or more GPS satellites. The system is widely used for aircraft, land vehicle, and vessel navigation and tracking; charting and surveying; routing automated vehicles; dispatching emergency services; and providing safe and efficient navigation. GPS enabled systems receive signals in the radio frequency (RF) spectrum from dedicated satellites orbiting approximately 12,500 miles above Earth, and are thus very weak by the time they reach receivers in cars, trucks, planes, ships, trains, and other systems [NCO 2018].

Like any systems that operate using RF spectrum, natural or human-made sources can interfere with the signals. Interference can affect vehicles, trucking, aviation, maritime, Positive Train Control, and other transportation systems using GPS. Human-made interference can be unintentional or intentional. Intentional interference can generally be broken into two categories: jamming and spoofing.

Jamming makes it difficult for the receiver to hear the GPS signals, while spoofing sends false signals to the system that mimic GPS in some ways, but deny, degrade, disrupt, or deceive a receiver's operation when they are processed.

Spoofing can cause a range of effects, from incorrect outputs of position, navigation, or timing to receiver malfunction. The onset of these effects can be instantaneous or delayed, and it is possible for effects to continue even after the spoofing has ended.

Recent examples of GPS interference include:

- *Port Said, Egypt, 2018*: Ships operating between Cyprus and Port Said, Egypt reported loss of GPS that caused audible and visual alarms in various GPS-enable systems on the bridge, including distorted radar and electronic chart displays as the ship's position jumped around. In addition, the Automatic Identification System (AIS) broadcast used to help ships avoid collisions was affected [MARAD 2018].
- *Black Sea, 2017*: Multiple ships in the Black Sea reported false locations being displayed on the navigation displays, including some ship positions shown as located at an airport. Similar position anomalies were reported in the AIS broadcast [MARAD 2017].
- *South Korea, 2016*: South Korea reported over 1,000 ships and 700 planes were affected by GPS interference that occurred over several days [AusBC News 2016].

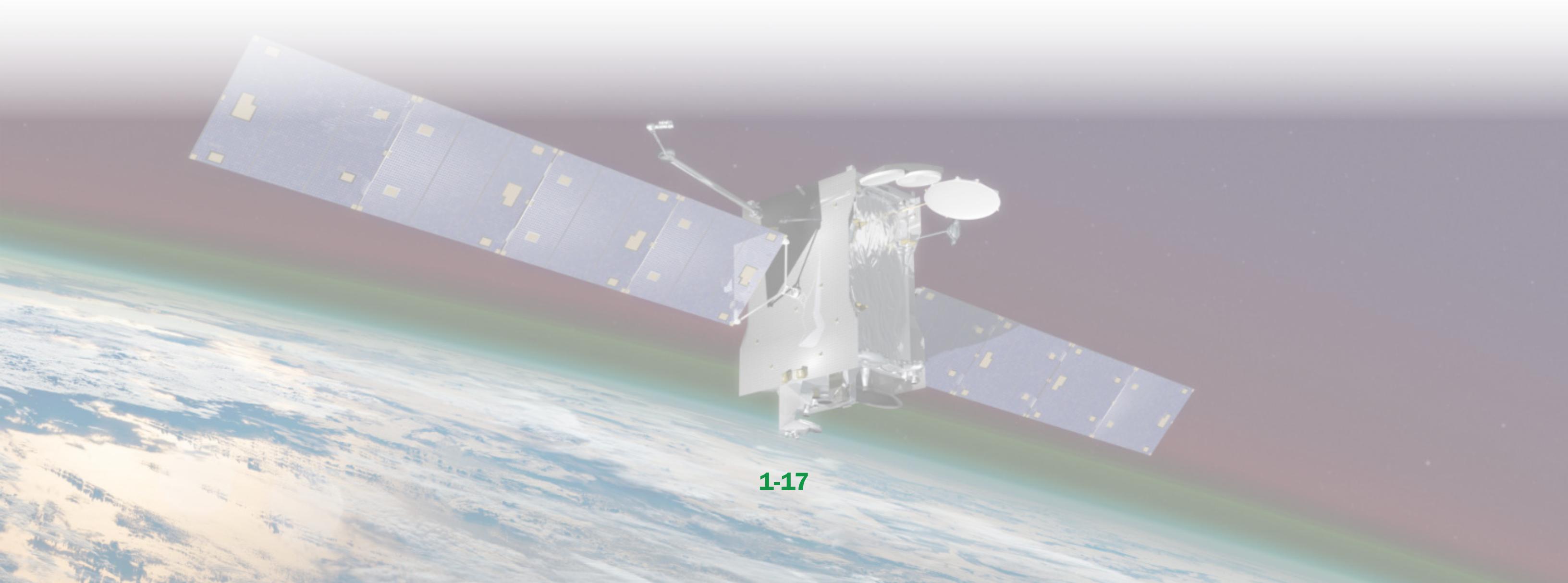


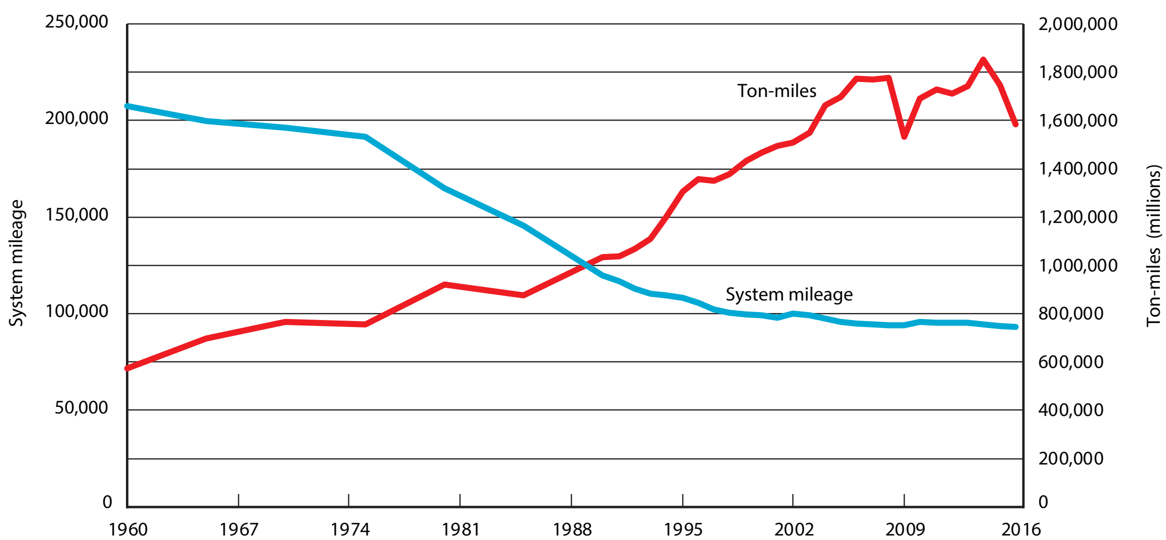
TABLE 1-4 Rail Transportation System: Fiscal Years 2000, 2010, and 2016

	2000	2010	2016
Equipment and Mileage Operated by Class I			
Locomotives	20,028	23,893	26,719
Freight cars[a]	560,154	397,730	315,227
Average freight car capacity (tons)	92.7	101.7	104.5
System mileage	99,250	95,573	93,339
Ton-miles (trillion)	1.47	1.69	1.59
Capital expenditures, $billion			
Roadway and structures	$4.55	$7.86	$9.45
Equipment	$1.51	$1.91	$4.35
TOTAL	**$6.06**	**$9.77**	**$13.80**

NOTES: Fiscal year ending in September. [a]Includes totals for Canada and Mexico.

SOURCES: *Class I railroads-Locomotives, Freight cars, and System Mileage*: Association of American Railroads, Railroad Facts (Annual issues) as cited in USDOT/BTS/NTS. Tables 1-1, 1-11, 1-49. Available at http://www.bts.gov/ as of August 2018. *Capital expenditures*: Association of American Railroads, Railroad Facts (Annual issues), as of August 2018.

FIGURE 1-9 Class I. Railroad System Mileage and Ton-Miles of Freight: 1960–2016



NOTE: Data includes every 5 years until 1970, and data are yearly thereafter.

SOURCE: Association of American Railroads, *Railroad Facts*, Statistical Highlights (Washington, DC: Annual Issues), available at https://www.aar.org/ as of August 2018.

TABLE 1-5 Passenger Rail Transportation System: Fiscal Years 2000, 2010, and 2016

	2000	2010	2016
Equipment and Mileage Operated by Amtrak			
Locomotives	378	282	434
Passenger cars	1,894	1,274	1,401
System mileage	23,000	21,178	21,358
Stations	515	519	U
Passengers (millions)	20.9	28.7	31.3
Passenger-miles travelled (millions)	5,498	6,420	6,520

NOTE: Fiscal year ending in September.

SOURCES: *Amtrak-Locomotives, Railcars, System mileage, Stations and Passenger-miles travelled*: Amtrak as cited in U.S. Department of Transportation (USDOT). Bureau of Transportation Statistics (BTS). National Transportation Statistics (NTS). Tables 1-1,1-7, 1-11, 1-40. Available at http://www.bts.gov/ as of October 2018. *Passengers*: USDOT, Federal Railroad Administration, Office of Safety Analysis, Available at www.fra.dot.gov as of October 2018.

Amtrak riders took a record 31.7 million trips, another record year [AMTRAK 2018]. When included with U.S. airlines, Amtrak ranks 6th in passengers carried (behind Southwest Airlines, Delta Air Lines, American Airlines, United Airlines, and JetBlue Airways) [USDOT BTS 2018c].

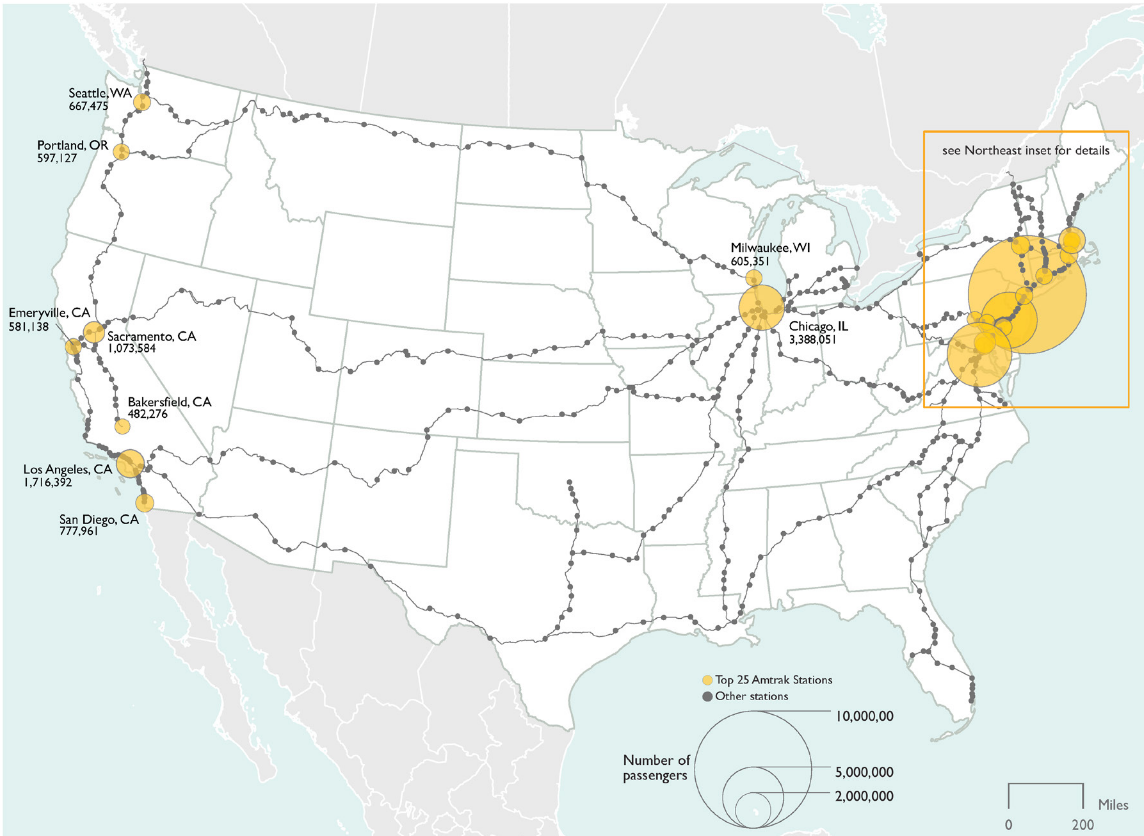
Figure 1-10 depicts where people ride Amtrak in the United States. The heaviest ridership is in the Northeast Corridor (NEC) between Boston and Washington, which also handles commuter rail service in the region's major cities. Ridership is also high around Chicago as well as at several locations in California and the Pacific Northwest. [AMTRAK 2018]. In FY 2017 the busiest Amtrak Station was Penn Station in New York City (10.4 million passengers) followed by Union Station in Washington, D.C. (5.2 million passengers) and Philadelphia 30th Street Station (4.4 million passengers).

Amtrak owns a small fraction of its route-miles, 363 miles of the 457-mile NEC plus three other shorter segments in the following corridors; New Haven, CT-Springfield, MA; Harrisburg, PA-Philadelphia, PA; and Porter, IN-Kalamazoo, MI; totaling 261 miles [AMTRAK 2018]. Nearly all passenger train services outside the NEC are provided over tracks owned by and shared with the Class I freight railroads. Thus, the condition of the tracks used for Amtrak service is largely dependent on the maintenance activities of freight railroads.

Ports and Waterways

There were about than 82,000 U.S. water transportation facilities, including cargo handling docks, in 2016 (table 1-6). About 69 percent of cargo-handling facilities are located on the Atlantic, gulf, and Pacific coasts. The remaining 31 percent are situated along the Great Lakes or inland waterways. These facilities are served by a fleet of more than 41,000 domestic vessels—about 32,350 barges and 9,000 self-propelled vessels, including more than 3,000 towboats used to move the barges [USACE IWR NDC 2017]. There were more than 82,000 vessel calls at U.S. ports; most of which were made by one of the more than 41,000 foreign flagged vessels [USDOT

FIGURE 1-10a Top 25 Busiest Amtrak Stations: 2017



SOURCE: National Rail Passenger Corp (Amtrak), *State Fact Sheets*, available at www.amtrak.com as of August 2018.

MARAD 2016a]. Based upon the maximum port call capacities, Post-Panamax or larger containerships[9] served 22 U.S. ports in 2016 [USDOT MARAD 2016b].

Dams and navigation locks are two of the principal infrastructure features of the U.S. inland waterway transportation system. They enable shallow draft operations on most rivers.[10]

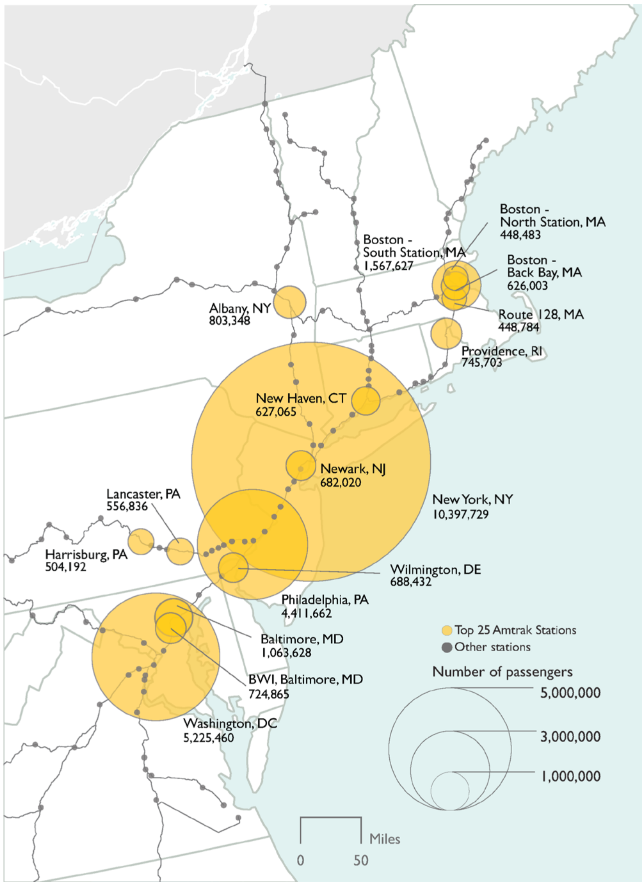
[9] Fully cellular containerships with twenty foot-equivalent unit (TEU) capacities of 4,500 or more.

[10] The principal exceptions are the Lower Mississippi River and the Missouri River, which are free-flowing but still require some type of hydrologic structures, such as large rock and concrete groins and revetments, to manage the flow of the river and preserve navigation.

The U.S. Army Corps of Engineers (USACE) owns and operates 239 lock chambers at 193 sites, which account for most of the U.S. inland navigation locks. Of the 193 lock sites, 39 have multi-chambered locks: 34 have 2 chambers, 4 have 3 chambers and 1 has 5 chambers.

Shallow and deep-draft ports and channels are other important infrastructure elements of the waterway system. There are several thousand inland river ports and terminals, most of which are privately owned and serve specific cargo-handling needs (e.g., coal loading or petrochemical transfers). Deep draft ports are large and capital-intensive

FIGURE 1-10b Top 25 Busiest Amtrak Stations: 2017



SOURCE: National Rail Passenger Corp (Amtrak), *State Fact Sheets*, available at www.amtrak.com as of August 2018.

facilities, typically with extensive docks, wharves, cranes, warehouses, and other cargo transfer equipment. They also have intermodal connections that integrate ocean transport with inland conveyance.

There were 2.3 billion tons of commodities moved on the waterway system in 2016, which is 6.9 percent less than the tonnage in 2000. The amount of food and farm products moving along the waterway system varies on a seasonal basis. As the waterway system ages, delays increase and other modes of transportation become more attractive. Over that period, domestic tonnage decreased by 18 percent, while foreign commerce grew by 1.7 percent. Foreign commerce was 56.5 percent of total tonnage in 2000, but increased to 61.8 percent in 2016.

To address the limitations on port performance data, BTS was directed by Congress to develop the Port Performance Freight Statistics Program and annual report. The latest edition of the report [USDOT BTS 2018d] identifies the top 25 U.S. ports as measured by total tonnage, containers, or dry bulk tonnage throughput. Most of the top container ports

TABLE 1-6 Water Transportation System: 2000, 2010, and 2016

	2000	2010	2016
Infrastructure			
Waterway facilities (including cargo handling docks)	9,309	8,060	8,227
Ports (handling over 250,000 tons)	197	178	181
Miles of navigable waterways	25,000	25,000	25,000
Lock chambers	276	239	239
Lock sites	230	193	193
U.S. Flag Vessels			
TOTAL, Commercial Vessels	**41,354**	**40,512**	**41,328**
Barge/non-self-propelled vessels	33,152	31,412	32,354
Self-propelled vessels	8,202	9,078	8,974
Recreational boats, millions	12.8	12.4	11.9
TOTAL, Vessel Calls	**U**	**59,000**	**U**
TOTAL, Waterborne Commerce (million tons)	**2,462**	**2,334**	**2,292**
Domestic	1,070	894	877
Foreign	1,392	1,441	1,416

KEY: U = unavailable.

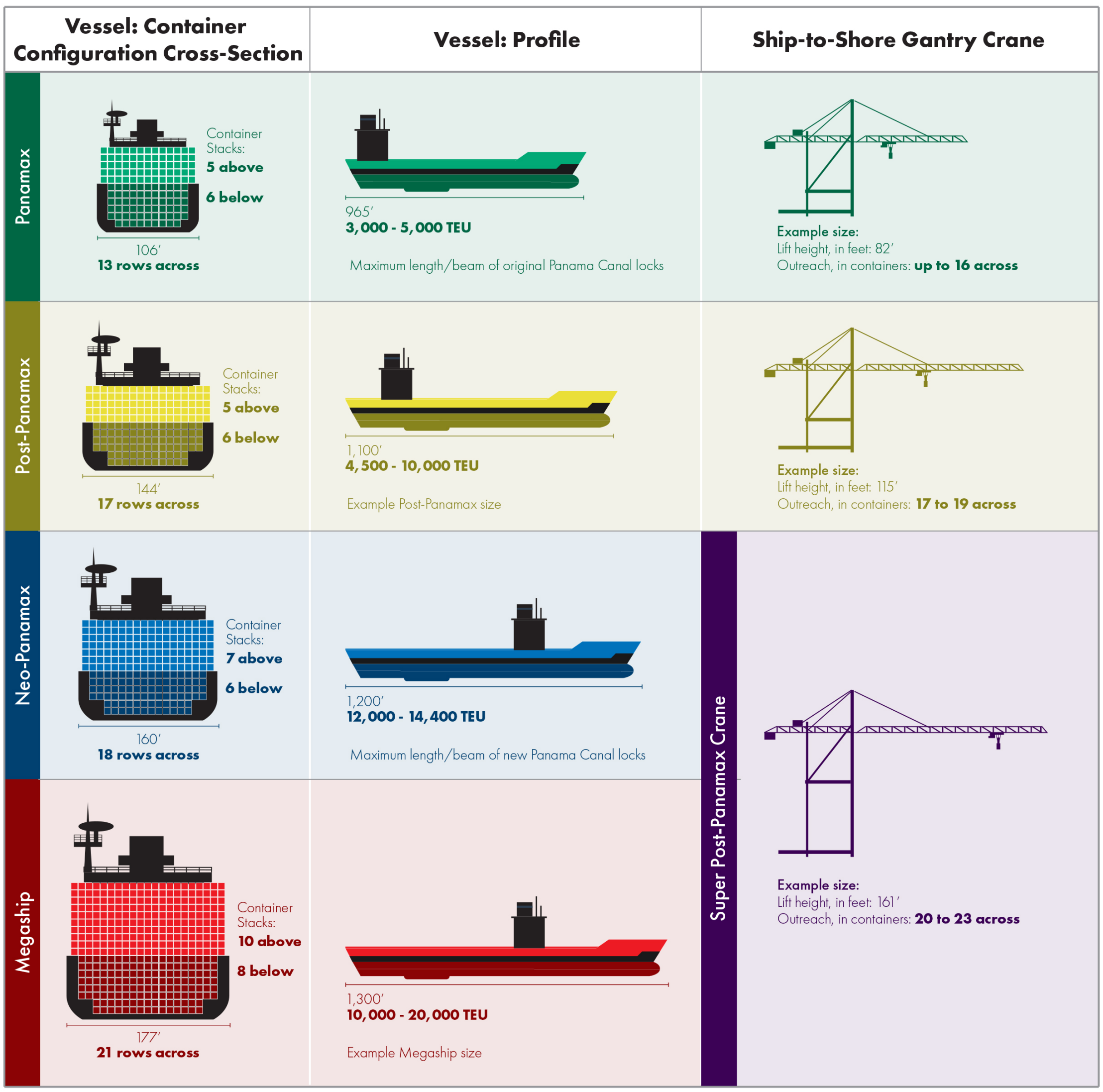
NOTES: *Vessel calls* includes only oceangoing self-propelled, cargo-carrying vessels of 1,000 GT and above. *Total, Commerical Vessels* includes unclassified vessels. Ports includes coastal, Great Lakes, and inland ports, including those on the inland rivers and waterways primarily serving barges. For reporting purposes, the U.S. Army Corps of Engineers tabulates traffic at the docks within the boundary of the port and uses 250,000 short tons as the reporting threshold.

SOURCES: **Fleet**: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, Navigation Data Center, *Waterborne Transportation Lines of the United States* (Annual issues), available at http://www.navigationdatacenter.us/ as of August 2018. **Recreational boats**: U.S. Department of Homeland Security, U.S. Coast Guard, Recreational Boating Statistics as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 1-11, available at http://www.bts.gov/ as of August 2018. **Waterways Locks, Facilities, and Vessels**: U.S. Army Corps of Engineers, Institute for Water Resources, available at https://www.iwr.usace.army.mil/ as of August 2018. *The U.S. Waterway System: Transportation Facts and Information* (Annual issues), as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, tables 1-1 and 1-11, available at http://www.bts.gov/ as of August 2018. **Vessel calls**: U.S. Department of Transportation, Maritime Administration, Vessel Calls in U.S. Ports, Selected Terminals and Lightering Areas, available at https://www.marad.dot.gov/resources/data-statistics/ as of October 2018.

are located on the Atlantic and Pacific coasts. The top tonnage ports, on the other hand, are heavily concentrated in the gulf coast, primarily due to petrochemical industry shipments. The top dry bulk ports have a strong inland waterways and Great Lakes presence. Port performance is discussed further in chapter 2.

The major development that affects U.S. coastal ports is the continuing increase in the size of the containerships calling due to the need to competitively serve the burgeoning international container trade business. Containerships calling at U.S. ports had an average capacity of 4,856 twenty-foot equivalent units (TEU) in 2016, an increase of 37 percent since 2013 [USDOT MARAD 2017]. Many of the coastal seaports are served by Neo-Panamax (also known as New Panamax) ships— sized for the expanded locks opened in 2016 as well as even larger megaships. Serving these large vessels efficiently calls for the port to have the requisite complement of large container cranes (figure 1-11). With the largest cranes having a price tag of over $10 million, ports are challenged to raise the capital needed for such investments. Furthermore, they may also need to deepen channels, increase bridge clearances, and improve other port and terminal infrastructure and landside access. Figure 1-12 shows the number of container cranes at the top 25 container ports by TEU in the United States. This shows the correlation between the number of container cranes and TEU handled.

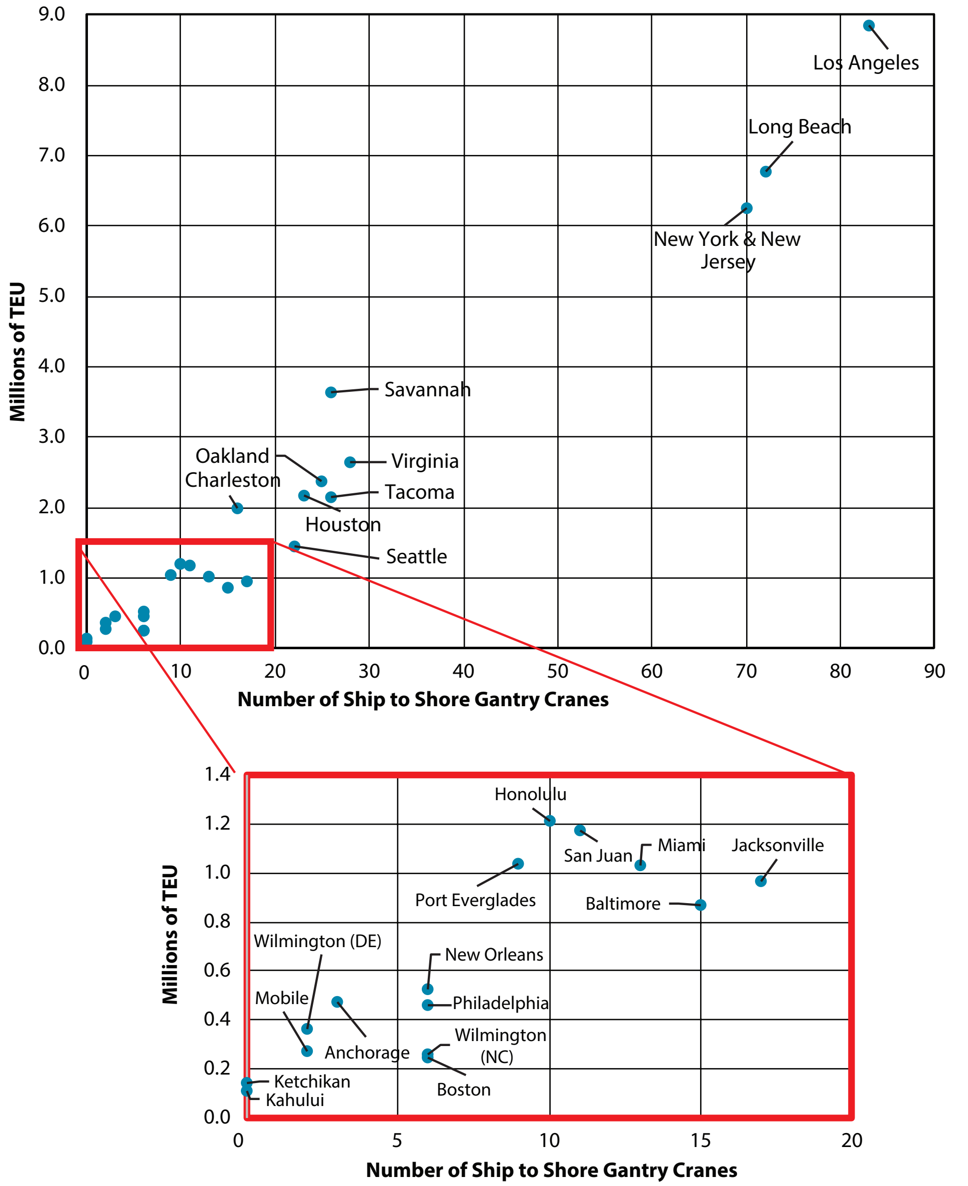
FIGURE 1-11 Vessel Size and Corresponding Port Infrastructure



All cranes or vessels in a column are to scale with each other, but scale differs between columns

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Port Performance Freight Statistics Program*, available at www.bts.gov as of September 2018.

FIGURE 1-12 Container Cranes versus Annual TEU at Top 25 Container Ports, 2016



KEY: TEU = Twenty Foot Equivalent Unit

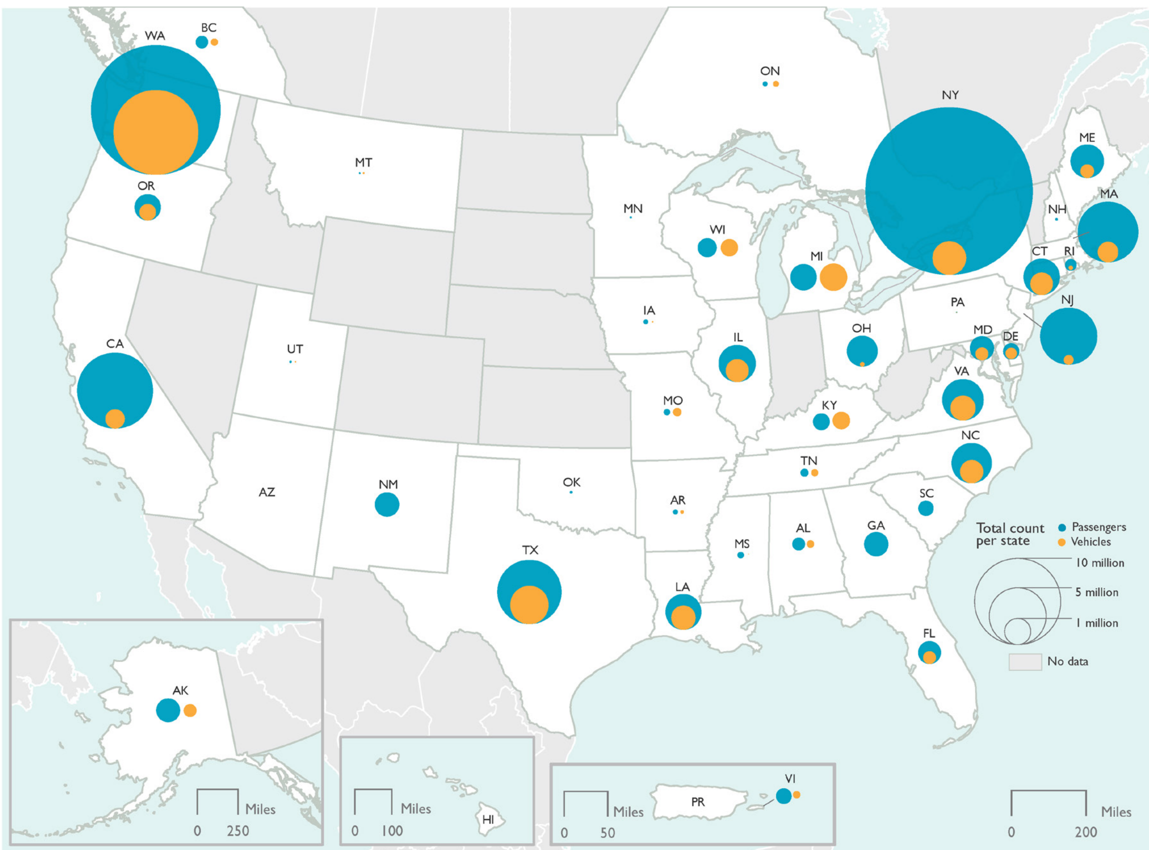
SOURCES: Annual TEU: AAPA, NAFTA Container Traffic: 1997-2016, available http://www.aapa-ports.org/ as of November 30, 2017, port authorities, and USACE, Waterborne Commerce Statistics Center, 2016 data, special tabulation, as of October 2017. **Number of cranes**: port websites including linked terminal-specific websites.

Based on those ferry operations that responded to the 2016 National Census of Ferry Operators (NCFO), a reported total of 118.9 million passengers and 25.0 million vehicles were transported by ferry in 2015.[11] Figure 1-13 shows that New York and Washington, the top two states for total passenger boardings, together reported transporting almost 70 million passengers in 2015 (43.6 and 26.1 million passengers, respectively). Ferry operators in Washington and Texas, the top two states for total vehicle boardings, reporting transport of 11.1 and 2.3 million vehicles, respectively, in 2015.

The highest number of reported ferry route segments were concentrated in the northeast, the west coast, and in Alaska. The top five states with the largest number of reported terminals operated half of the total reported segments. Those top five states are: Alaska (13.8 percent of segments), California (11.1 percent of segments), New York (10.8 percent of segments), Washington (8.9 percent of segments), and Michigan (6.0 percent of segments) [USDOT BTS NCFO 2016].

[11] The National Census of Ferry Operators is conducted every other year and the last available data are from 2015.

FIGURE 1-13 Ferry Passenger and Vehicle Boardings by State: 2016



SOURCE: United States Department of Transportation, Bureau of Transportation Statistics, *National Census of Ferry Operators*, available at www.bts.gov as of August 2018.

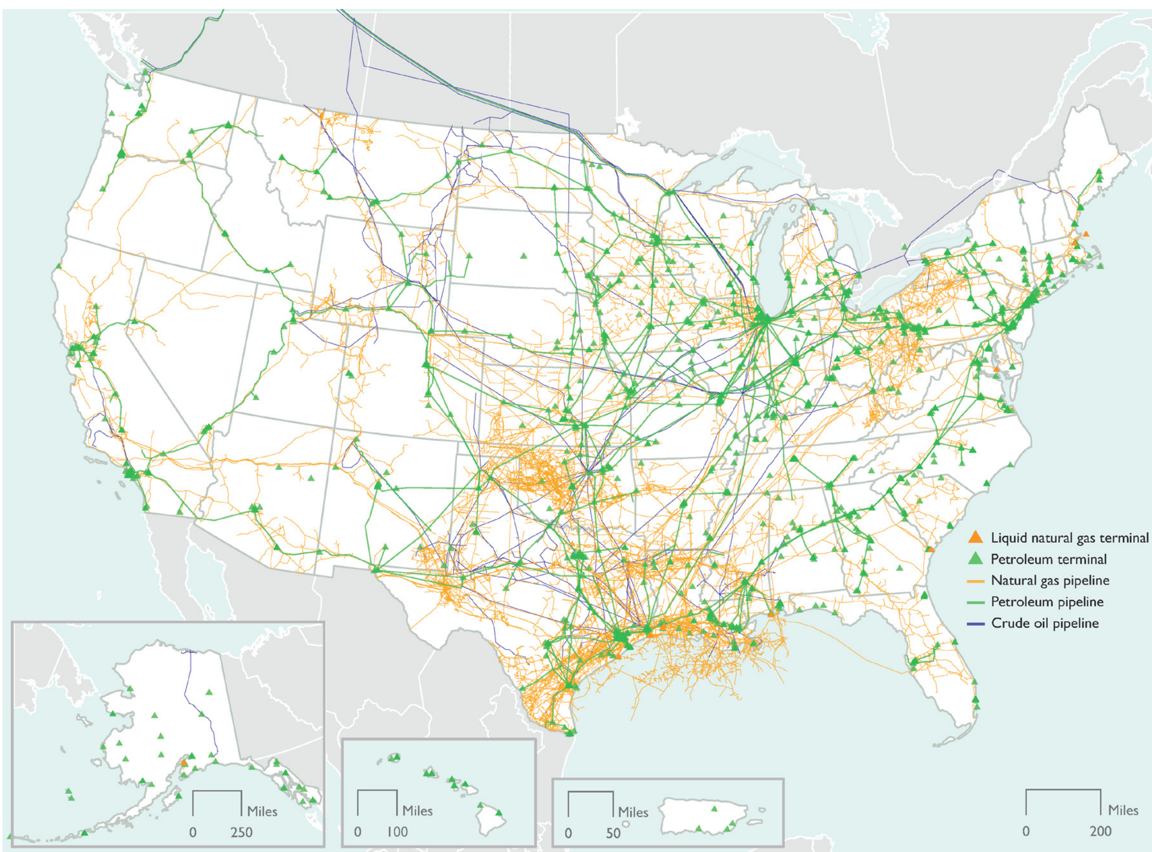
Pipelines

The U.S. natural gas terminal and pipeline system extends across the lower 48 states with higher concentrations in Louisiana, Oklahoma, Texas, and the Appalachia region. The Trans-Alaska Pipeline System is major crude-oil pipeline that extends from Prudhoe Bay to Valdez, Alaska. (figure 1-14). In 2017 natural gas was transported via about 320,000 miles of transmission and gathering pipelines and over 2.2 million miles of distribution main and service pipelines. These pipelines connect to 61 million households and 5 million commercial and industrial users [AGA 2017].

Petroleum terminals, crude oil, and petroleum pipelines form a system that transports crude and refined petroleum to markets across the country (figure 1-14). There were over 215,000 miles of crude/refined oil and hazardous liquid pipelines in 2017. This system carried 3.1 billion barrels across the United States, an increase of 7.6 percent over 2016 [USDOE EIA 2018a].

U.S. natural gas production reached 27.3 trillion cubic feet in 2017. Pipelines deliver about 34 percent of natural gas production to power plants to produce electricity, 29 percent to the industrial sector, 12 percent to the

FIGURE 1-14 U.S. Petroleum and Natural Gas Pipelines: 2018



SOURCE: U.S. Department of Energy, Energy Information Administration, *U.S. Energy Mapping System* available at www.eia.gov as of July 2018.

commercial sector, and 16 percent to homes for heating and cooking [USDOE EIA 2018b].

Although U.S. consumption accounted for 96 percent of the natural gas produced domestically in 2016, an export market is developing for liquefied natural gas (LNG) and numerous LNG marine export terminals [USDOE EIA 2016]. Many terminals in the gulf coast are in the planning, permitting, or construction phases. The United States began exporting LNG in 2014 when a total of 13.3 billion cubic feet were shipped. The transportation of LNG is discussed further in chapter 4.

Intermodal Facilities

Of the approximately 14,000 intercity and transit rail, air, intercity bus, ferry, and bike-share stations in the United States, 57.2 percent offer travelers the ability to connect to other passenger transportation modes [USDOT BTS IPCD 2018a]. The Bureau of Transportation Statistics' Intermodal Passenger Connectivity Database (IPCD) includes the location of the terminal as well as the availability of intercity, commuter, and transit rail; scheduled air service; intercity and transit bus; intercity and transit ferry services; and bike-share availability. There are over 14,000 unique passenger travel facilities, of which 42.8 percent do not offer connections to other passenger transportation modes, 48.3 percent connect to one other mode, 8.7 percent connect to two other modes, and 0.2 percent connect to three other modes (e.g., bus, air, rail, ferry, or bikeshare).

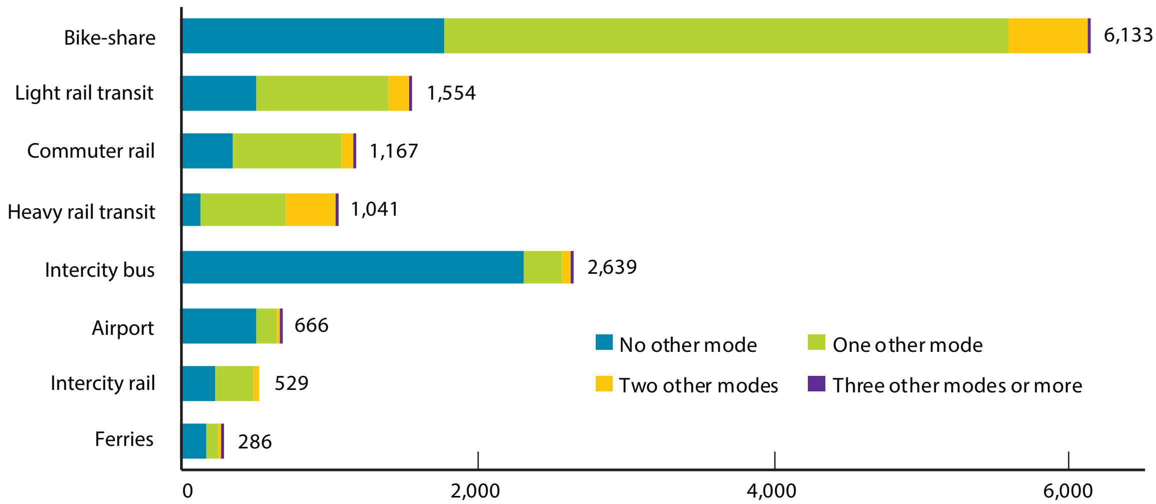
After bike-share, the transit modes that have the highest percent of intermodal connections are heavy rail transit (87.1 percent of 1,041 facilities), commuter rail (70.4 percent of 1,167 facilities), and light rail transit (67.5 percent of 1,554 facilities) (figure 1-15). Of the intercity modes, there are more intercity bus stops (2,639) than air (666) and intercity rail facilities (529) but only 12.6 percent of intercity bus stops connect to another passenger transportation mode, including bike-share and transit bus. In contrast, 54.1 percent of intercity rail facilities and 23.7 percent of airports connect to another passenger transportation mode.

Challenges

The National Transportation Atlas Database (NTAD), released annually by BTS, is a set of nationwide geographic databases of transportation facilities, transportation networks, and associated infrastructure. These datasets include spatial information for transportation modal networks and intermodal terminals, as well as the related attribute information for these features. For intermodal freight terminals, the attribute data show the geographic location of the facility, which modes connect, and the directionality of the connections [USDOT BTS NTAD 2018b].

Both databases are focused on geography, as they indicate where things are and what interconnects are possible. However, they do not provide any operational data and information on their usage. Also, there has not been a recent summary analysis of the content and coverage of the NTAD freight intermodal connectors.

FIGURE 1-15 Intermodal Passenger Facilities by Mode: 2018



NOTES: *Intercity bus connection* includes: intercity, code share, and supplemental bus service. *Transit rail connection* includes: light rail, heavy rail, and commuter rail. *Ferries* includes both transit ferry and intercity ferry.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Intermodal Passenger Connectivity Database*. Available at www.bts.gov as of October 2018.

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CHAPTER 2

Condition and Performance

Highlights

- The average age of many U.S. transportation system components is increasing, indicative of long-term trends in condition deterioration. For example, in 2017 nearly 60 percent of structurally deficient bridges were built prior to 1960, which is approaching the life expectancy of a bridge without major rehabilitation.
- The Nation's inland water lock system faces the most condition and performance challenges given the average age of all locks is over 60 years. Of the nine waterways for which the U.S. Army Corps of Engineers has responsibility for lock operation and condition, the average delay per vessel in 2017 had increased by 140 percent since 2000.
- Due to reinvestment in the system, the condition of the Nation's highway system for higher function roads and bridges has improved since 2000. Asset conditions that limit use can have significant disruptive impacts (e.g., load restrictions on bridges) and result in increased costs (e.g., delivery delays, costly detours, the need for lighter trucks or loads).
- Half of all highway vehicles owned by households in 2017 were more than 9 years old. Keeping old cars on the road slows adaptation of the latest vehicle technologies. For example, estimates indicate that 4 out of 10 drivers could be driving vehicles that do not have safety technologies that are standard in newer vehicles.
- From 2013 to 2017, 14 of the 52 largest metropolitan statistical areas showed reductions in congestion, while 9 showed worsening congestion, and 39 had some congestion measures increase while others decreased.
- Accessibility to jobs and other destinations is an important characteristic of transportation system performance. Although no national data is collected as part of Federal programs, recent studies have found that the number of jobs reachable within a given driving time was typically 10 to 25 percent lower during the congested times of the day for the top 10 cities as ranked by job accessibility.
- Although airline on-time departures and arrivals have seen steady improvement in recent years, the average duration of delays has increased.
- The percent of on-time arrivals for Amtrak service improved from 67.8 percent in 2006 (the worst performance since 2000) to 79.1 percent in 2016, with long-distance trips the most likely to be delayed.
- Risk-based asset management programs have become an important tool for transportation agencies to manage assets while considering potential disruptions to the transportation system, thus improving system reliability.

Condition and Performance Relationship

The performance of transportation systems depends on many factors, including whether the system has the physical capacity to handle demand (e.g., are there enough lanes to handle peak motor vehicle traffic or enough vehicles to serve transit ridership?) Is there adequate operational capacity (e.g., is the system efficiently managed to obtain maximum throughput?). Is the system resilient enough to efficiently recover from disruptions? Is the condition of the system and its corresponding assets sufficient to achieve the desired performance? This latter issue is of particular concern to transportation officials in that growth in travel demand, which has characterized U.S. transportation systems over the past several decades (see chapter 1), often results in more wear and tear on the system.

The connection between asset condition and overall system use and performance is a well-known relationship, generally showing that system performance deteriorates as the condition of assets worsens [SPY POND PARTNERS ET AL 2018]. Examples of this relationship include the following:

- deficient bridges and the subsequent load restrictions on trucks;
- deteriorating rail track and mandatory lower train speeds over affected track sections;
- poor conditions of waterway locks and delayed barge travel as locks are closed for repair or maintenance;
- transit and rail vehicle breakdowns and subsequent delays to the rest of the system (especially on dedicated right-of-ways, causing delays to ripple through the network);
- rough pavement conditions resulting in lower speeds and potential damage to vehicles using the road; and
- general aging of a vehicle fleet, leading to a more cautious and limited provision of service.

Various measures are used to gauge the condition and performance of the national transportation system. Measures of the physical condition of an asset are reported to national databases for some asset categories, such as roads and bridges. Others measures report average age of a system's assets or do not report any condition measure at all. "Average age" is often viewed as a surrogate measure for the condition of a transportation system's assets. Although there is some validity to this relationship, assets can be rehabilitated and/or receive preventative maintenance to function as desired (referred to as state-of-good-repair). For example, 12.3 percent of the Nation's road bridges built in the period 1950 to 1959 (i.e., older bridges) are rated in poor condition[1] today as compared to just less than 2 percent of the bridges constructed from 1990 to 1999 [FHWA 2018a]. The percentage of older bridges in poor condition would likely be much higher without preventative maintenance or rehabilitation.

This chapter presents the transportation system condition and performance measures

[1] Bridge condition is determined by the lowest rating of National Bridge Inventory (NBI) condition ratings for decks, superstructure, substructure, and culverts.

as found in national databases. In some cases, in the absence of age or asset condition data, this chapter uses the change in level of rehabilitation/reconstruction investment as an indication of the need to bring assets up to a state-of-good-repair. Note that the use of rehabilitation/reconstruction investment as a surrogate for financial need is simply an indicator and only represents a close estimate if the cost is incurred in the near term. For example, a $100 million rehabilitation need today will cost more in the future (due to inflation) if the investment is not undertaken during the early years of the investment program. "Condition" and "performance" will thus be presented in different ways for different modes of transportation. Box 2-A includes a discussion of risk-based transportation asset management.

Roads, Bridges, and Vehicles

Condition

Roads and Highways

The U.S. Department of Transportation's (USDOT's) Federal Highway Administration (FHWA) reports the International Roughness Index (IRI), which measures the smoothness of pavement and is a key indicator of highway condition.[2] The physical deterioration of roads and bridges typically does not produce abrupt failures; rather, continued rough riding produces repetitive and gradual increases in vehicle maintenance and other highway user costs. For both urban and rural roads, as the

[2] A highway with a roughness rating greater than 170 inches per mile is considered in poor condition.

Box 2-A Risk-Based Transportation Asset Management

Over the past 20 years many transportation agencies throughout the world have adopted transportation asset management principles and approaches for managing the condition and performance of their transportation assets. Transportation asset management has been defined by the American Association of State Highway and Transportation Officials (AASHTO) as "a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycle" [USDOT FHWA 2017a]. Recently, transportation asset management has incorporated concepts of risk management to account for "risks that are inevitable; and it is incumbent on every steward of shared resources to anticipate risk, strategize how to mitigate it or capitalize upon it and be prepared to act when it arises" [USDOT FHWA 2012].

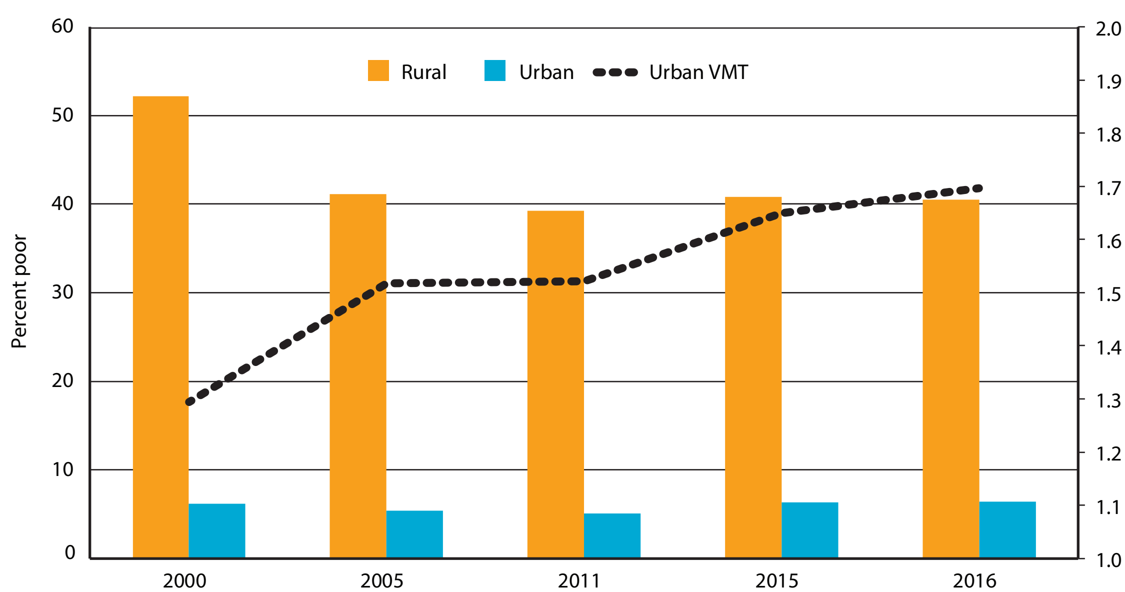
Every state Department of Transportation (DOT) in the United States is required to have a risk-based asset management program in place, while the Federal Transit Administration (FTA) requires Federal transit grantees to develop asset management plans for their public transportation assets, including vehicles, facilities, equipment, and other infrastructure. Much of the transportation asset condition data in the United States are found in these agency asset management systems and are not incorporated into compilations of national transportation statistics. The "picture" of a state's transportation asset condition is most likely best developed by accessing these individual databases.

classification of roadways decreases from a higher to a lower road classification (e.g., from interstates to local roads), the percentage of roads with rough pavements increases. This pattern is likely the result of road maintenance, rehabilitation programs, and budgets that favor roadways with higher throughput (i.e., higher roadway classification).

The percentage of high function roads with poor pavement conditions has stayed relatively stable since 2005 (figure 2-1) for both urban and rural National Highway System (NHS) roads[3] [USDOT BTS 2017a]. The roads that handle the greatest percentage of vehicle traffic are the roads that are most eligible for Federal funding as part of the NHS. The noticeable improvement from 2000 to 2005 in urban pavements occurred due to the targeted investment of state transportation agencies on improving pavement conditions. Pavement condition improvements post 2005 also reflect grants from the *Transportation Income Generating Economic Recovery* (TIGER) program authorized by the *American Recovery and Reinvestment Act* of 2009. Even with increases in traffic volumes over this period in urban areas (resulting in more stress on pavement conditions), figure 2-1 suggests that states have been able to maintain the pavement condition on high function roads due

[3] The National Highway System (NHS) is a network of major highways proposed by the States, approved by the U.S. DOT and submitted to Congress.

FIGURE 2-1 Rural v. Urban High Function Roads with Poor Pavement Condition, and Urban Vehicle-Miles Traveled: 2000, 2005, 2011, 2015, and 2016



NOTES: In the above figure, the higher functionally classified roads in the urban category included interstates, other freeways and expressways, and other principal arterials for the entire road network. For the rural classified roads, the functional classification included interstates and other principal arterials. No data was reported for 2010 due to a change in the data model, so the data reported for 2011 was used for this period. Poor condition is defined as any pavement with an IRI value greater than 170 inches/mile.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, tables 1-27 and table 1-36, available at https://www.bts.gov/ as of September 2018.

primarily to increased investment in pavement replacement and rehabilitation.

A closer look at the pavement condition data by road type (functional classification) shows the differences between urban and rural areas for both pavement condition and the trends over time. Table 2-1 indicates the short-term (2011– 2016) and long-term change (2000–2016) for pavements rated in poor condition by class of road and by urban versus rural classification [USDOT BTS 2017a]. The trend in improved pavement condition was more evident for urban than for rural roads between 2011 and 2016. Each of the rural road categories showed declining pavement condition, whereas three of the five urban road categories showed improvement, although the change in percentages was relatively small (figure 2-1). For lower classified roads in rural areas, 22.1 percent of rural collector road pavements in 2000 were rated in poor condition; this percentage had decreased to 21.9 percent by 2016. The corresponding change in urban collector roads was an improvement from 52.3 percent in poor condition in 2000 to 50.8 percent in 2016.

Bridges

The number of the Nation's bridges in poor condition[4] declined by nearly 9,500 between 2012 and 2017— a decrease from 9.4 percent

[4] A "poor" bridge condition rating is determined by the lowest rating of the National Bridge Inventory (NBI) condition ratings for bridge deck, superstructure, sub-structure, or culverts.

TABLE 2-1 Trends in Rural v. Urban Pavement Conditions (as measured in trend of "poor" rating), 2000–2016 and 2011–2016

Classification	Long-term 2000–2016	Short-term 2011–2016
Urban		
Interstates	↑	↓
Other freeways/expressways	↑	↓
Other principal arterials	↑	↑
Minor arterials	↓	↑
Collectors	↓	↑
Rural		
Interstates	↑	↓
Other principal arterials	↑	↓
Minor arterials	↑	↓
Major collectors	↑	↓

NOTE: An up arrow indicates improved pavement condition, while a down arrow indicates deterioration.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 1-27, *Condition of U.S. Roadways by Functional System*. Available at https://www.bts.gov/ as of September 2018.

of 607,380 bridges (57,049) to 7.7 percent of 615,002 bridges (47,619) [USDOT FHWA 2018a]. Over this same period, the percent of NHS bridges[5] considered in poor condition declined from 4.4 percent of 117,485 bridges to 3.3 percent of 145,104 bridges. The percent of non-NHS bridges in poor condition declined from 10.6 percent in 2012 to 9.1 percent in 2017 [USDOT FHWA 2018b].[6] The percent of bridges in poor condition was two-and-a-half to almost three times more for non-NHS bridges as compared to NHS bridges. While the NHS covers 221,919 miles of the total of 4,140,108 miles of road in the Nation [USDOT FHWA 2017b], it carried 54.8 percent of the Nation's total 3.2 trillion vehicle-miles of travel in 2016 [USDOT FHWA 2017c].

The FHWA recently created the "poor" condition for bridges that have section loss, deterioration, cracking, spalling, scour, or seriously affected primary structural components, whereas previously "structurally deficient" was used to identify bridges with a reduced load bearing capacity due to the deterioration of one or more bridge elements. Structurally deficient bridges are not necessarily unsafe, but they do require maintenance and repair to remain in service and will eventually require rehabilitation or replacement. Over the long term, the percent of the Nation's bridges rated as structurally deficient was reduced by almost half between 2000 and 2017. In 2017, 8.9 percent (54,560) of all the Nation's bridges were considered structurally deficient, an improvement from 11.7 percent (70,427) in 2010 and 15.2 percent (89,415) in 2000 [USDOT FHWA 2018a]. The decreasing percentage of bridges considered structurally deficient is evident for NHS bridges. This reduction in structurally deficient bridges and the number of bridges considered in poor condition was primarily the result of targeted investment on the part of State DOTs to improve bridge conditions.

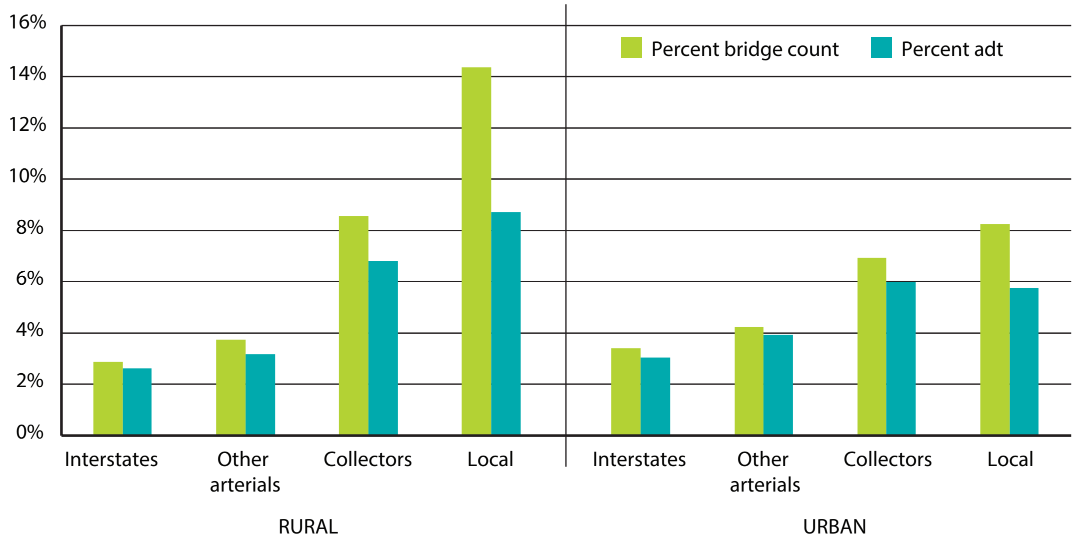
The same improvement is shown for structurally deficient bridges in both urban and rural areas [USDOT FHWA 2018a]. In 2000, 16.7 percent of rural bridges and 10.2 percent of urban bridges were considered structurally deficient. By 2017 the relative percentages were 10.1 and 5.7 percent, respectively. Similar to the previous observation concerning bridges considered in poor condition, in 2017 the percent of rural bridges considered structurally deficient was nearly twice that of bridges in urban areas. Figure 2-2 shows deficient bridges account for 14.4 percent of bridges and 5.7 percent of the throughput (average daily traffic[7]) on rural local roads. In comparison, deficient bridges account for 8.3 percent of bridges and 8.7 percent of the throughput (average daily traffic) on urban local roads. Essentially, the most-used bridges are in better shape, just as NHS interstates and bridges are in better shape than their smaller, non-NHS counterparts.

[5] NHS bridges are those bridges located on the designated network.

[6] 2012 is the first year available reflecting the Federal Highway Administration new condition-based performance measures, such as "the percent of NHS bridges by deck area classified as in poor condition."

[7] Average daily traffic is the average 24-hour volume, calculated as the total volume during a stated period divided by the number of days in that period. Normally, this would be periodic daily traffic volumes over several days, not adjusted for days of the week or seasons of the year.

FIGURE 2-2 Percent of Deficient Bridges and Average Daily Traffic on Deficient Bridges by Urban and Rural Road Function 2017



KEY: ADT = Average Daily Traffic

NOTES: Average daily traffic is the average 24-hour volume, calculated as the total volume during a stated period divided by the number of days in that period. Normally, this would be periodic daily traffic volumes over several days, not adjusted for days of the week or seasons of the year.

SOURCE: U.S. Department of Transportation, FHWA, Office of Bridge Technology, National Bridge Inventory (NBI), *Count of Bridges by Highway System*, available at http://www.fhwa.dot.gov/bridge/fc.cfm as of September 2018; and Bureau of Transportation Statistics, National Transportation Statistics, table 1-28.

Of the 54,560 structurally deficient bridges in 2017, 59.4 percent (32,380 bridges) were built prior to 1960, nearly 60 years old, which is approaching the life expectancy of a bridge without major rehabilitation.[8] Just over 34 percent (18,659 bridges) of structurally deficient bridges were built prior to 1940 [USDOT FHWA 2017d].

In 2017, 61,020 out of the 610,981 total bridges open to traffic had some type of load restriction, comprising 10.0 percent of all bridges [USDOT FHWA 2017e]. The percentage of the Nation's bridges with restricted postings was 11.0 percent in 2010 and 12.6 percent in 2000, showing a slight improvement in poor bridge condition. These load restrictions can cause commercial vehicle operators to carry smaller payloads or take circuitous routes, either of which can increase delivery costs.

Vehicle Fleet

The average age of the highway motor vehicle fleet in the United States has increased over time. As of 2017, the average age of the light-duty vehicle fleet[9] in the Nation was 10.3 years; half of all household vehicles were older

[8] Note that one cannot determine from the national database summaries which specific bridges have been rehabilitated or how many have received more than one rehabilitation treatment.

[9] A light-duty vehicle is defined by the U.S. Environmental Protection Agency as a passenger car with a maximum Gross Vehicle Weight Rating (GVWR) < 8,500 lbs.

than 9 years (the median age) [USDOT BTS 2017b]. In comparison, the average vehicle in 1977 was just under 7 years old and in 2001 it was 9.1 years. The 2017 National Household Travel Survey (NHTS) found that 19.7 percent of the Nation's household vehicles were 20 years or older and 59 percent were 10 years or older [USDOT NHTS 2018]. For pick-up trucks, the change in average age went from 10.1 years in 2001 to 13.1 years in 2017. The average age for vans increased from 7.6 years in 2001 to 10.7 years in 2017. The commercial truck fleet is slightly older with an average age of 11.9 years. The average age of a heavy commercial truck was 14.0 years in 2015, up from 12.5 years in 2007. Box 2-B describes the implications of an aging motor vehicle fleet, especially for the adoption of new automotive technologies.

Transit Systems

Condition

With a few exceptions, the average age of the Nation's transit fleet declined from 2000 to 2010, although it has been on the increase since 2010 (figure 2-3). The decline in the average age of rail vehicles and ferryboats in the mid-2000s was due to an investment by many cities in expanding rail transit systems and replacing ferry assets. The greatest increase in average age was for commuter rail

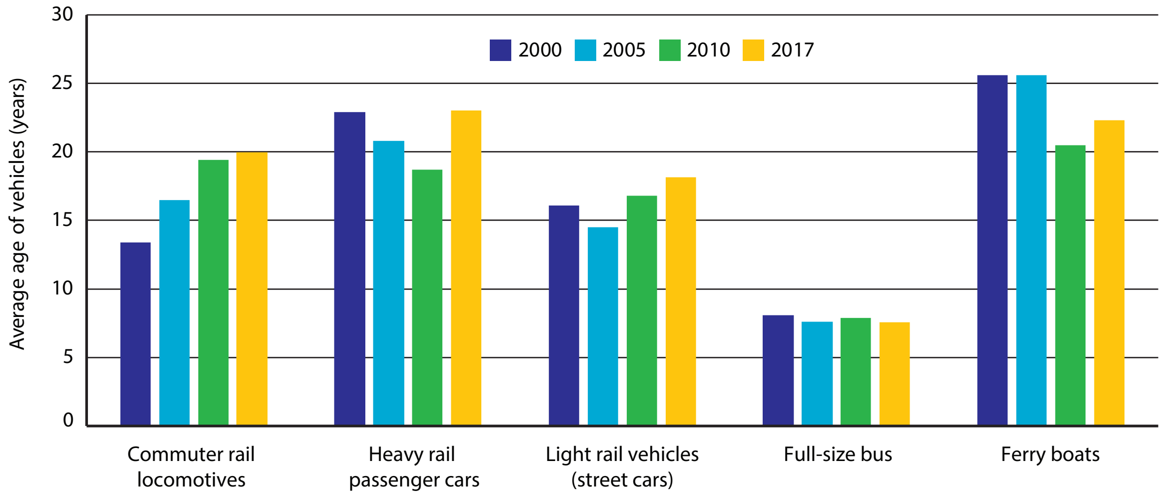
Box 2-B Implications of the Aging Motor Vehicle Fleet for Adoption of New Technology

This increasing average age of the vehicle fleet is the result of vehicle owners keeping older vehicles longer than in the past, which may be due to a host of reasons, such as changes in driving habits, deferred new car purchases due to budget constraints, and vehicles lasting longer due to improvements in vehicle quality.

According to the 2017 National Household Travel Survey (NHTS), the youngest and oldest drivers are more likely to drive older vehicles, which is a reflection of the income effect on vehicle ownership. The differences are greater for people living in rural areas, where just over 11 percent of drivers aged 16–19 and 20–24 and almost 14 percent of drivers 85 and older are driving pre-1998 model year vehicles. A higher proportion of younger and older drivers are also driving vehicles from 1998–2007 model years, which has safety implications [USDOT FHWA NHTS 2017].

Tracking the age of the household-based fleet is important in part because the longer people keep their cars the longer it takes for a new vehicle technology to penetrate the market in a significant way. For example, in the 1990s airbags were required as standard equipment, and in 1998 passenger-side airbags were made standard equipment on new vehicles. In 2007, electronic stability control (ESC), which uses computer-controlled braking, was mandated on all passenger and light-duty vehicles. Before the mandate (in model year 2006), about 29 percent of vehicles were equipped with ESC, which the National Highway Traffic Safety Administration (NHTSA) mandated to be standard equipment for all new vehicles by 2012. According to the 2017 NHTS, 36 percent of the vehicles in daily use are model years between 1999 and 2007. Thus, nationwide, up to 4 out of 10 drivers could be driving vehicles that do not have at least one of these two standard safety technologies (i.e., passenger-side airbags and ESC).

FIGURE 2-3 Average Age of U.S. Transit Vehicle Fleets, Select Modes: 2000, 2005, 2010 and 2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 1-29, available at https://www.bts.gov/ as of September 2018.

locomotives, which increased from 13.4 years in 2000 to 19.7 years in 2016 [USDOT BTS 2017c].

The Nation's transit full-size bus fleet is newer than the commuter rail fleet, which has locomotives and rail cars that typically last for decades. The average age of ferry boats makes them the oldest part of the Nation's transit system, although the average age of rail transit vehicles increased to a comparable level in recent years.

According to the USDOT's 2015 *Biennial Conditions and Performance Report*,[10] 31.4 percent of the Nation's transit guideways (tracks, ties, switches, ballasts, tunnels, elevated structures, and bus guideways) were in poor condition—defined as having seriously damaged components in need of immediate repair [USDOT FHWA 2015]. The percentages for control and communications systems, facilities, vehicles, and stations in poor condition were 15.1, 4.8, 4.0, and 2.1 percent, respectively. For rail guideways and stations, over one-third of these assets were considered in a poor state-of-good-repair.

Most of the data on transit asset condition come from national statistics reported for urban areas, with limited data available on the condition of transit vehicles in rural areas. The Upper Great Plains Transportation Institute estimated that the average age of buses in rural area service rose between 2011 and 2015, from 6.4 to 7.8 years (21.9 percent increase); for vans from 5.4 to 6.9 years (27.8 percent increase); and for school buses from 10.0 to 13.7 years (37.0 percent increase) [UGPTI 2017]. This is comparable to the trends seen during this period for urban transit fleets as well.

[10] The most recent available at time this analysis was conducted.

The transit industry has made progress improving the reliability of service, primarily through preventative maintenance and investments in state-of-good-repair. The number of major mechanical failures (the bar graph in figure 2-4) for transit vehicles and the number of miles between such failures (the line graph in figure 2-4) have both shown improvement since 2010. Major mechanical system failures decreased 25.4 percent between 2010 and 2016. The number of miles driven between mechanical failures increased 33.1 percent over the same period.

Performance of Highway and Transit Systems

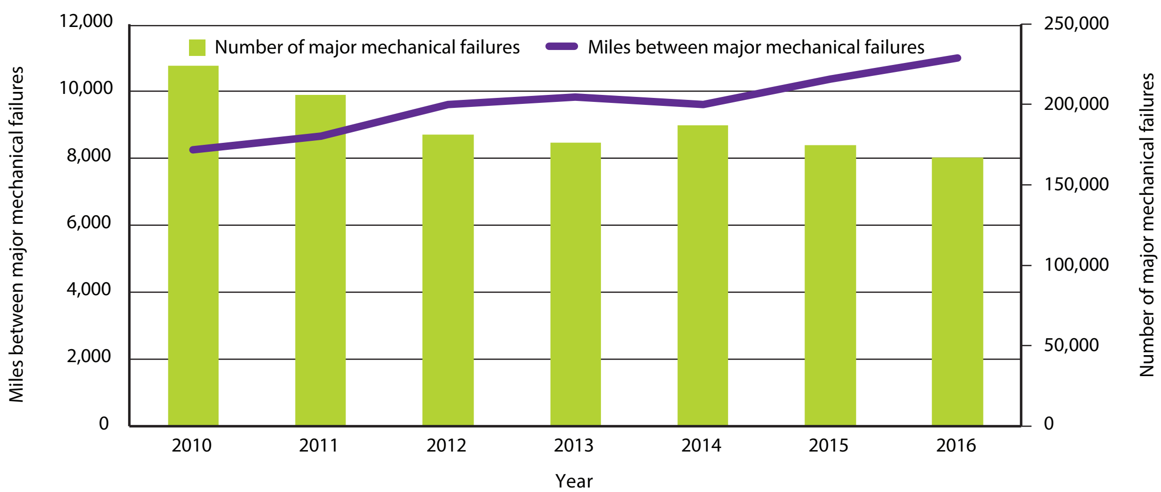
Many characteristics of the Nation's highway and transit systems' performance influence traveler decisions on when, how, and where they travel, especially for discretionary trips. Two important transportation system characteristics that reflect highway and transit system performance are system congestion and accessibility to destinations.

System Congestion

Road congestion is one of the most visible and challenging characteristics of transportation system performance.[11] Relieving road congestion has been one of the main incentives for investing in the Nation's road network. Since the early 1980s, when national congestion indices were first applied, the trend in road congestion was steadily increasing in urban areas of all sizes. The most recent data suggests that the trend is now mixed, with some areas still seeing increased congestion, while others saw little change or even declines [USDOT FHWA 2017f].

[11] Accessibility and congestion are often linked in that accessibility usually uses travel time for determining levels of accessibility, and travel time is affected by congestion.

FIGURE 2-4 Bus Miles Failures and Number of Major Failures: 2010–2016



SOURCE: U.S. Department of Transportation, FTA, *National Transit Summaries & Trends 2016*, available at https://www.transit.dot.gov/ as of September 2018.

Congestion measures on a national scale are reported in the FHWA Urban Congestion Report based on vehicle probe data.[12] The report tracks congestion measures in the 52 largest metropolitan statistical areas (MSAs). The freeway traffic speeds database used by FHWA provides day-to-day travel times in 5-minute intervals for trucks, passenger vehicles, and all vehicles. One of the key performance measures is hours of congestion—the daily amount of time that freeways operate at less than 90 percent of free-flow freeway speeds.

Table 2-2 shows the change in daily congestion hours and minutes from 2013 to 2017, the period having the most complete data. Thirteen of the 52 MSAs (25 percent) showed a decrease in daily hours of freeway congestion times of more than an hour (e.g., Memphis, Minneapolis, and Pittsburgh). Three of the MSAs (5.8 percent) showed an increase in daily hours of freeway congestion times of more than an hour (specifically, Atlanta, Birmingham, and Portland). The overall average of daily freeway congestion time for the 52 MSAs shows a 5.9% reduction of 16 minutes.

System Accessibility

One of the fundamental purposes of all transportation systems is to provide access to destinations. The Nation's road network provides access to nearly every destination in the United States (although some cities and towns in Alaska are only accessible by ship and/or airplane). Thus, for roads, accessibility measures often include an indication of the amount of time necessary to reach certain locations (e.g., how many jobs can be reached within 30 minutes?). For transit, system performance includes the degree to which transit service is available to the service area population or key destinations [TRB 2013].[13]

The University of Minnesota Center for Transportation Studies (CTS) examined private automobile access in the top 50 most populous U.S. metropolitan areas [Accessibility Observatory 2016]. This study looked at the "congestion effect," which was defined as the percent decrease in the number of jobs that can be reached within specified time thresholds at congested times of day relative to free-flow times. The report noted that for the top 10 cities as ranked by job accessibility, the number of jobs reachable within a given driving time was typically 10 to 25 percent lower during congested times of the day.

One of the key measures used for transit accessibility is the number of jobs within a certain distance from a transit route (often one-quarter mile for bus and one-half mile for rail services). Another CTS study, this one on transit, found an increase in job accessibility by transit in 42 of the 49 most populous metropolitan area between 2015 and 2016. The greatest increases occurred in medium-sized cities, such as Kansas City, MO where accessibility to jobs improved by more than 17 percent, Charlotte, NC, at 11 percent, Austin, TX, at 9.8 percent and Columbus, OH, at 9.0

[12] Vehicle probe data are based on real-time vehicle positions, typically obtained from the vehicle's global positioning system (GPS) receiver or the operator's mobile phone.

[13] Accessibility for those with mobility impairments is discussed in chapter 3.

TABLE 2-2 Congested Hours (metropolitan statistical areas with a population > 1 million): 2013 v. 2017

MSA name	Congested hours (hh:mm) 2013	Congested hours (hh:mm) 2017	Congested hours, change (hh:mm)
All 52 MSAs	4:33	4:17	-0:16
Atlanta GA	3:21	4:58	+0:00
Austin TX	3:57	4:56	+0:00
Baltimore MD	5:58	6:01	+0:00
Birmingham AL	0:39	2:06	+0:00
Boston MA	6:30	5:13	-1:17
Buffalo NY	5:56	4:51	-1:05
Charlotte NC	3:31	3:17	-0:14
Chicago IL	6:35	5:28	-1:07
Cincinnati OH	3:15	2:53	-0:22
Cleveland OH	4:06	2:28	-1:38
Columbus OH	2:52	2:32	-0:20
Dallas-Fort Worth TX	6:12	4:44	-1:28
Denver CO	6:50	6:11	-0:39
Detroit MI	4:17	3:55	-0:22
Hartford CT	2:45	3:02	+0:00
Houston TX	4:53	5:50	+0:00
Indianapolis IN	2:32	2:13	-0:19
Jacksonville FL	3:03	3:23	+0:00
Kansas City MO	3:20	2:48	-0:32
Las Vegas NV	3:57	3:49	-0:08
Los Angeles CA	9:31	9:22	-0:09
Louisville KY	2:51	2:06	-0:45
Memphis TN	4:30	2:53	-1:37
Miami FL	7:03	6:08	-0:55
Milwaukee WI	4:27	3:16	-1:11
Minneapolis-St. Paul MN	6:53	5:02	-1:51
Nashville TN	3:15	2:50	-0:25
New Orleans LA	4:07	4:08	+0:00
New York NY	8:56	7:03	-1:53
Oklahoma City OK	2:54	2:11	-0:43
Orlando FL	5:17	3:48	-1:29
Philadelphia PA	6:00	4:46	-1:14
Phoenix AZ	2:51	2:41	-0:10
Pittsburgh PA	5:32	3:40	-1:52
Portland OR	6:25	7:40	+0:00
Providence RI	3:47	4:34	+0:00
Raleigh NC	1:37	2:16	+0:00
Richmond VA	3:00	2:05	-0:55
Riverside-San Bernardino CA	4:39	4:55	+0:00
Rochester NY	3:19	3:06	-0:13
Sacramento CA	4:47	4:39	-0:08
Salt Lake City UT	2:30	3:20	+0:00
San Antonio TX	3:22	3:27	+0:00
San Diego CA	3:30	4:27	+0:00
San Francisco CA	7:12	7:08	-0:04
San Jose CA	5:06	5:43	+0:00
San Juan PR	3:21	4:16	+0:00
Seattle WA	6:44	7:16	+0:00
St Louis MO	3:55	2:17	-1:38
Tampa FL	2:41	2:59	+0:00
Virginia Beach VA	5:32	5:07	-0:25
Washington DC	6:45	6:54	+0:00

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics based upon data from USDOT, FHWA, available at https://ops.fhwa.dot.gov/ as of September 2018.

percent. The largest metropolitan area with the greatest increase was San Francisco, CA, at 8.7 percent [Accessibility Observatory 2017].

Airports and Airplane Fleet

Condition

Airports

Although the Nation's aviation system consists of numerous airport assets, including runways/aprons, terminals, air traffic control systems, support structures, and parking garages, the only airport-related asset condition data reported to the Federal Aviation Administration (FAA) is the condition of runway pavements. The FAA's goal is to ensure that not less than 93 percent of runways at 503 commercial airports (those receiving scheduled passenger service and having at least 2,500 enplaned passengers per year) receive at least a "fair" rating. Since 2000 this rating has been a stable 98 percent [USDOT BTS 2016].[14] For the 3,332 airports (2017) in the National Plan of Integrated Airport Systems (NPIAS),[15] this percentage was 95 percent in 2000 and has stayed at a consistent 98 percent since 2011.

The NPIAS report, submitted by the FAA to Congress every 5 years since 1984, provides an estimate of the capital needs of the Nation's airports. The latest 5-year report for fiscal years 2017 to 2021 identified 3,340 public-use airports that are important to national air transportation and estimated a need of approximately $32.5 billion in Airport Improvement Program (AIP)-eligible airport projects during that period [USDOT FAA 2016]. The report concluded that the allocation of these funds for airport infrastructure capacity improvement had declined in recent years, while funding for reconstructing pavements, bringing airports up to design standards, and expanding or rehabilitating terminal buildings was projected to increase. Many of these projects are focused on complying with safety standards. Although there is some overlap in how the types of investments are categorized, just over 68.5 percent ($22.3 billion) of the total projected costs in the NPAIS timeframe are for reconstruction or bringing assets into compliance with safety and design standards [USDOT FAA 2016]. This funding allocation is an indication of the relative importance of asset condition as part of the Nation's investment in airports.

Aircraft

The average age of U.S. commercial airline aircraft declined slightly between 2000 and 2017 [USDOT BTS 2017d]. In 2017 the average aircraft age for the largest airlines (called majors[16]) was 13.2 years. For the next level of airlines (called nationals[17]), the average aircraft age was 10.8 years; and for regional airlines the average aircraft age was

[14] FAA rates pavement as: "good"—all cracks and joints are sealed; "fair"—mild surface cracking, unsealed joints, and slab edge spalling; and "poor"—large open cracks, surface and edge spalling, vegetation growing through cracks and joints.

[15] The NPIAS contains all commercial service airports, all reliever airports, and selected public-owned general aviation airports identified by FAA Order 5090.3C.

[16] Major airlines are those with more than $1 billion dollars of annual revenue.

[17] National airlines include those with over $100 million to $1 billion dollars of annual revenue.

25.3 years.[18] The aircraft flown by major and national airlines are roughly half the age of smaller planes used by regional airlines. There are no public data to indicate the condition of the aircraft fleet.

Performance

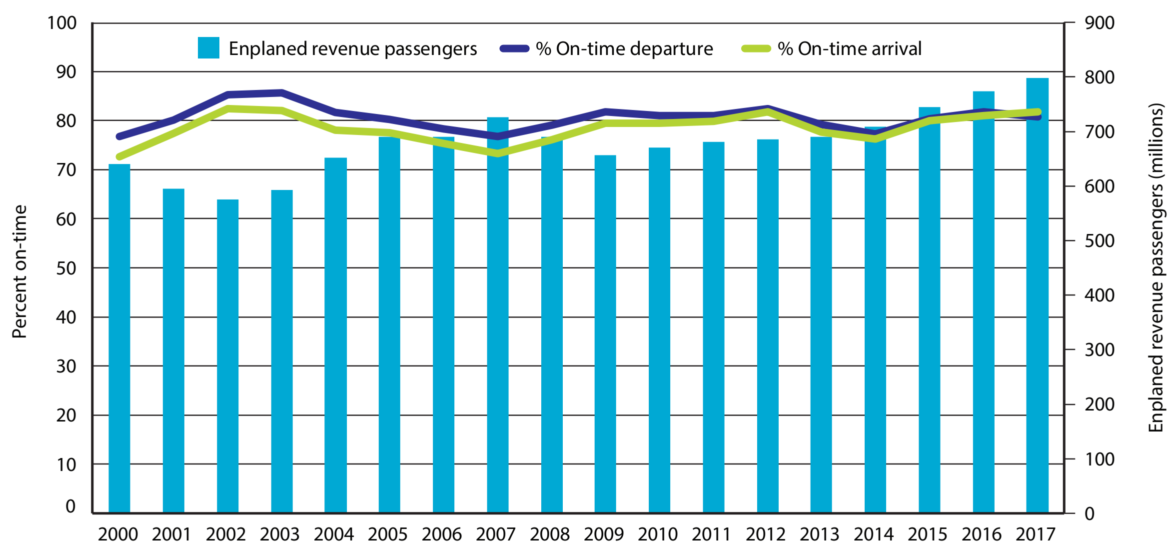
The on-time departure and arrival performance of the aviation system has seen improvement since 2007, the lowest performance in the past 10 years (figure 2-5). The percent of on-time arrivals increased from 73.4 percent in 2007 to 80.2 percent in 2017 [USDOT BTS 2018b]. The percent of on-time departures during that period rose from 76.7 percent of on-time in 2007 to 80.7 percent in 2017 (although there were fluctuations during the intervening years).

[18] Regional airlines are those with annual revenue of $100 million and under.

The causes for flight arrival delays have remained relatively constant since 2005 (figure 2-6), except in 2005 when more delays were attributed to the National Aviation System (NAS) (this percentage dropped below air carrier delays in 2009 and has remained lower since).[19] The largest cause for arrival delay continues to be the aircraft arriving late from its previous destination, which can cause delay to reverberate throughout the plane's remaining schedule (depending on the recovery time built

[19] National Aviation System (NAS)-related delays and cancellations refer to a broad set of conditions, such as moderate or non-extreme weather conditions, airport operations, heavy traffic volume, and air traffic control. Extreme weather is significant meteorological conditions (actual or forecasted) that, in the judgment of the carrier, delays or prevents the operation of a flight such as tornado, blizzard or hurricane. Moderate or non-extreme weather within the NAS category reflects the situation where weather slows the operations of the system, but does not prevent flying with corrective action by the airports or the Federal Aviation Administration.

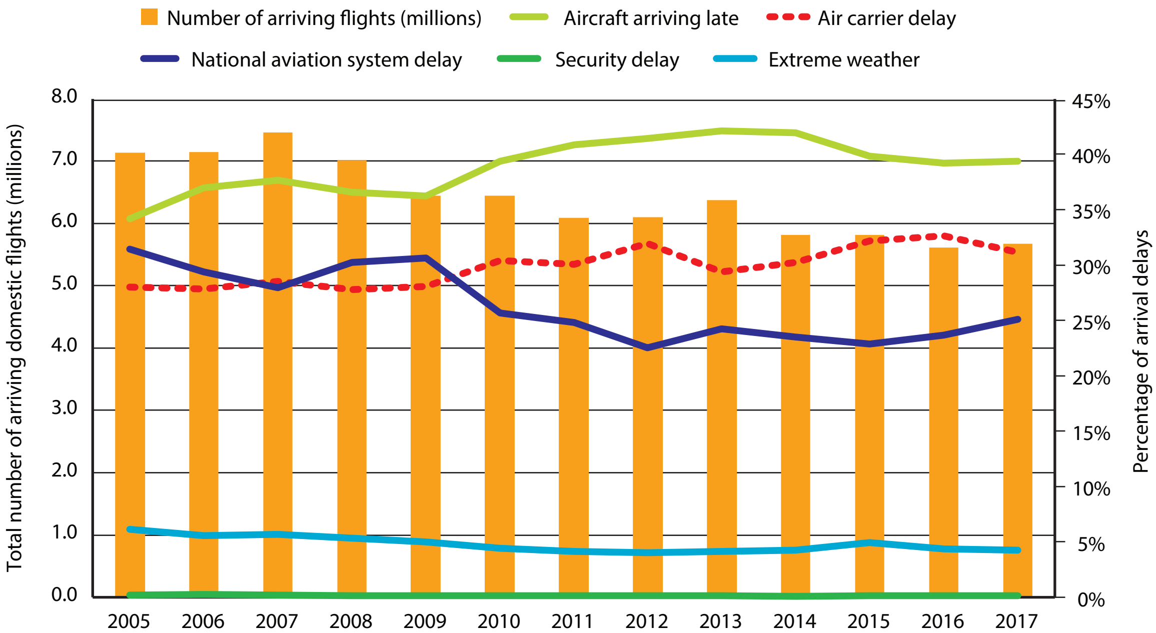
FIGURE 2-5 Percent On-Time Departures and Arrivals: 2000–2017



NOTES: A flight is considered delayed when it arrived 15 or more minutes later than the scheduled arrival or departed 15 or more minutes later than the scheduled departure.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Transtats*, available at https://www.transtats.bts.gov/ as of September 2018.

FIGURE 2-6 Domestic Flight Delays by Cause, Percent of Total Delays in Minutes: 2005–2017



NOTES: Air Carrier Delay— the cause of the cancellation or delay was due to circumstances within the airline's control (e.g. maintenance or crew problems, etc.). **Aircraft Arriving Late—**previous flight with same aircraft arrived late which caused the present flight to depart late. **Security Delay—**delays caused by evacuation of terminal or concourse, reboarding of aircraft because of security breech, inoperative screening equipment and long lines in excess of 29 minutes at screening areas. **National Aviation System (NAS) Delay—**delays and cancellations attributable to the national aviation system refer to a board set of conditions, including non-extreme weather conditions, airport operations, heavy traffic volume, air traffic control, etc. **Extreme Weather Delay—**significant meteorological conditions (actual or forecasted) that, in the judgement of the carrier, delays or prevents the operation of a flight.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Delay Cause by Year as a Percent of Total Delay Minutes*, available at https://www.bts.gov/ as of September 2018.

into the schedule). In 2017 aircraft arriving late caused 39.4 percent of delays, follow by air carrier delay (31.2 percent), National Aviation System (NAS) delay (25.1 percent), security delay (0.1 percent), and extreme weather (4.3 percent). NAS delays include moderate or non-extreme weather conditions (53.0 percent), heavy traffic volume (31.9 percent), closed runways (10.5 percent), and other delays (4.6 percent) [USDOT BTS 2018d].

In 2017 weather, the sum of extreme weather delays, NAS weather delays, and weather-related delays in the late-arriving aircraft category, accounted for 33.2 percent of delayed flights. Weather's share of delay had decreased from 43.6 percent in 2007. This moderate weather slows the operations of the system, but does not prevent flying, and resulting delays or cancellations can be reduced with corrective action by the airports or the Federal Aviation Administration [USDOT BTS 2018d]. Although the total amount of arrival delay declined between 2005 and 2017, the average delay per delayed flight arrival grew by more than 11 minutes over the period—from 52.2 minutes in 2005 to 63.9 minutes in 2017. The greatest increase in the cause of delay between 2005 and 2017 associated with the NAS was the large volume of flights, which represented 18.7 percent of in-flight delays in 2005 but had risen to 32.0 percent in 2017 [USDOT BTS 2018d].

Flight delays can ripple through the U.S. aviation system as late arriving flights, for whatever reason, delay subsequent flights throughout the day (figure 2-7). Figure 2-8 shows that the number of passengers impacted by a delay of at least 120 minutes more than doubled from just over 4 million in 2010 to over 10 million passengers in 2017.

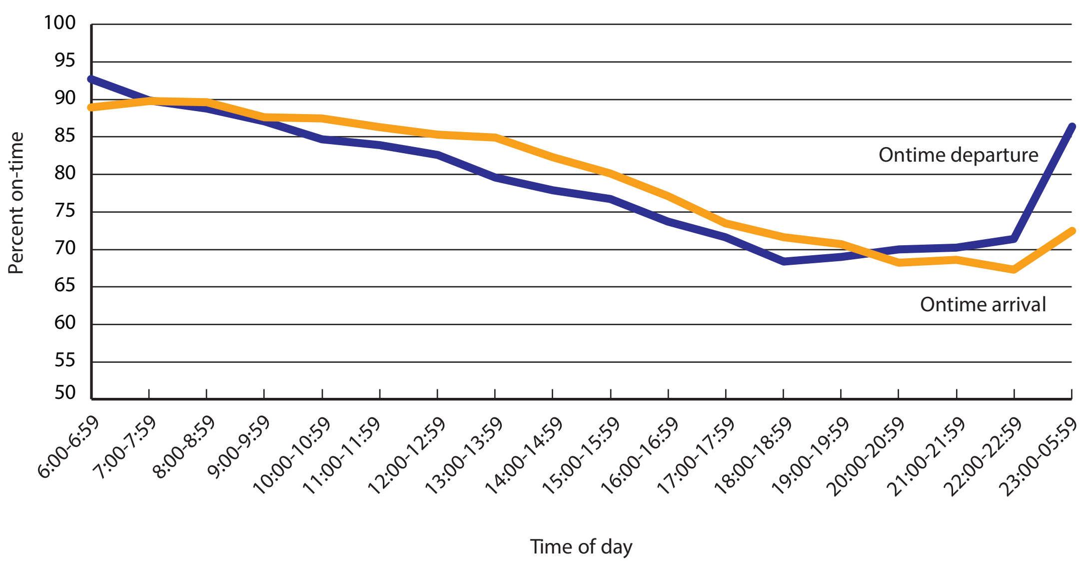
Railroads

Amtrak Condition

As discussed in chapter 1, most passenger train services outside the Northeast Corridor (NEC) are provided over tracks owned by and shared with Class I freight railroads. Approximately 72 percent of Amtrak's train-miles are run on tracks owned by freight railroads. Hence, the condition of the infrastructure Amtrak uses is largely dependent on the condition of the track for the host railroads, except for the NEC tracks and a few other miles of track owned by Amtrak. In the NEC, Amtrak has identified a $38 billion state-of-good-repair backlog "with no long-term and stable funding program yet available to fund the majority of costs" [AMTRAK 2018a]. Factors identified by Amtrak that could affect its ability to deliver service include infrastructure condition, severe weather conditions, terrorism, and major accidents.

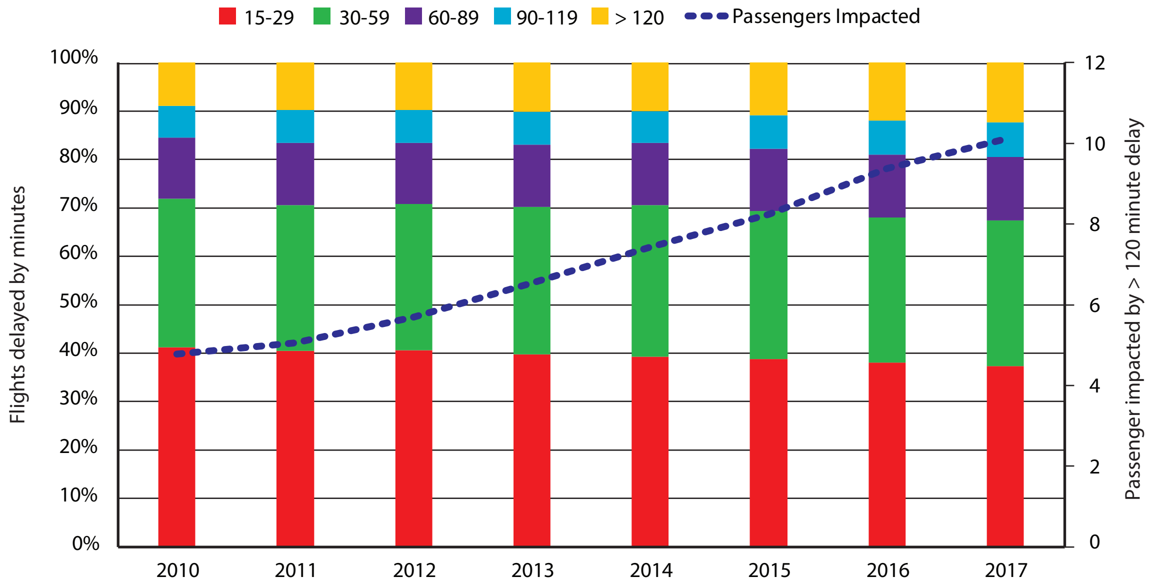
The average age of locomotives rose from 16.5 years in 2005 to 19.1 years in 2010 and to 21.1 years in 2015, the last reported year [USDOT BTS 2017e]. The average age for passenger cars was 21.5 years in 2005, 25.6 years in

FIGURE 2-7 Percent of On-time Arrivals and Departures by Time of Day (Top 30 U.S. Airports): 2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Airline On-Time Performance Data, available at www.bts.gov as of October 2018.

FIGURE 2-8 Percent of Flights by Length of Time Delayed and Passenger impacted by > 120 minute delay: 2010-2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Delay Cause by Year, as a Percent of Total Delay Minutes*, available at www.bts.gov as of October 2018.

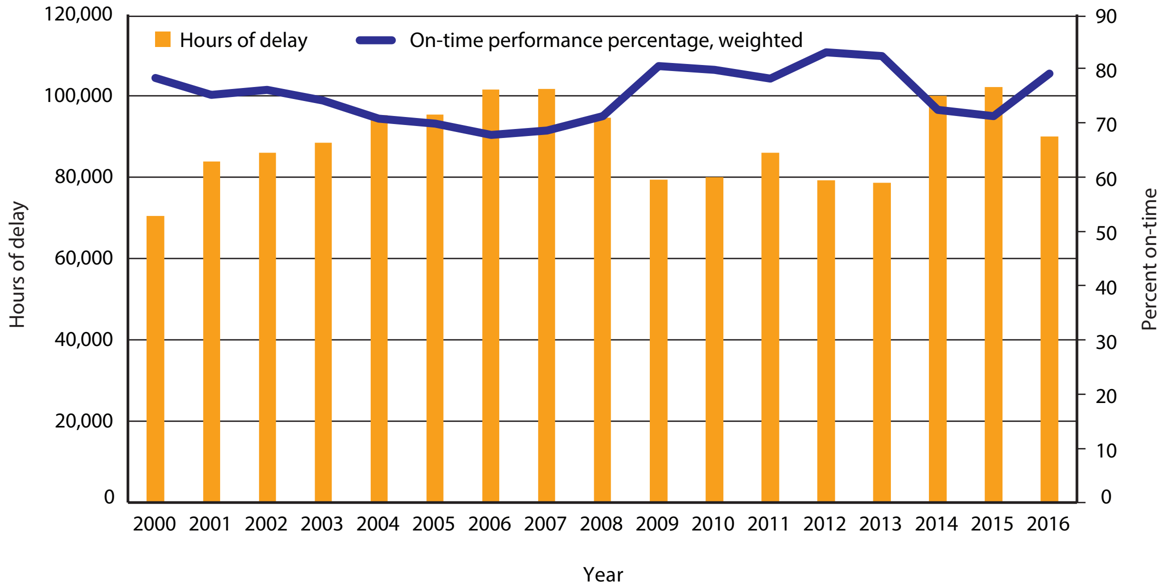
2010, and 30.7 years in 2015. The aging of the fleet may also be affecting equipment reliability. The average miles between service disruption for cars and locomotives was 390,865 and 25,889, respectively, in FY 2015. Both worsened by FY 2017, with 364,428 miles between service disruptions for rail cars and 25,225 miles between locomotive service disruptions [AMTRAK 2018b].

Amtrak Performance

The hours of delay experienced on Amtrak services fluctuated between 2000 and 2016 (figure 2-9). The percent of on-time arrivals improved from 67.8 percent in 2006 (the worst performance since 2000) to 79.1 percent in 2016. With respect to short- and long-distance trips, the on-time performance for trips less than 400 miles in 2016 was 81.1 percent compared to 84.5 percent in 2012 (the best performance since 2000). For trips greater than 400 miles, the 63 percent on-time arrival rate in 2016 fell well below the 75 percent on-time arrival mark set in the best year of 2009 [USDOT BTS 2017f].

National databases report several sources of delay for passenger operations. These include delays caused by Amtrak itself (e.g., operational delays and breakdowns), those caused by the host freight railroad, and other non-railroad sources, such as customs inspections. Delays attributed to Amtrak increased 12.9 percent between 2000 and 2016 (from 23,337 hours in 2000 to 26,339 hours in 2016) [USDOT BTS 2017f]. Delays caused by the host railroads increased by 10.7 percent (4,674 hours) over that period. The biggest change between 2000

FIGURE 2-9 Hours of Delay and On-time Performance of Amtrak: 2000–2016



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 1-73, Available at https://www.bts.gov/ as of September 2018.

and 2016 is the percent of the total delay associated with other factors, such as customs and immigration inspections. In 2000 such delays accounted for 4.5 percent of total delay but had reached 16.8 percent of total delay by 2016. Delay caused by host railroads remains the major source of Amtrak delays, accounting for 54 percent of total delay in 2016.

Freight Rail

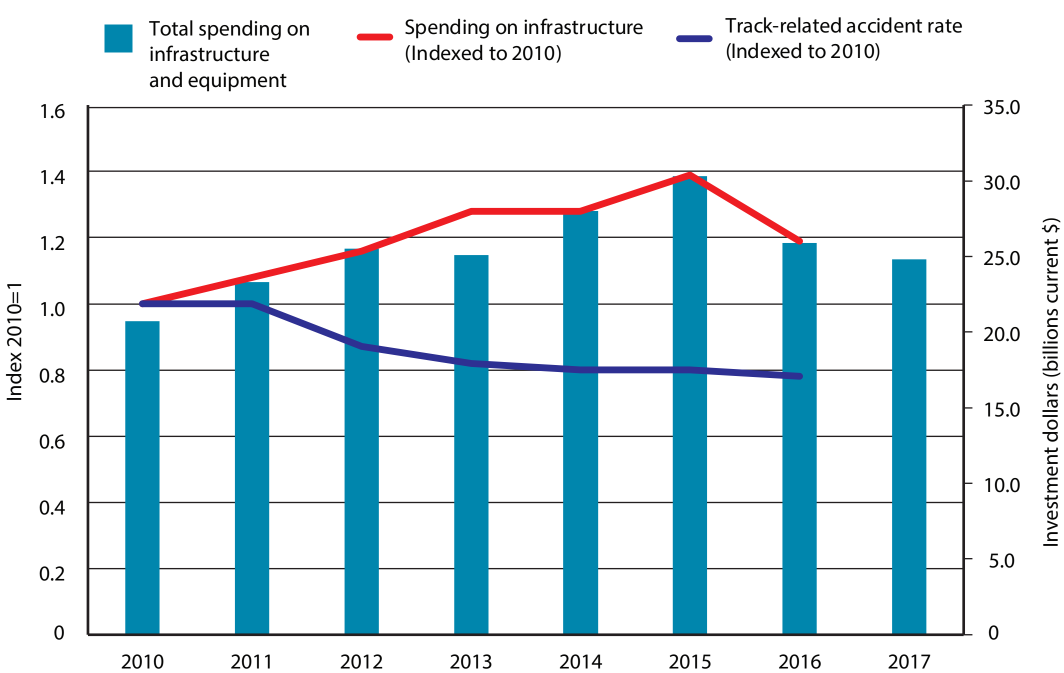
Freight rail carriers are under no obligation to report freight track conditions to public agencies. Thus, universal track condition reports are unavailable. However, railroads regularly inspect their track and perform necessary repairs to ensure track safety. Federal Railroad Administration (FRA) regulations require railroads to maintain track inspection records and make them available to FRA or state inspectors on request. The FRA's rail safety audits focus on regulatory compliance and prevention and correction of track defects. FRA publishes an annual enforcement report, summarizing the civil penalty claims for violations. In FY 2016 just more than 4,000 track violations were cited by FRA inspectors or other railroad regulators, compared to 3,353 in FY 2015 [USDOT FRA 2016].

In addition, FRA's Automated Track Inspection Program (ATIP) utilizes a small fleet of highly instrumented track geometry inspection cars to survey tens of thousands of miles of high traffic density and other high-priority routes each year. The FRA upgraded the inspection and collection technology in the ATIP fleet in 2013, which increased its ability to detect track deficiencies. Because of this upgrade, earlier results may not be comparable to those for the most recent years. Since 2013 the incidence of all eight track inspection exceptions[20] has decreased—with the number of rail track defects per 100 miles of rail track decreasing from 28.7 in 2010 to 4.5 in 2017. The number of locations and miles inspected vary by year due to the limited number of surveying cars and are prioritized by factors, such as safety risk analysis and operation types, so these results are not a representative sample of the Nation's freight rail track condition.

Time-series data on the level of investment of the seven Class I railroads in infrastructure and equipment and on infrastructure- and equipment-related accidents suggests an important relationship. The major freight railroads increased their reinvestment in their networks beginning in 2010 (coinciding with rebounding capital); this investment peaked in 2015 and then declined to mid-2011 levels (figure 2-10). The impact of this investment on track-related accidents and derailments appears to be significant.

[20] The ATIP program does not provide a comprehensive evaluation of the national rail network on an annual basis due to the limited number of surveying cars. Inspection locations vary by year and are prioritized by factors, such as safety risk analysis and operation types. Detailed definitions and standards may be found in U.S. Department of Transportation, Federal Railroad Administration, *Track and Rail and Infrastructure Integrity Compliance Manual*, July 2012.

FIGURE 2-10 Rail Capital and Maintenance Investment on Infrastructure and Track-Caused Accidents per Million Train-miles: 2010–2017 (Indexed to 2010)



SOURCES: Total Spending on Infrastructure and Equipment—American Association of Railroads (AAR). Freight Railroad Capacity and Investment (2018), available at https://www.aar.org/ as September 2018. **Relative Change in Infrastructure and Track-Caused Accident Rates and Infrastructure and Track Spending—**American Association of Railroads (AAR). *Higher Rail Spending Has Led to Fewer Track-Caused Accidents* (2017), available at https://www.aar.org/ as September 2018.

Waterways and Ports

Roughly 98 percent of America's overseas international trade (by weight) uses assets maintained by the U.S. Army Corps of Engineers (USACE). The USACE civil works program maintains approximately 12,000 miles of inland waterways with 218 locks at 176 sites, approximately 300 deep-draft and 600 shallow-draft Great Lakes and coastal harbor channels, and more than 900 coastal navigation structures [USACE 2017].

Waterways

The USACE maintains comprehensive data on lock traffic, lockage time and delay, and lock outages for waterway performance analysis. In addition, the USACE maintains an extensive database of marine terminals, both shallow draft and deep draft, but it is largely descriptive and does not include condition or performance data. Private terminal operators do not routinely release data publicly on the condition of their facilities.

The average age of locks was over 60 years in 2015, although a report by the Transportation Research Board (of the National Academies of Science) showed that major rehabilitation projects on some of the locks effectively lowered the average lock age by about 10 years [TRB 2015]. Table 2-3 shows both condition (age) and performance metrics for the nine waterways for which the USACE has responsibility for lock operation and condition. The average delay in minutes and the percent of vessels delayed has risen, with average delay in 2017 just over 140 percent of the delay in 2000. The Tennessee River, with the worst performance of all the highly traveled waterways, experienced an average delay of 205.8 minutes per tow in 2017 [USACE 2018]. For context, in 2017 there were 584,563 lockages allowing the passage of 746,095 vessels through the USACE lock system.

The number of instances where an unexpected mechanically driven failure at locks caused more than 24 hours of delay declined from 35

TABLE 2-3 Total Lockages, Percent Commercial, Average Delay, and Percent of Vessels Delayed on U.S. Waterways with U.S. Army Corps of Engineers' Locks: 2000, 2010, 2017

	Total lockages	Percent commercial lockages of all lockages	Average age of locks	Average delay in minutes	Percent of vessels delayed
2000	797,137	73.1	NA	63.6	35.0
2010	641,846	74.5	NA	79.8	36.0
2017	584,563	78.8	61	154.2	49.0

KEY: NA = Not available

NOTES: A lockage is the movement through the lock by a vessel or extraneous matter, such as manatee, debris, ice, etc. Commercial lockages are all those that service vessels operated for purposes of profit and include freight and passenger vessels. The USACE operates locks at 193 sites having a total of 239 chambers.

SOURCE: U.S. Army Corps of Engineers, Public Lock Usage Report files, *Calendar Years 1993-2017*, available at https://www.iwr.usace.army.mil/About/Technical-Centers/NDC-Navigation-and-Civil-Works-Decision-Support/ as of September 2018.

in FY 2014 to 18 in FY 2017. The number of instances causing delays of more than 1 week declined from 18 to 14 during the same period [USACE 2018].

The USACE is also responsible for dredging navigation channels to foster safe and efficient use of the Nation's ports and waterways. The USACE maintains detailed dredging data, but it does not produce summary tabulations that differentiate the work by deep or shallow draft channels. USACE dredges removed 186 million cubic yards of material in FY 2015 and removed 202.4 million cubic yards in FY 2016. Ninety-two percent of this removal was done for navigational maintenance purposes.

Ports

The Bureau of Transportation Statistics' Port Performance and Freight Statistics Program produced a *2017 Annual Report to Congress* that presented publicly available and nationally consistent throughput, capacity, and performance statistics for the Nation's top 25 tonnage, container, and dry bulk ports. The report also includes background information on U.S. ports and discussions of throughput and capacity concepts to provide a more complete picture of port activity and place the statistics in context. The 2017 edition provided additional descriptions of global and national maritime trends to provide a more robust context for understanding port performance as well as the emerging issues affecting ports, such as the increasing size of container vessels calling at U.S. ports, changes in energy commodities flows, and the impact of the 2017 hurricane season [USDOT BTS 2018e].

The total tonnage handled at the 25 top tonnage ports increased by 4.7 percent between 2016 and 2017 to 1.83 billion tons, with 779.1 million tons of domestic cargo and 1,052.4 million tons of foreign cargo. Foreign cargo tonnage increased at a faster rate than domestic tonnage between 2016 and 2017, with gains of 6.9 and 1.9 percent respectively. The dry bulk tonnage handled at the 25 top tonnage ports increased by 6.7 percent between 2016 and 2017 to 729.4 million tons. Domestic cargo increased by 2.3 percent to 397.4 million tons, while foreign cargo increased by 12.4 percent to 332.0 million tons. The 25 top container ports handled a total of 51.1 million TEU[21] in 2017, a 7.6 percent increase over the 47.5 million TEU moved in 2016. Loaded inbound containers increased by 7.8 percent to 23.6 million while loaded outbound containers increased by 4.5 percent to 14.4 million TEU; the remainder were empty [USDOT BTS 2018e].

Based upon AIS[22] data, the average container vessel dwell time at U.S. ports was 24.8 hours. Results from the AIS data analysis suggests that while container vessel size (measured in TEU capacity) does influence terminal dwell time, the cargo volume handled per call is the major factor [USDOT BTS 2018e].

Pipelines

The USDOT Pipeline and Hazardous Materials Safety Administration (PHMSA) is responsible for regulating nearly 3,000 companies that operate 2.7 million miles of pipelines, 148 liquefied natural gas plants, and 7,571 hazardous liquid breakout tanks. PHMSA

[21] TEU = twenty foot equivalent unit

[22] AIS = Automatic Identification System

collects annual data from pipeline operators, covering their system mileage, commodities transported, and inspection activities. Leakages and/or spill incidents are required to be reported by the operators. When enforcement actions are necessary, they often include the following:

- requirements for the pipeline operator to implement procedures and programs associated with corrosion control;
- pipeline inspection, testing, and repairs;
- emergency safety devices and remote instrumentation;
- right-of-way marking;
- valve operability;
- equipment maintenance;
- interaction with emergency services officials;
- personnel training and qualification;
- emergency response preparedness; and
- other pipeline safety and compliance tasks [USDOT PHMSA 2018a].

There is no publicly available database that tracks pipeline condition. PHMSA tracks the number of pipeline inspections, incidents, and corrective actions. In 2016 PHMSA pipeline safety personnel initiated 1,175 pipeline inspections.

PHMSA data for the 2004–2017 period suggests that the number of leaks occurring on pipelines is not due primarily to poor pipeline condition. For example, data for gas transmission pipelines for this period showed that 5.6 percent of the leaks were caused from external corrosion and 1.4 percent from internal corrosion. The largest cause for leaks, at 29.6 percent, was third-party damage [USDOT PHMSA 2018b].

System Resiliency

Many parts of the Nation's transportation system are vulnerable to both natural and manmade disruptions. Because of this vulnerability, transportation firms and government agencies have become interested in providing a system that is resilient to disruptive impacts, including the ability to prepare, resist, recover, and adapt to disruptions (Figure 2-11). A resilient transportation system has design-level robustness that can withstand severe blows, respond appropriately to threats, and mitigate the consequences of threats through response and recovery operations [USDOT VOLPE 2013].

FIGURE 2-11 Transportation Resiliency Cycle

SOURCE: U.S. Army Corps of Engineers, Personal Communications, 2018.

System Disruptions from Extreme Weather

With the heavy concentration of the Nation's population in urban areas (many along the coasts) and with a strong reliance on the efficient movement of people and goods, recent weather events have resulted in extensive economic and community costs. The U.S. Department of Commerce (USDOC), National Oceanic and Atmospheric Administration (NOAA) estimated that from 1980 to 2018 (as of October) the United States experienced 238 weather disasters, including events such events as hurricanes, tornadoes, floods, and droughts/wildfires. The overall damage from each of these events exceeded $1 billion, resulting in more than a $1.5 trillion cumulative cost to the Nation [USDOC NOAA NCEI 2018]. Part of the physical recovery costs and overall economic impact were due to the damage and disruption to the transportation system.

These extreme events are increasing in frequency. The annual average for 1980–2017 was 6.0 events (Consumer Price Index-adjusted); the annual average for the most recent 5 years (2013–2017) is 11.6 events (CPI-adjusted). As of October 9, 2018, there were already 11 weather and climate disaster events in 2018 with losses exceeding $1 billion each across the United States, the fourth largest number of such events for an entire year.

Hurricanes Katrina, Harvey, Irma, Maria, Michael, Florence, and Superstorm Sandy severely impacted large portions of the Nation's transportation system. Record flooding in many locations caused severe disruptions of the transportation system. Highways, railroads, and bridges were damaged throughout the affected regions, and many bridges had to remain closed until their structural safety could be evaluated. Major airports were closed for several days, and in some of the worst cases transit service was severely curtailed for many weeks. Maritime ports had to close for several days, but many had difficulty reopening due to shortages of workers, who were busy dealing with their own losses (e.g., in Puerto Rico). The Bureau of Transportation Statistics (BTS) estimated that numerous flight cancellations in hurricane-ravaged areas in 2017 left 2 million would-be passengers without the flights they had booked— 815,000 passengers in Texas, 1 million in Florida, and 221,000 in Puerto Rico and the Virgin Islands. Additionally, there was significant pressure on the numerous petroleum facilities along the gulf coast, which is home to 45 percent of total U.S. petroleum refining capacity and 51 percent of total U.S. natural gas processing plant capacity [USDOE EIA 2018].

The 2017 hurricane season produced 17 named storms, and when combined with the arrival of 8 major hurricanes in 2018 (categories 3, 4, or 5), they challenged the transportation system and its ability to deliver critical services to the United States and its territories. During 2017, 3 major hurricanes (figure 2-12) made landfall in succession (Harvey in Texas, Irma in the Caribbean and southeastern United States, and Maria in the Caribbean and Puerto Rico). In 2018 hurricanes Florence and Michael challenged the Carolinas and the Florida panhandle, respectively (figure 2-13, and figure 2-14).

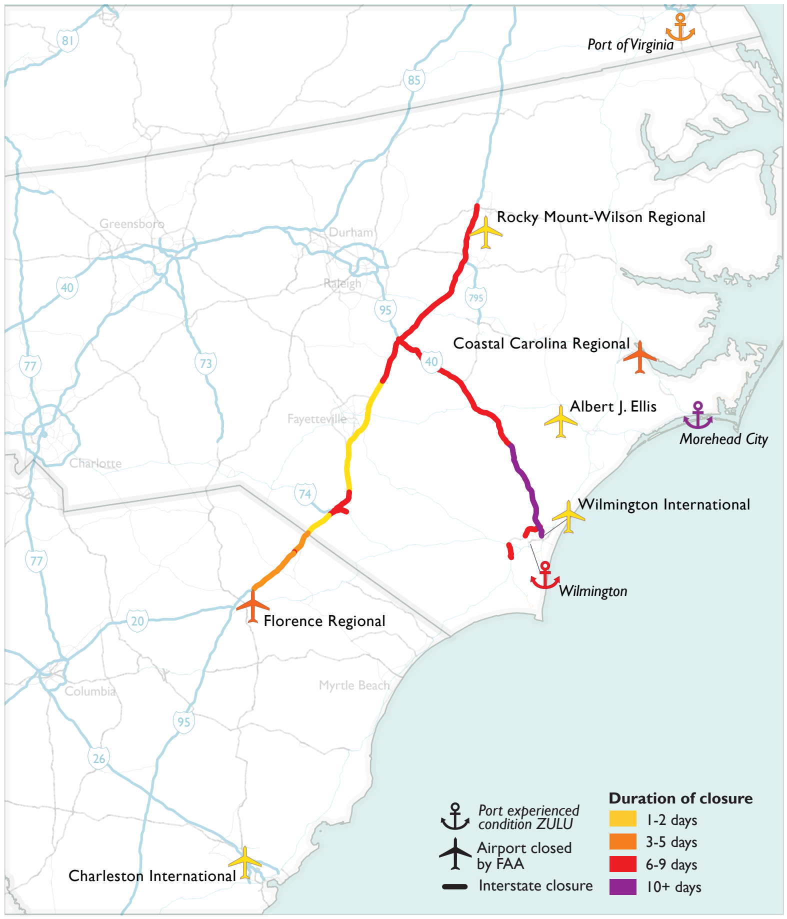
These hurricanes each had unique disruptive impacts across a large geographic region within a short amount of time. Many seaports, airports, and Interstate highways were closed for many days, impacting travel and goods

FIGURE 2-12 Impact of Select Hurricanes on U.S. Ports: 2017, 2018

NOTES: Condition ZULU—all port waterfront operations are suspended, except final preparations that are expressly permitted by the U.S. States Coast Guard's Captain of the Port necessary to ensure the safety of the ports and facilities.

SOURCE: Hurricane paths—based on preliminary best track data from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Hurricane Center (NHC), NHC Data in GIS Formats, available http://www.nhc.noaa.gov/gis/ on October 2018. **Condition ZULU**—based on data from the U.S. Coast Guard's Homeport as of October 2018.

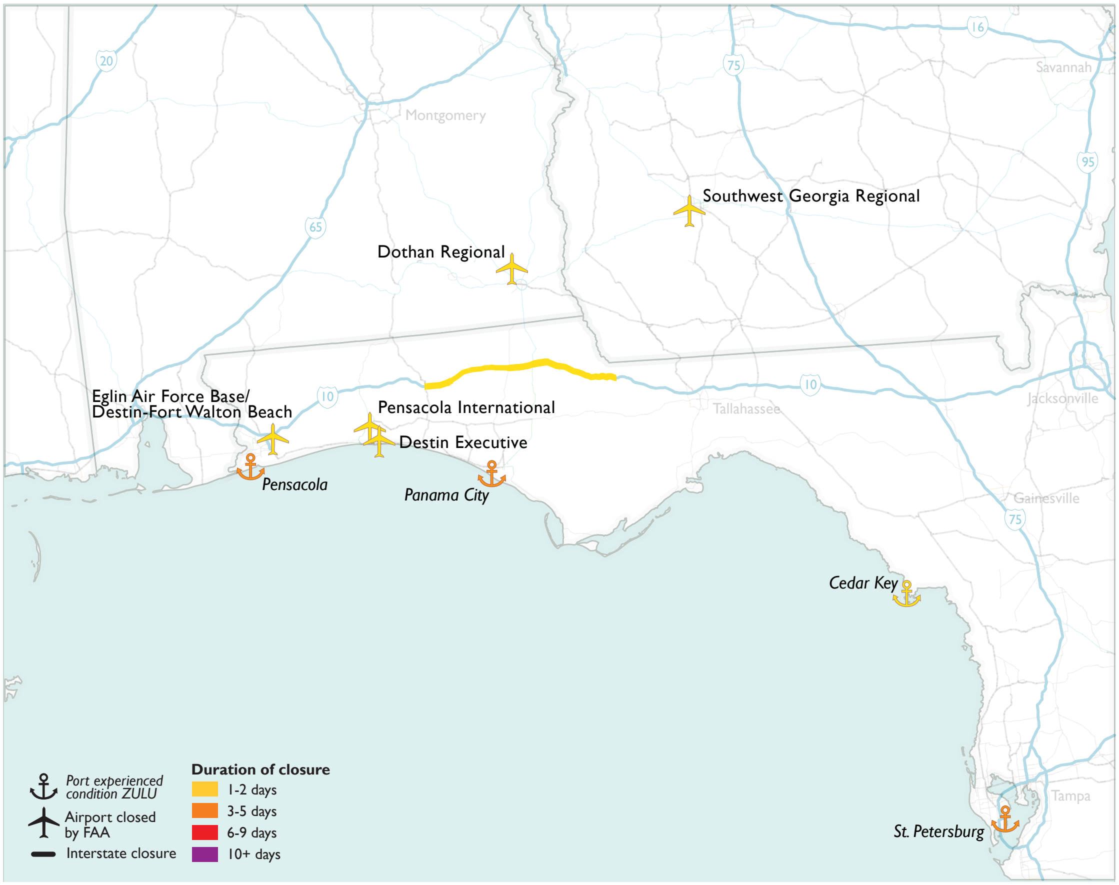
FIGURE 2-13 Impact of Hurricane Florence on Transportation Infrastructure: 2018



NOTES: Condition ZULU— all port waterfront operations are suspended, except final preparations that are expressly permitted by the U.S. States Coast Guard's Captain of the Port necessary to ensure the safety of the ports and facilities.

SOURCES: Various datasets from U.S. Department of Transportation Crisis Management Center (CMC), personal communication, as of September 2018.

FIGURE 2-14 Impact of Hurricane Michael on Transportation Infrastructure: 2018



NOTES: Condition ZULU— all port waterfront operations are suspended, except final preparations that are expressly permitted by the U.S. States Coast Guard's Captain of the Port necessary to ensure the safety of the ports and facilities.

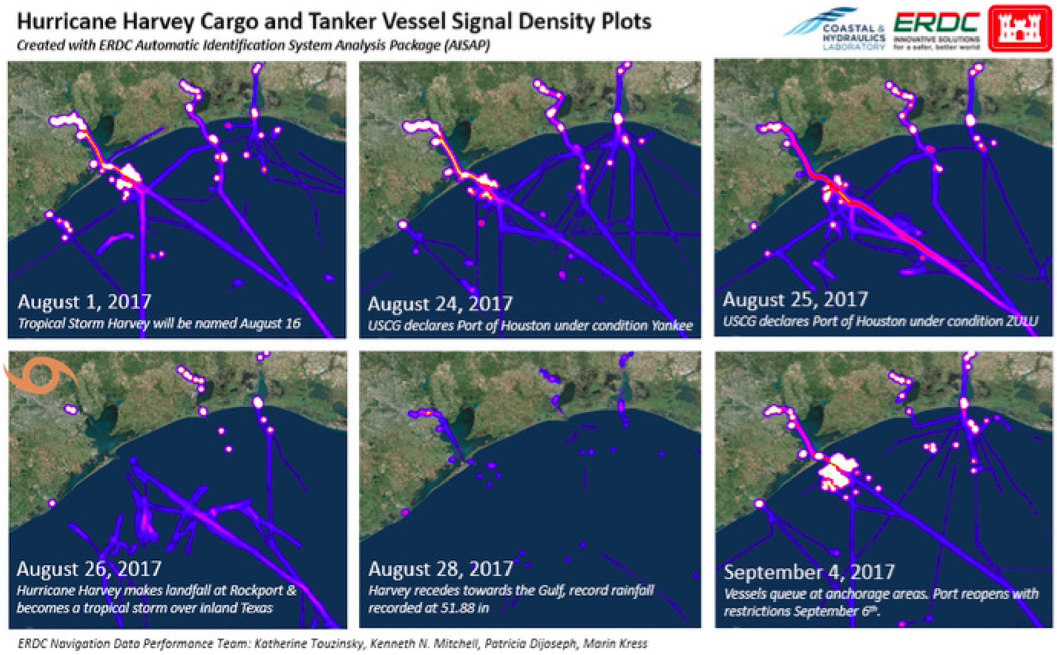
SOURCES: Various datasets from U.S. Department of Transportation Crisis Management Center (CMC), personal communication, as of September 2018.

moved (figure 2-15 and figure 2-16). This included the operations of at least 45 ports throughout the lower continental United States and U.S. Caribbean territories.

Automatic Identification System (AIS) data can be utilized to understand the impacts that disruptions have on individual ports and port systems. The Houston-Galveston area was particularly hard hit by Hurricane Harvey. These impacts can be observed via vessel heat maps created from AIS signal densities. These signal density heat maps show normal vessel operating conditions on August 1st, after the U.S. Coast Guard declared the Port of Houston under port condition Zulu[23], and vessels made their way out of the area on August 25th (figure 2-15). When the port reopened on September 4th, vessels were queued in anchorage areas awaiting permission to enter the harbor.

[23] Port Condition Zulu—all port waterfront operations are suspended, except final preparations that are expressly permitted by the U.S. States Coast Guard's Captain of the Port necessary to ensure the safety of the ports and facilities.

FIGURE 2-15 Use of Vessel Heat Signals to Observe Hurricane-Related Operational Impacts, Port of Houston, Hurricane Harvey: 2017

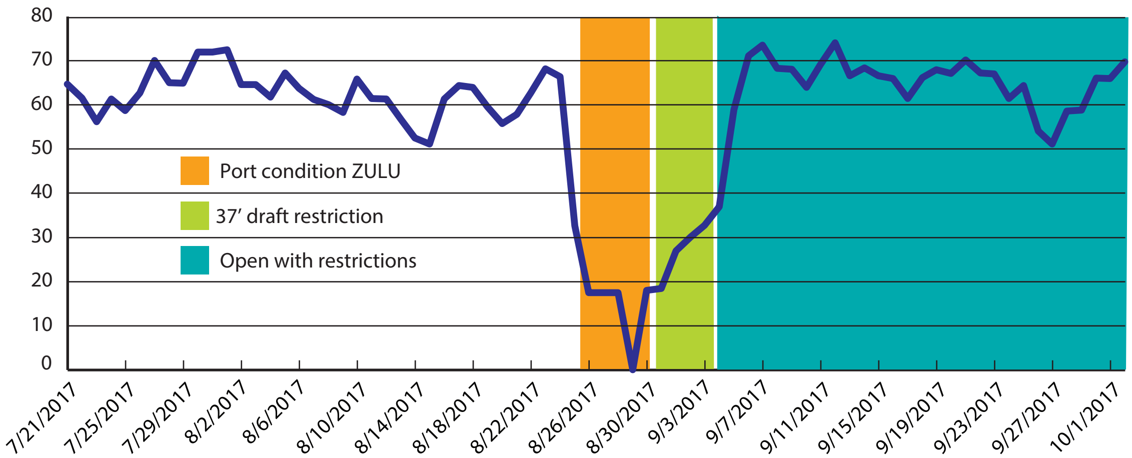


KEY: White = heavy vessel traffic. Magenta = medium vessel traffic. Blue = low vessel traffic.

NOTE: Port Condition Yankee—affected ports are closed to inbound vessel traffic.

SOURCE: U.S. Army Engineer Research and Development Center, Automatic Identification System Analysis Package, available at https://ais-portal.usace.army.mil as of October 2018.

FIGURE 2-16 Port of Houston Daily Average Cargo and Tanker Net Vessel Counts During Hurricane Harvey, 2017



NOTES: Condition ZULU— all port waterfront operations are suspended, except final preparations that are expressly permitted by the U.S. States Coast Guard's Captain of the Port necessary to ensure the safety of the ports and facilities.

SOURCE: U.S. Army Engineer Research and Development Center, Automatic Identification System Analysis Package, available at https://ais-portal.usace.army.mil as of October 2018.

These impacts can also be observed via indicators and statistical analysis. For example, net vessel counts are useful to describe the traffic in and out of a port or major waterway and provides qualitative insights into the magnitude of the disruption and length of time before the port is fully recovered (figure 2-16) [Touzinksky et al 2018]. Figure 2-16 shows the vessel count quickly drops from about 60 vessels per day to 0 when Port Condition Zulu is declared and counts then return to normal as the port is reopened.

One of the key lessons learned from these disaster events was the importance of transportation system resilience. In most cases, major transportation facilities—roads, bridges, transit systems, ports, and airports—were open for operations within days or weeks of the severe event. In most cases, advanced preparations by state and local government agencies (e.g., moving transit vehicles out of vulnerable areas and establishing emergency management centers) can mitigate disruption to transportation systems. The existence of redundant paths in the transportation network provided travel options for both person and freight trips seeking to avoid travel blockages. By putting critical links in the transportation system back into operation, the economic impact to state and regional economies can be minimized.

Human-Caused Disruptions

Transportation disruptions can also have human causes. For example, a fire under an elevated section of I-85 in Atlanta caused it to collapse, closing the highway for 6 weeks. Similar impacts were observed in the I-35W bridge collapse in Minneapolis in 2007, which has also been attributed to human causes.

Cybersecurity

Human-caused disruptions could also include calculated attacks against transportation infrastructure and services, or against the command and control systems that enable system management.

Transportation systems have been identified as the third most vulnerable sector (behind the healthcare and pharmaceutical sectors) to cyberattacks [Grzadkowska 2018]. Position, navigation, and timing (PNT) services are widely used by all transportation modes. Global Positioning Systems (GPS) help prevent transportation accidents, aid search and rescue efforts, and speed the dispatch of emergency services [NCO 2014]. Most transportation agencies, especially state DOTs, rely on large scale information systems to manage their capital investment programs and human resources. Protecting the Nation's cyber network is thus a critical component of a resilient transportation system. Several key characteristics of the transportation cyber network reflect its importance.

- Positive Train Control (PTC) works in conjunction with GPS technologies to track train location and speed. Specifically, they are used to prevent train-to-train collisions, overspeed derailments, and the unauthorized movement of trains into work zones [NTSB 2016].
- On waterways and especially in ports, GPS helps vessels maneuver around navigational hazards and traffic [NCO 2014]. GPS technologies can help track freight vehicles and their valuable cargo, which may help to reduce the loss of $15

to $30 billion annually in cargo theft and pilferage from commercial motor vehicles [FMCSA 2011].

- In October 2016 NHTSA released proposed guidance for improving motor vehicle cybersecurity, especially since hackers may attempt to gain unauthorized access to vehicle systems to manipulate functionality or retrieve private driver data. The guidance focuses on layered solutions to ensure vehicle systems are designed to protect critical vehicle controls and take appropriate and safe actions if an attack is successful [USDOT NHTSA 2017]. Signal jamming devices can prevent completion of 911 and other emergency calls and can also interfere with communications networks utilized by police, fire, and emergency medical services. Because signal jamming devices pose such significant risks, Federal law prohibits consumers from operating these devices within the United States, and violations are punishable by fines of up to $112,500 per violation [FCC 2014].
- The Next Generation Air Transportation System (NextGen) integrates GPS to help increase operational safety and situational awareness for aviation system users, especially during approaches and departures, and while taxiing on the ground [NCO 2014]. The impact of recent information technology (IT) system failures on the NAS are highlighted in Box 2-C.

A recent study conducted by the United Kingdom government estimated that the economic impact of a 5-day GPS disruption on the UK transportation system to be $2.5B, or $500M a day. Given the amount of roadway traffic in the United States is 10 times of that in UK, a simple interpolation of the economic impact of a 5-day GPS disruption on U.S. transportation could be about $25 billion, or $5 billion per day [London Economics 2017].

Other Security Concerns

The Transportation Security Administration (TSA), of the U.S. Department of Homeland Security, screens people as they pass through security checkpoints at 450 airports and at other passenger checkpoints. In 2017 TSA officers screened over 750 million passengers (more than 2 million per day) and 511 million bags. These TSA inspections prevented a wide array of prohibited items from being brought onto passenger aircraft, including 3,957 firearms; thousands of knives, swords, and other sharp blades; ammunition; gunpowder, black powder, flashbang grenades, and fireworks; and inert and replica explosive devices [USDHS TSA 2018].

International piracy incidents at sea, including attacks, boardings, hijackings, and kidnappings, are another security concern affecting U.S. citizens traveling overseas. Piracy activity has been monitored closely by the Office of Naval Intelligence (ONI), especially after the hijacking of the U.S.-flagged *Maersk Alabama* on April 8, 2009. In 2017 the waters of Southeast Asia experienced 97 piracy events, 20 less than the 117 events of 2016. The Gulf of Guinea, in West Africa, had 120 events in 2017, which is comparable to the 122 in 2016.[24] The Horn of Africa waters, which have been of major concern since 2009, had 6 events in 2017 [USN ONI 2018].

[24] This number is lower than previously reported due to a methodological change to include militant activity.

Box 2-C Vulnerability of the Nation's Aviation System to Information Technology System Failures

The complexity of the Nation's air traffic system requires extensive reliance on information technology (IT) systems to manage and ensure the safe operations of approximately 87,000 daily flights.

Recent examples of the disruptive effects of IT failures include the following:

- A September 28, 2017, outage of software used to allow passengers to check into flights and drop off luggage and for airlines to communicate flight changes affected airline travel worldwide. Travelers on selected airlines from Singapore to Baltimore experienced delays of anywhere from a few minutes to 2 hours.
- After a major storm in Atlanta in April, 2017, a major airline crew-scheduling system failed, causing a 5-day period of recovery that affected air travel nationally. Hundreds of flights were canceled, and crews were stranded in airports across the country.
- On February 22, 2017, a major airline's flights were prevented from taking off from or landing at Philadelphia International Airport after maintenance software went down. The FAA issued a ground stop for this airline's flights into and out of Philadelphia that was lifted after the software was back online about 4 hours after the incident. As a result, 135 of this airline's flights into and out of the airport were delayed and 21 canceled.
- A major electrical fire at Atlanta's Hartsfield-Jackson International Airport, the world's busiest, on December 18, 2017, destroyed the airport's main power supply and the back-up systems. The airport was shut down for 11 hours, causing close to 1,600 flight cancellations and 735 delayed flights, with rippling effects throughout the aviation system [Yanofsky 2015-2017].

These examples illustrate the vulnerability of air travel to failures in IT systems, often blamed on aging systems. These incidents resulted in major impacts at specific airports, with cascading effects throughout the aviation system. With today's risks associated with cyber-attacks, a concerted attack on key IT systems nationwide could result in massive disruption to the Nation's aviation system with severe economic consequences.

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CHAPTER 3

Moving People

Highlights

- In 2017 people made fewer everyday trips than previously. The decline in travel for shopping and running errands was primarily due to the increase in online shopping and home deliveries.
- Overall, the amount of driving declined by 24 percent between 2001 and 2017 in urban areas, compared to 19 percent in rural areas. Young people (25–34) in urban areas showed the greatest decline.
- New travel options (e.g., Uber, Lyft) can complement or compete with existing transportation. Thirty percent of people who used transit in urban areas also used ride-hail. Nearly half of 30 to 44 year old transit users also used a ride-hail service.
- The proportion of adults aged 65 and older who are still in the workforce is doubled that of fifteen years ago. Older workers are more likely to work from home, work part-time, and have shorter commutes. Older people as a whole are driving more and keep driving longer than previous generations.
- Travel by air continues to grow—the number of commercial air passengers broke records each year in 2015–2017. The enplanements increased by 67 million, from 898 million in 2015 to 965 million in 2017.
- In 2017 approximately 75.1 million international visitors traveled to the United States, a decline from the peak of 77.5 million in 2015.
- About 25 million people have a disability that makes travel difficult, and more than 3.6 million reported being homebound because they are disabled or housebound.
- About 70 percent of all bike-share docking stations are within one block of another public passenger transportation mode, facilitating intermodal connections.

The Nation's transportation system accommodates extensive local and long-distance travel to meet the demands of more than 326 million U.S. residents and about 75 million foreign visitors. In 2016 U.S. person-miles of travel (pmt) amounted to roughly 5.7 trillion, of which nearly 70 percent (68.4 percent) was in cars or other personal vehicles (table 3-1).[1] Domestic and international air travel to and from this country accounted for about 24 percent of pmt—11.6 percent domestic and 12.4 percent international. Transit, intercity rail, and bus services accounted for the remaining pmt. Walking and biking also tallied a notable number of local trips and travel-miles, with nearly 5 million people getting to work under their own power daily [USDOC CENSUS 2017a].

The number of commercial air passengers and airline revenue passenger-miles reached new peaks in 2017, following previous highs in 2016 and 2015, as discussed in the long-distance travel section. Passenger-miles by air

[1] The 5.7 trillion number does not include pmt in large trucks.

TABLE 3-1 Person-Miles of Travel by Mode: 2005–2017
(in millions)

	Light-duty highway vehicles	Air carrier, domestic	U.S. and foreign air carrier, international	Bus	Motorcycle	Transit	Intercity/ Amtrak
2005	4,319,993	583,771	451,386	278,864	17,492	47,125	5,381
2006	4,332,465	588,471	472,005	297,631	24,329	49,504	5,410
2007	4,341,984	607,564	496,088	307,753	27,173	51,873	5,784
2008	4,248,783	583,292	503,056	314,278	26,430	53,712	6,179
2009	3,625,598	551,741	481,049	305,014	22,428	53,898	5,914
2010	3,646,451	554,618	510,884	291,914	19,941	52,627	6,420
2011	3,650,223	564,685	535,928	292,716	19,927	54,328	6,568
2012	3,669,278	569,931	558,046	313,357	23,034	55,169	6,752
2013	3,688,161	578,723	588,249	321,539	21,937	56,467	7,283
2014	3,731,888	595,970	621,915	339,177	21,510	57,012	6,675
2015	3,828,301	631,100	666,115	344,073	21,118	56,109	6,536
2016	3,924,199	659,997	711,817	346,610	22,022	56,672	6,520
2017	U	684,221	751,187	U	U	54,826	U

KEY: R = revised; U,=unavailable.

NOTES: U.S. and foreign air carrier, international includes only scheduled flight segments to and from the United States. Light-duty highway vehicle includes both short and long wheel base passenger cars, pickup trucks, vans, and sport utility vehicles (SUVs). Bus and demand response are included in both Bus and Transit, which results in some double counting. Amtrak does not include contract commuter passenger-miles. The data in table above may not be consistent with other sources, particularly data that are revised on an irregular or frequent basis. Different vehicle occupancy rates were used to estimate passenger-miles for Light-duty highway vehicles and Bus beginning with 2009. Nationwide travel data for walking and biking are not collected on an annual basis.

SOURCES: **U.S. foreign air carrier, international**: U.S. Department of Transportation, Bureau of Transportation Statistics, T-100 Market Data, available at http://www.transtats.bts.gov/ as of July 2018. **All other categories**: Various sources as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 1-40, available at http://www.bts.gov/publications/national_transportation_statistics/ as of October 2018.

in 2017 exceeded the low levels during the December 2007 to June 2009 Great Recession by nearly 25 percent. Highway pmt by cars and other personal vehicles in 2016 had yet to fully rebound to their previous peak set in 2007, prior to the recession.

Transit and intercity passenger rail services grew in number of passengers and passenger-miles during the recession and in most years thereafter, with some year-to-year fluctuation.

After decades of rapid growth in personal travel, travel behavior seems to be changing as is shown in data released this year from the Federal Highway Administration's 2017 National Household Travel Survey (NHTS) (box 3-A) [USDOT FHWA NHTS 2017]. The survey results show the impact of demographic and technological changes on everyday travel trends. For example, the data show that Americans are traveling less for everyday purposes than they did in the past. The larger demographic context is that younger people are staying single longer, renting in urban areas longer, and using personal vehicles less for their travel. In many urban areas people have multiple travel options (e.g., light rail, ride-hailing, and bike-sharing), and the data show that they use these options. People in rural areas are also traveling less for everyday purposes compared to previous years. However, rural Americans with fewer options continue to be more dependent on personal vehicles than residents in urban areas.

Another travel trend identified in the data is that older people are working past the traditional age of retirement, working at home

Box 3-A The National Household Travel Survey (NHTS)

The National Household Travel Survey is the U.S. Department of Transportation's recurring inventory of daily travel. The survey has been conducted periodically since 1969 and has evolved in methods and uses across the decades. The 2017 NHTS, the most recent data released in April 2018, contains information for 264,000 completed responses from people aged 5 and older in 130,000 households. Every respondent recorded their travel for a single, assigned travel day. This allows the analysis of the interactions between household members and the linking of travel to the individual and household characteristics, such as income, number of vehicles, and the presence of children. The findings of the survey are documented in the *Summary of Travel Trends*, which is available at https://nhts.ornl.gov/. This chapter presents further analysis of the new data to describe significant changes in travel.

The 2017 NHTS survey methodology underwent a redesign that improved the coverage of the sample and robustness of the data estimates. However, these changes could affect comparisons with data from previous surveys in many ways. For example, the earlier surveys sampled only households with landlines; cell-phone only households were excluded. The 2017 NHTS used an address-based sample that included more Hispanic and lower income households. Changes in question wording, placement, and categories of response can all have an impact on the estimates. Further research is needed to identify the impact on the data estimates from these changes. For more detail see the *NHTS User's Guide* (as provided at https://nhts.ornl.gov/assets/2017UsersGuide.pdf).

at higher rates than in the past, and driving into their elder years. This phenomenon is part of a larger demographic shift dubbed the "longevity revolution" [BUTLER], but it is also enabled by burgeoning communication technology—which allows many more workers of all ages to work from home.

Online shopping and home delivery of goods and services more than doubled between 2009 and 2017. Younger people and parents of children and teens ordered deliveries the most often, but older people (those over 65 years of age) had the greatest growth in their online shopping since 2009. That said, it is difficult to prove these online purchases substitute for specific shopping trips. Academic theory also notes that advancements in communication technology may increase travel (e.g., e-communications might encourage travel by helping coordinate social activities and travel plans) as all advances in communications have done in the past [MOKHTARIAN].

Local Travel

While daily travel behavior remained somewhat stable over the last two decades, the 2017 National Household Travel Survey (NHTS) showed that the average American traveled less, especially for shopping and running errands and used ride-hail services more. Compared to the peak in 2001, the typical American in 2017 was at least 10 percent less likely to travel, as measured by the number of daily miles or daily trips taken.

In 2017 the average American traveled about the same number of miles by all modes of transportation as in 2009, but made fewer trips for everyday purposes [USDOT FHWA NHTS 2017].[2] On average, he or she traveled 36 miles and took slightly fewer than 3.4 trips per day in 2017, suggesting each trip became slightly longer in distance in 2017 than in 2009.

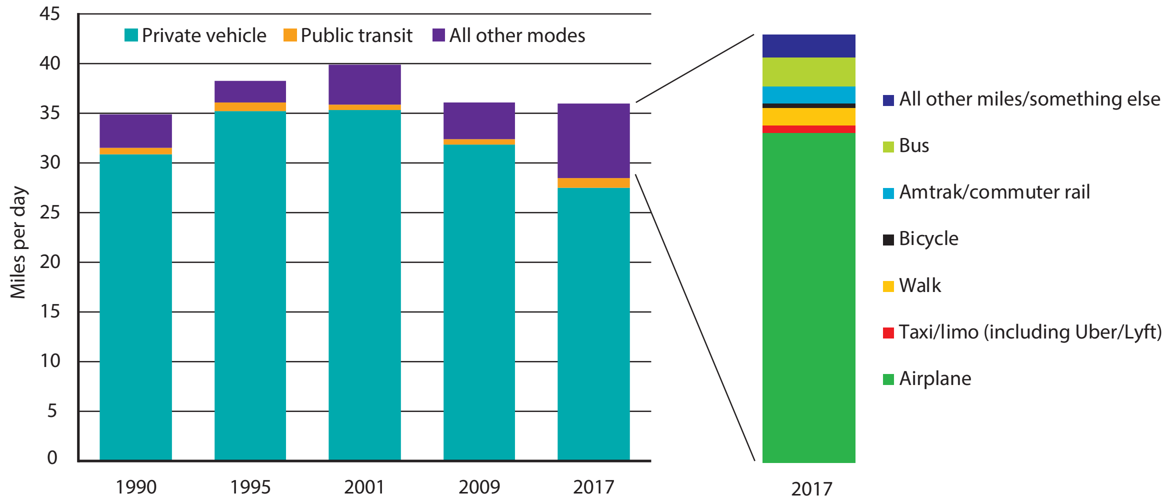
Urban areas have experienced an explosion of new rideshare (e.g., Uber, Lyft) and the data show that many used their private vehicles less (figure 3-1) and these new options more. While trip-making for work and school has not changed much over many decades, in the most recent data people reported fewer discretionary trips, such as for shopping and errands and for social and recreational purposes (figure 3-2).

The majority of the daily trips took place between 6 a.m. and 7 p.m. However, this temporal pattern varied by trip purpose (figure 3-3). The 2017 data clearly show that the morning and evening peak periods include not just commutes, but shopping and family errands (which includes dropping children at school) and other non-work trips. While most vehicle commutes started between 6 a.m. and 9 a.m. and between 4 p.m. and 7 p.m., more than half of non-work related trips started during non-peak hours, between 9 a.m. and 4 p.m., perhaps to avoid peak rush-hour periods. This behavior leads to midday traffic congestion.

Recent research indicates an unprecedented shift in attitudes and daily travel behavior related to convenience, privacy, and sustainability [e.g., TCRP 2017]. Many respondents in urban areas have access to transit, ride-hailing, bike-share, and other transport options. People who use these travel

[2] The NHTS collects daily local travel, and does not specifically include long-distance travel.

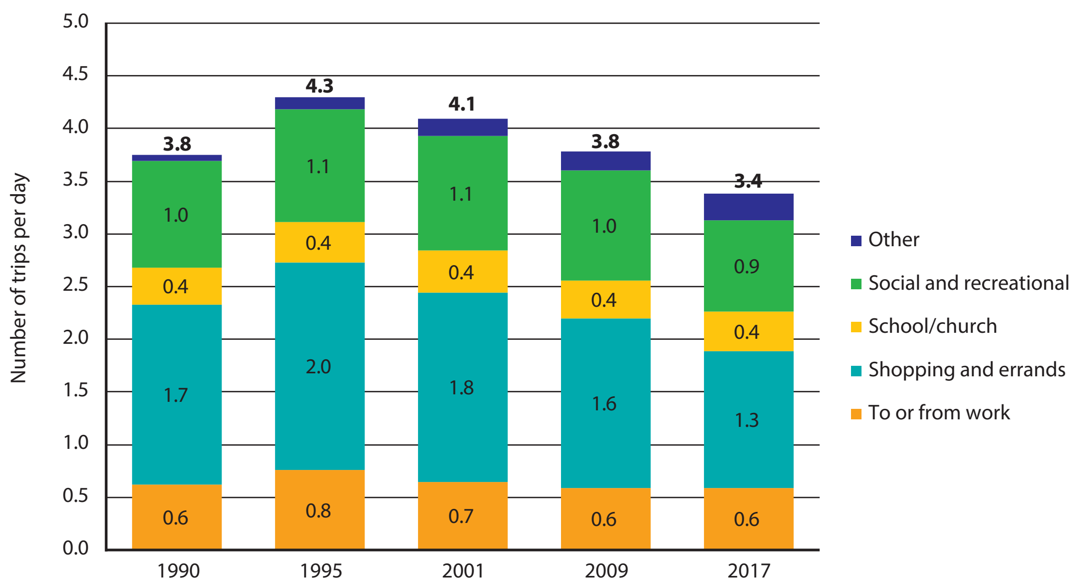
FIGURE 3-1 Daily Person-Miles of Travel by Mode: 1990, 1995, 2001, 2009, and 2017



NOTES: 2017 NHTS collected trip distance differently than previous surveys, which could impact the data shown. Private vehicle includes car, SUV, van, pickup truck, motorcycle / moped, RV (motor home, ATV, snowmobile), and rental car (Including Zipcar / Car-2Go). Public Transit includes public or commuter bus, paratransit / Dial-a-ride, subway / elevated / light rail / street car, and boat / ferry / water taxi. All Other Modes includes walk, bicycle, golf cart / segway, school bus, private / charter / tour / shuttle bus, city-to-city bus (Greyhound, Megabus), Amtrak / commuter rail, taxi / limo (including Uber / Lyft), airplane, or "something else."

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

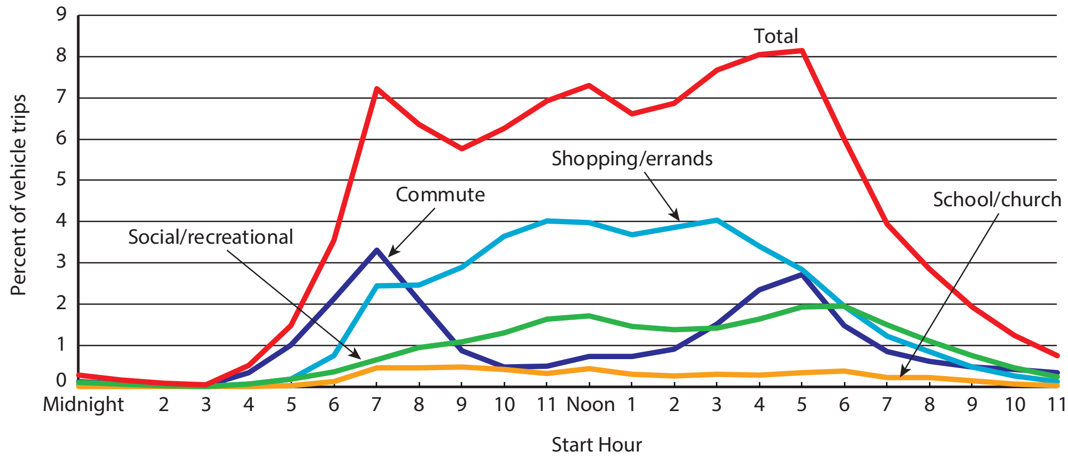
FIGURE 3-2 Number of Daily Trips per Person by Purpose: 1990, 1995 NPTS and 2001, 2009, 2017 NHTS



KEY: NHTS = National Household Travel Survey, NPTS = National Personal Travel Survey

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

FIGURE 3-3 Distribution of Vehicle Trips by Trip Purpose and Start Time: 2017



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *2017 National Household Travel Survey*, available at https://nhts.ornl.gov as of October 2018.

options may select their mode of travel based on daily circumstances rather than habit [TCRP 2016].

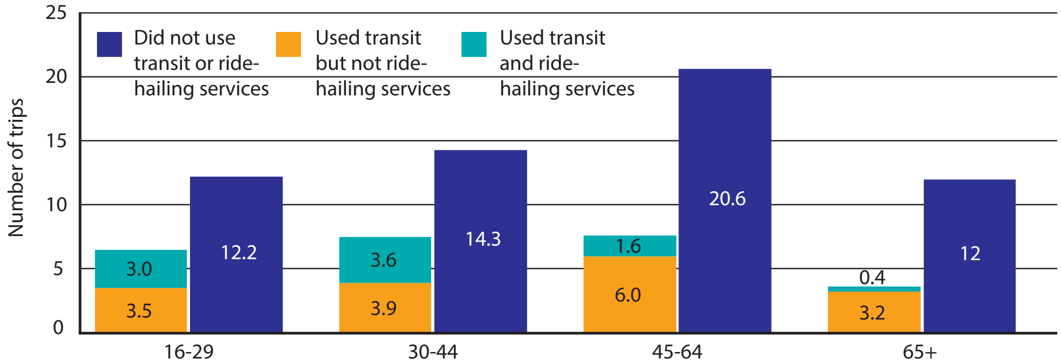
New travel options can compete with or complement existing transportation. The 2017 NHTS data show that people who use transit in urban areas also use ride-hailing services—especially younger people (figure 3-4). On average, it was estimated that one-quarter of the respondents used transit within the 30 days prior to the day of the survey, and one-third of them reported that they also used a ride-hail service during that period. However, this pattern was correlated with the age of the traveler. Almost half (3.6 million or 47.5 percent) of transit users aged 30–44 also used a ride-hailing service compared to about 400,000 (or 11 percent) of transit users 65 and older.

About 35 percent of the U.S. population takes a trip by walking for any reason on an average day, an estimate that has not changed in almost two decades (the 2017 estimate is within the margin of error of the 2001 estimate). Overall, nearly half (47.5 percent) of all walks are for social and recreational reasons (figure 3-5), followed by shopping and errands (29.5 percent) and walks to school or church (10.6 percent).

Nationally, only a small percentage of people walk or bike to work. However, these non-motorized modes are important in many cities of all sizes, as shown by the 2017 American Community Survey (ACS). Averaged across the 50 largest U.S. cities, 4.9 percent of workers walked to work and another 1.2 percent biked. Over 14 percent of workers in Boston, MA, walked to work, as did more than 10 percent of commuters in Washington, DC; San Francisco, CA; Seattle, WA; and New York City.

Portland, OR (6.3 percent); Washington, DC (5 percent); and Minneapolis, MN (3.9 percent) had the highest percentage of bicycle

FIGURE 3-4 Urban Transit Users by Age Group Who Also Used Ride-Hail Services in the 30 Days Prior to the NHTS Survey: 2017

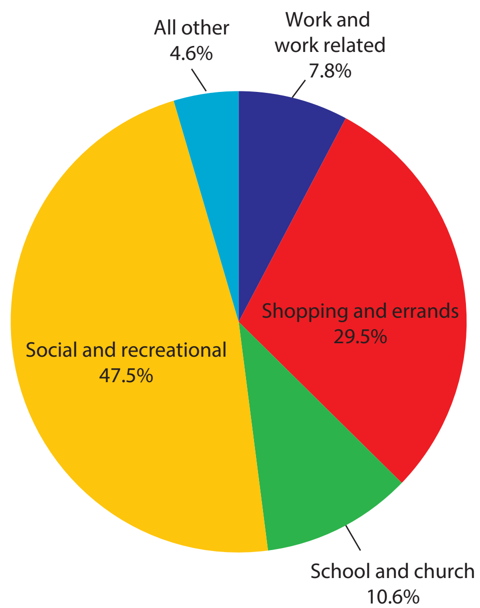


KEY: NHTS = National Household Travel Survey

NOTES: *Transit users* includes people 18 and older who used transit at least once in the last 30 days in MSAs with 3 million or more population. *Ride-hailing* use includes those who purchased a ride using a smartphone ride-hailing app (such as Uber, Lyft, or Sidecar).

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *2017 National Household Travel Survey*, available at https://nhts.ornl.gov as of October 2018.

FIGURE 3-5 Daily Walking by Purpose: 2017



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *2017 National Household Travel Surveys*, available at https://nhts.ornl.gov as of October 2018.

commuters. These cities have invested in infrastructure to facilitate biking (e.g., building dedicated bike lanes). Some smaller cities, sized 20,000 to 99,999, exceed these larger city rates of walking and biking. For example, about 40.5 percent of workers in Amherst Center, MA, home to the University of Massachusetts, Amherst, walk to work; and 33 percent in Isla Vista, CA, home to the University of California, Santa Barbara, commute by bike. Among Census regions, the Northeast has the highest rate of walking to work, while the West had the highest rate of biking [USDOC CENSUS 2017].

As of May 2018, there were a total of 106 bike-share systems with fixed docking stations available to the general public for a fee. About 70 percent of all bike-share docking stations are within one block of another public passenger transportation mode, providing seamless multimodal connections (see chapter 1 for further discussion of bike-share systems).

Looking further back to include the 1995 and 2001 NHTS surveys, the changes in trip-making have been most apparent in young people who lived in urban areas, leading to widespread reporting of millennials changing travel preferences. Research found changing travel behavior across the population—by all ages in urban and rural areas. More research is needed, but some of the changes, such as declines in trips for shopping and errands, coincide with the rise in online shopping and household deliveries. Work at home has increased dramatically, aided by e-communication and fueled by a trend called "working retirement." The impacts of e-commerce and working retirement on personal travel are discussed in subsequent sections.

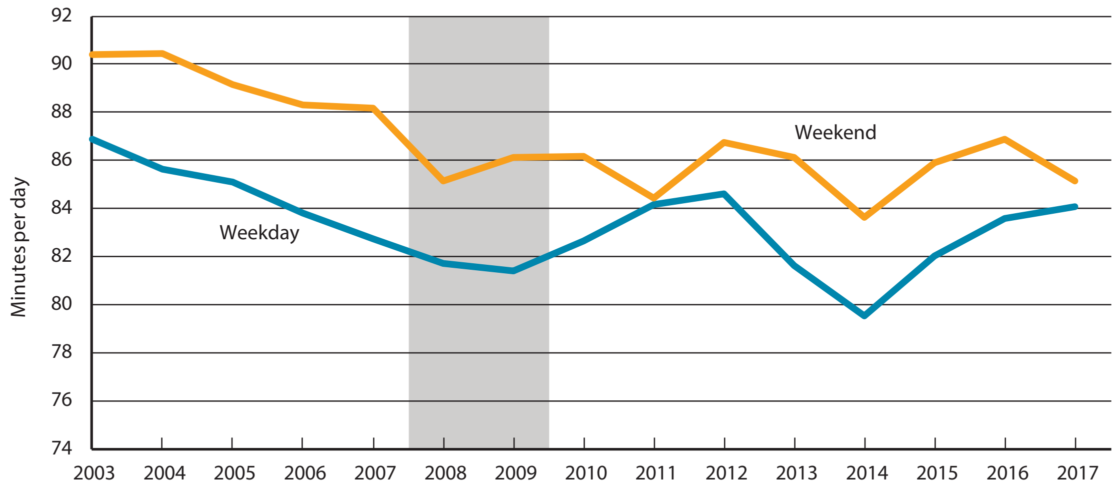
Time Spent Traveling

In 2017, the average person spent 84.1 minutes per weekday traveling for a variety of activities—slightly up from 83.6 minutes in 2016 (American Time Use Survey (ATUS)). Among the 45.1 percent of people who engaged in travel for work, the average person in this group spent 50.0 minutes per day on work travel, the most travel time for all activities in 2017 [USDOL BLS 2018]. The 50 minutes spent on daily work travel was an increase of almost 10 percent from the 45.5 minutes in 2016.

In 2017 people averaged 1.1 more minutes in weekend and holiday travel activities than on weekdays, an average of 85.1 minutes per day. The average person spent the most weekend and holiday travel time (47.9 minutes) for activities related to personal care, about 15.8 minutes per day more than on weekdays. Travel related to eating and drinking accounted for 35.4 minutes—about 7.9 minutes more than on weekdays.

People spent less time traveling in 2017 than in 2003 (figure 3-6). On weekdays in 2017, people spent 2.8 fewer minutes traveling per day, a decrease of 3.2 percent from 2003. On weekends and holidays, people spent 5.3 fewer minutes traveling per day, a 5.8 percent decrease.

FIGURE 3-6 Trends in the Total Time Spent Traveling on Weekdays and Weekends: 2003–2017



NOTE: Shaded area indicates economic recession.

SOURCE: U.S. Department of Labor (USDOL). Bureau of Labor Statistics (BLS). *American Time Use Survey* 2003-2017 Microdata files (October 2018). Available at www.bls.gov as of October 2018.

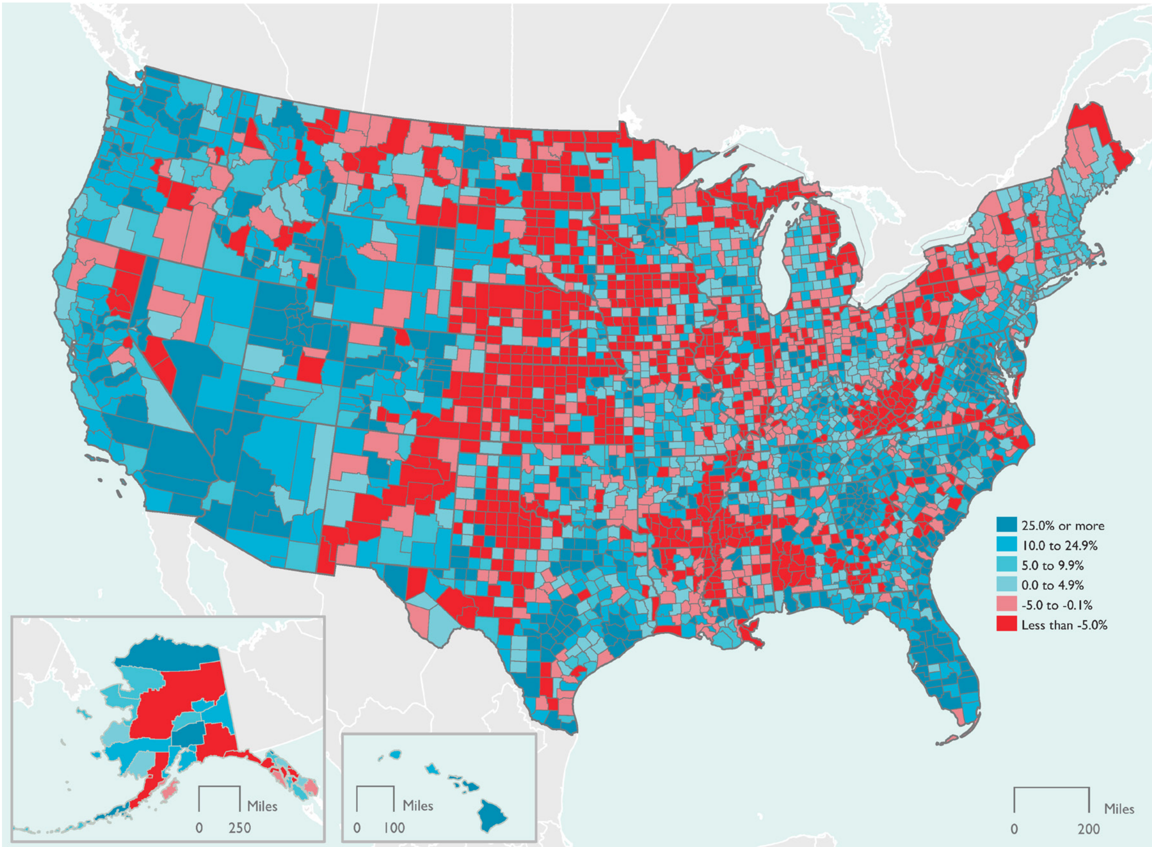
Geographic and Demographic Shifts

Although the United States is geographically vast, its population is concentrated in a relatively small number of large urban areas. In 2010 nearly 250 million people lived in the country's urban areas—more than 80 percent of the total U.S. population [USDOC CENSUS 2017]. The largest 75 metro areas account for about half the population. U.S. population growth continues moving south and west—Florida and Texas added the most new residents between 2016 and 2017 (figure 3-7)—as has been the case for decades [USDOC CENSUS 2006].

The population growth in rural areas has stalled—in 2010 about the same number of people lived in rural areas as in 1980. On the other hand, the urban population almost doubled over the last half century (figure 3-8). Urban areas grow via the natural increase in the city's population, the migration of new people—from rural areas, other cities, or abroad—and the annexation of newly developed areas, usually at the outskirts of existing urban areas.

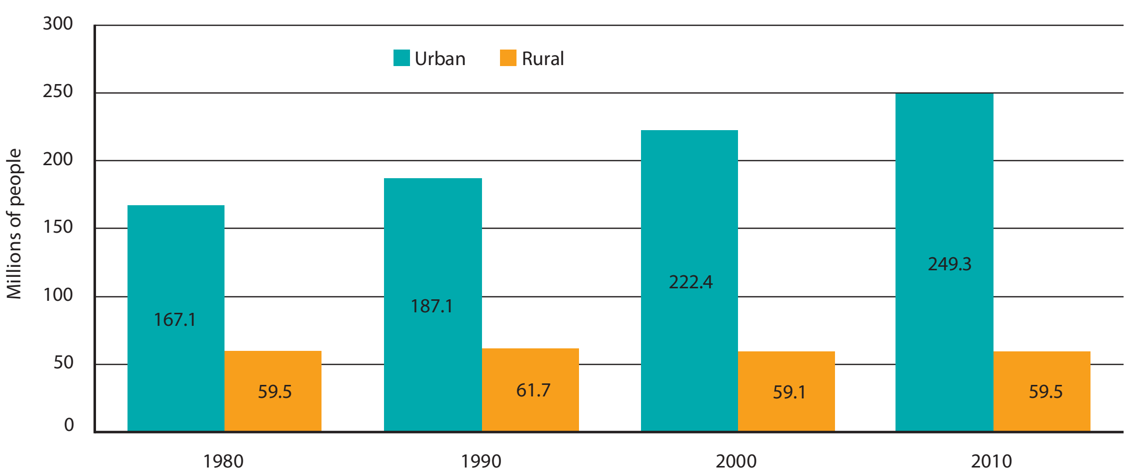
People who live in metro areas generally have very different travel choices compared to those who live in rural areas. Access to transit, even sidewalks and bike lanes, and new travel options (e.g., Uber/Lyft), are concentrated in urban areas. Compared to people in urban areas, people in rural areas generally live in larger households with more vehicles available and rely more on personal vehicles [USDOT FHWA NHTS]. One in every 10 people live in an urban household without any vehicles compared to one in 30 in rural areas (table 3-2). Table 3-2 presents other differences between urban and rural residents related to everyday travel. One of the important shifts in behavior revealed in the 2017 NHTS is the

FIGURE 3-7 Percent Change in Population by County, 2000–2017



SOURCE: U.S. Department of Commerce, Census Bureau, Population, County Population, available at https://www.census.gov/ as of October 2018.

FIGURE 3-8 Number of People Living in Urban and Rural Areas: 1980–2010



SOURCE: U.S. Census Bureau, *Population Estimates*, available at https://www.census.gov/ as of September 2018.

TABLE 3-2 Characteristics of Urban and Rural Residents: 2017

Characteristics	Living in urban areas	Living in rural areas	U.S. (all)
Percent of people 16 and older who are drivers	85.9%	91.9%	87.2%
Percent of people 16 and older who work (part- or full-time)	62.0%	57.9%	61.3%
Percent of people living in households without a vehicle	10.2%	3.1%	8.9%
Percent of people who did not travel on travel day	16.3%	20.0%	17.1%
Number of everyday trips per person for people aged 16 and older	3.5	3.2	3.4
Average trip length for people aged 16 and older	10.4	14.2	11.1
Average daily person miles of travel for people aged 16 and older	36.7	46.1	38.4
Average daily vehicle miles of travel for people aged 16 and older	20.8	30.3	22.5

NOTE: 2017 NHTS collected trip distance differently than previous surveys, which could impact the data shown.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, National Household Travel Surveys, available at https://nhts.ornl.gov as of October 2018.

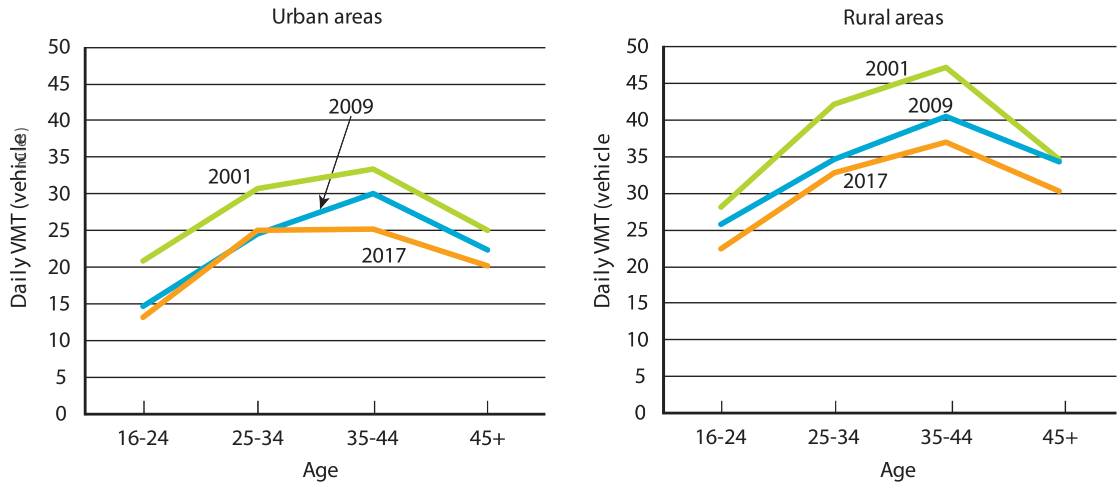
number of people who report not traveling at all on the assigned day: 16.3 percent of urban residents and 20 percent of rural residents, report no trips at all on an average day.

Many factors impact household formation, location decisions, and even employment status—all of which in turn impact travel patterns. As these factors change over time, travel patterns also change along with them. An examination of the changing economics and demographics of young people between 1975 and 2016 found that: a third of people 25–34 years old have a college degree, compared to a quarter in 1975; and one in three 18–34 year olds lived in their parents' home in 2016, compared to about one in four in 1975 [VESPA]. Additionally, the average age of a first marriage in 2015 rose to 29.5 for men and 27.4 for women—an all-time high in U.S. history. Younger people rent for a longer period than in the past before purchasing a home [NAR].

The delay in family-building impacts travel behavior. Households with children travel more than those without children. Renting for longer periods of time by younger people in urban areas may also have an impact on their everyday travel. People who live in denser urban areas overall have fewer vehicles, drive for fewer miles, and take transit more than people in other areas. People with greater educational attainment generally have higher household incomes and travel further to work than those with less education (USPZRG).

Although young people are changing their travel behavior the most, the NHTS has tracked declines in vehicle use across all ages by people in all areas (figure 3-9). Overall, vehicle-miles of travel per person in urban areas declined 24 percent between 2001 and 2017, compared to 19 percent in rural areas. Young people (16–34) in urban areas had declines in vehicle travel between 2001 and 2009, but no decline between 2009 and 2017.

FIGURE 3-9 Vehicle-Miles of Travel in Urban and Rural Areas by Age: 2001–2017



NOTE: 2017 NHTS collected trip distances differently than previous surveys, which could impact the data shown.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

In rural areas, most of the declines in vehicle travel occurred between 2001 and 2009, with slight declines between 2009 and 2017 across all age groups [USDOT FHWA NHTS 2017].

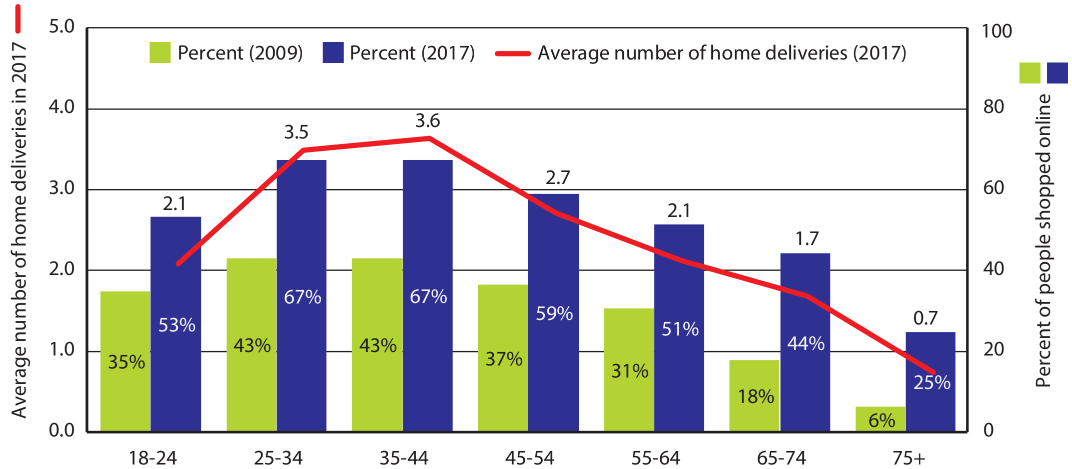
New Technologies

Information and communication technology have changed how everyday activities, such as shopping and hailing a ride, are done. This section outlines some of the potential impacts of new technologies on travel behavior as reflected in the NHTS data.

One of the major new conveniences for U.S. households is online shopping and home delivery of many types of goods. Whether goods were delivered to a household was first asked in the 2009 NHTS. The estimated average number of deliveries in a month more than doubled, from 2.4 in 2009 to 4.9 in 2017 [USDOT FHWA STT 2018]. Online shopping is more prevalent in households with children, especially older teens and young adults (aged 16–21). Across all age groups, the percent of people who use on-line purchases increased significantly from 2009 to 2017 (figure 3-10). As shown in figure 3-10, the largest group of people by age that use on-line purchases delivered to the house were those younger to middle aged (from 25 to 44), with an average between 3.5 and 3.6 deliveries per month. However, older people had the largest percent increase in using on-line purchases delivered to the household. This includes nearly one internet delivery per month in 2017.

Another technology that has impacted urban travel is the ride-hailing app. In the 2017 NHTS, respondents were asked what alternate form of transportation they could take if their car was not available. Slightly more people chose ride-hail than transit (table 3-3). People who use ride-hailing are more likely to be urban workers with no children and have

FIGURE 3-10 On-line Purchases and Deliveries by Age Groups: 2009 v. 2017



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (2009 and 2017), available at https://nhts.ornl.gov as of October 2018.

TABLE 3-3 Ranking Alternative Transportation Choices: 2017

If you couldn't use your car for this trip, how would you travel?	Percent
Ride from friends and family	42.1
Ride-hail (Uber/Lyft-Taxi)	24.7
Public transit	24.3
Walk	21.4
Rental or Zip Car	16.3
Bicycle	11.6

SOURCE: U.S. Department of Transportation, Federal Highway Administration, Summary of Travel Trends 2017, *National Household Travel Survey*, available at https://fhwa.dot.gov as of October 2018.

higher travel rates compared to people who don't use these apps [USDOT FHWA STT 2018]. There is growing evidence that suggests ride-hailing is being used in part as a substitute for transit—possibly lowering transit ridership and revenues [BLISS].

Finally, because of greater access to information and communication technology, people may be spending more time at home. Americans spent on average an extra 8 days at home in 2012 compared to 2003 and one fewer day traveling. The greatest change was seen in people ages 18–24, who spent 70 percent more time at home compared to the general population. People over 65 were the only group to spend more time outside the home in 2012 compared to 2003 [SEKAR]. Additionally, the percentage of all people that did not travel on an average day increased from 12 percent in 2009 to 18 percent in 2017 [USDOT FHWA NHTS].

Overall, changes due to new technologies have potential implications for travel demand. The declines in everyday personal travel for shopping (as shown in figure 3-2 above) may be offset in part by increased activity by commercial/freight vehicles that deliver goods to households.

Journey-to-Work

The work trip is important to transportation planning. For most workers commuting is still predominantly a weekday activity, tied to the morning and evening hours. Commuting is regular in frequency, time of departure, and destination—which contributes to local congestion. According to the 2017 NHTS data, three-quarters of the respondents attributed their slow commutes to congestion. Work trips are also critical to transit planning—about half of transit trips are commutes [TCRP 2017].

In 2017 commuting accounted for 17.4 percent of all trips and 18.6 percent of all person-miles of travel (table 3-4). Commuting represented nearly a quarter of vehicle trips and 30 percent of vehicle-miles of travel. The average length of a commute trip has remained relatively stable at 11 miles per trip, while the speed of an average commute continues to fall [USDOT FHWA STT 2018]. Survey respondents to the 2017 NHTS reported that they have spent additional time commuting in 2017 due to factors such as congestion (75 percent of the respondents), construction (15 percent), bad weather (5 percent), and accidents (5 percent).

While the annual number of commutes per worker has remained virtually the same over many years, the total number of workers in the United States continues to increase along with the total population. From the beginning of the NHTS series, private vehicle travel to work has predominated in commuting (figure 3-11), and transit, walk, and other means of travel to work have been relatively small proportions of overall work trips. [USDOT FHWA STT 2018]

On average, larger metro areas have slower commute speeds—both because of more congestion, but also because more workers

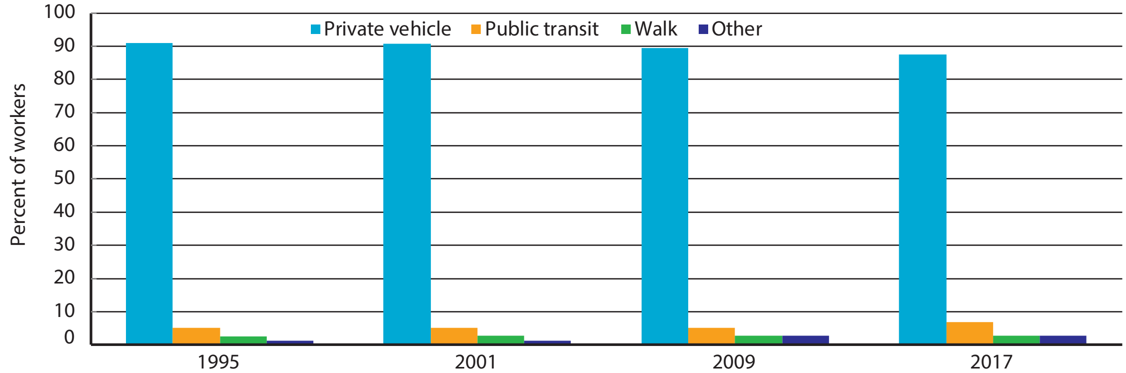
TABLE 3-4 Commute Characteristics: 1995 NPTS and 2001, 2009, and 2017 NHTS

Trends in Commute Characteristics	1995	2001	2009	2017
Workers as percent of all people 16+	66%	70%	64%	61%
Average commute trip length all modes (miles)	11.6	12.1	11.8	11.5
Average commute speed for all modes (mph)	34.7	32.2	27.5	23.4
Commutes as a percent of all:				
Person trips	16.4%	14.9%	15.6%	17.4%
Vehicle trips	23.8%	22.1%	22.1%	24.1%
Person-miles of travel	22.5%	19.0%	19.0%	18.6%
Vehicle-miles of travel	31.1%	27.0%	27.8%	30.2%

NOTE: 2017 NHTS collected trip distance differently than previous surveys, which could impact the data shown.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

FIGURE 3-11 Distribution of Workers by their Usual Means of Travel to Work: 1995 NPTS and 2001, 2009, and 2017 NHTS



NOTE: 1969 NPTS did not include walk trips.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

commute by non-auto means of travel, like transit and walking, which ordinarily have relatively slow travel times. However, since 1995 there has been a noticeable decline in commute speeds across the Nation, while the average distance to work has remained about the same (table 3-4). Between 1995 and 2017, the average overall commute speed for all areas of travel dropped by 34 percent, from 35 miles per hour to 23 miles per hour. [USDOT FHWA STT 2018]

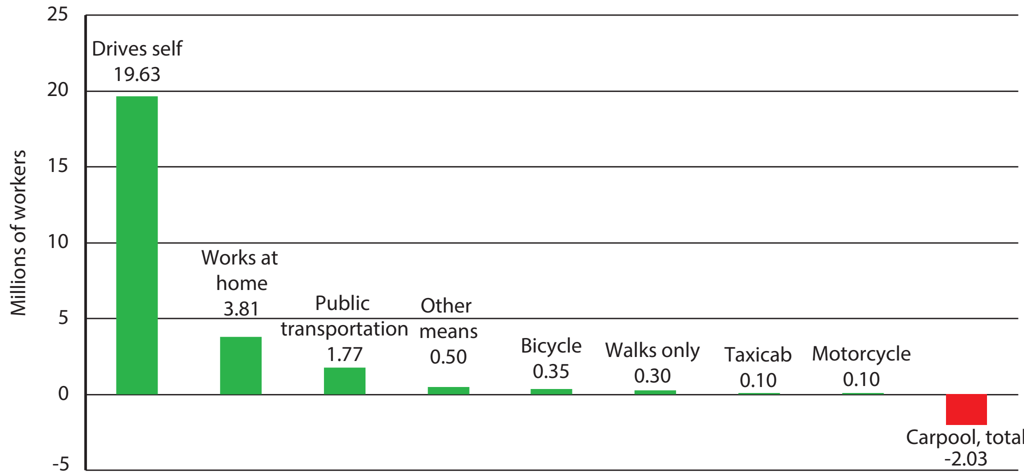
Even with slower speeds, in most areas driving alone to work continues to grow as the number of commuters grows. Nearly 20 million more commuters drove alone to work in 2017 than in 2000, while about 2 million fewer people carpooled to work (figure 3-12).

Work from Home

The growth in the number and percent of workers over 65 (the traditional retirement age) is notable—this trend has been called "working retirement" [SRINIVASAN]. The baby boomers— people born between 1946 and 1964— began turning 65 years of age in 2011 and are driving growth in the older population. By 2029, when all the baby boomers will be aged 65 or older, more than 20 percent of the total U.S. population will be over the age of 65 [COLBT; ORTMAN]. Because of the baby boomers remaining in the workforce, the average age of an American worker has increased [BLS 2016].

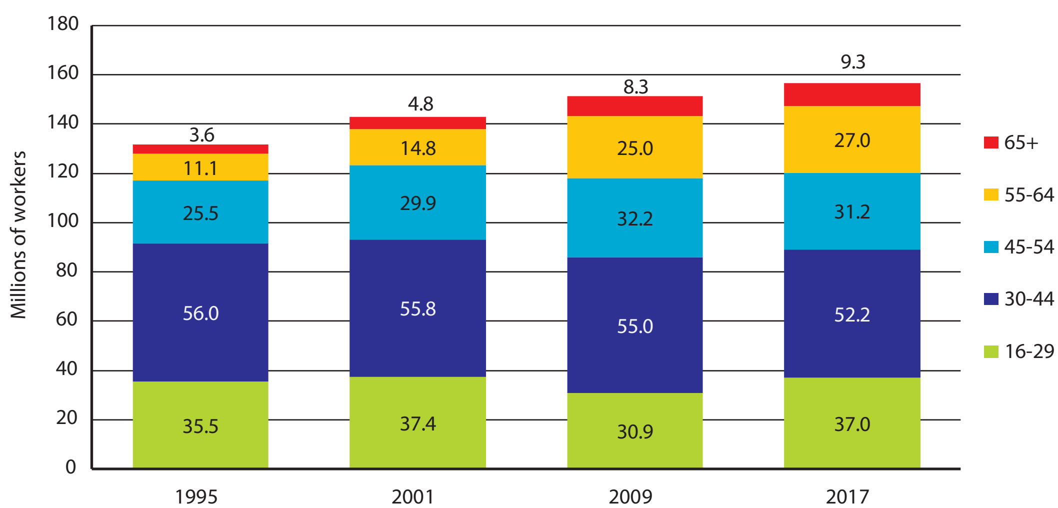
According to the 2017 NHTS, nearly 30 percent of people aged 65–75 are still in the workforce, double that of almost 15 years ago and nearly triple the 1995 estimate (figure 3-13). Older workers have different commute behavior compared to younger workers: older workers are more likely to work part-time, to work closer to home, and to work from their home [SRINIVASAN].

FIGURE 3-12 Workers Net Change by Mode of Transportation: 2000–2017



SOURCES: **2000**: U.S. Department of Commerce (USDOC), Census Bureau (CB), Decennial Census. About Commuting (Journey to Work). Available at http://www.census.gov/ as of October 2018. **2017**: U.S. Department of Commerce, Bureau of Census, American Community Survey, 1-year estimates, available at http://factfinder.census.gov/ as of November 2018.

FIGURE 3-13 Number of Workers by Age Group: 1995 NPTS and 2001, 2009, and 2017 NHTS



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

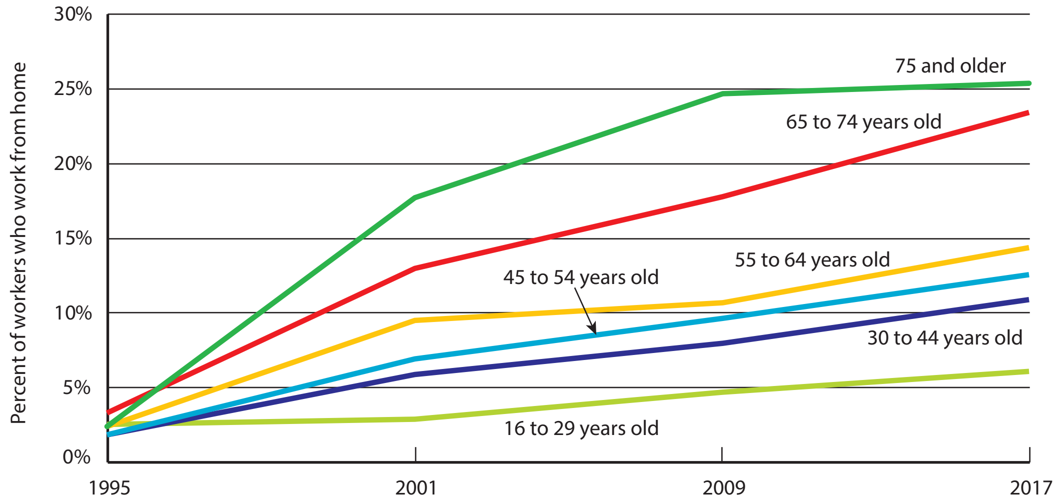
The overall growth in the number of workers who usually work from home is remarkable, from 5.8 million in 2010 to 7.9 million in 2017. In 1995 fewer than 3 percent of workers of any age worked only from home (not including occasional telecommuting). By 2017, 10–15 percent of workers aged 30–64 reported that they worked from home, and nearly 25 percent of workers aged 65 and over reported working only from home (figure 3-14). The characteristics of workers who work from home have also changed. In 1990 people who worked from home were mostly small farmers, dentists, hairdressers, and the like. Between 2001 and 2017, the percent of workers who work from home in technical and professional job classifications more than doubled.

The characteristics of workers who only work from home differ from those who commute daily. For example, workers who work from home are older and more highly educated, on average. For most workers, the commute trip is the longest trip of the day, about 11.6 miles one-way in 2017 and 27.5 minutes of travel. People who work from home do not have the average commute of 23 miles and 55 minutes a day of travel [USDOT FHWA STT 2018]. Whether workers who work from home substitute other travel in their daily travel budget is a topic for further study.

Complex Commutes

Many commuters do not make a direct trip from home to work but include an intervening stop along the way—dropping off children, picking up necessities, going to the gym, or checking in on a sick friend. Some of these trips are regular daily stops, some are scheduled and recurring but not daily, and some are infrequent. These non-work trips woven into the commute are called "trip-chains" because they link together segments

FIGURE 3-14 Percent of Workers by Age Group Who Work from Home: 1995, 2001, 2009, and 2017



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

of travel. Trip-chaining is important to analyze because these intervening trips can affect the departure time, travel time, route, and mode of commuting.

Trip-chaining increases the efficiency of an individual's travel day—and may even save gas (and pollution from "cold starts") versus making separate trips for each activity or task. However, these stops can also increase the number of non-work-related trips occurring in the peak period, potentially adding to congestion. In addition, people who need to make an intervening stop may find it impractical to carpool or take transit, and thus continue to rely on single-occupancy vehicles.

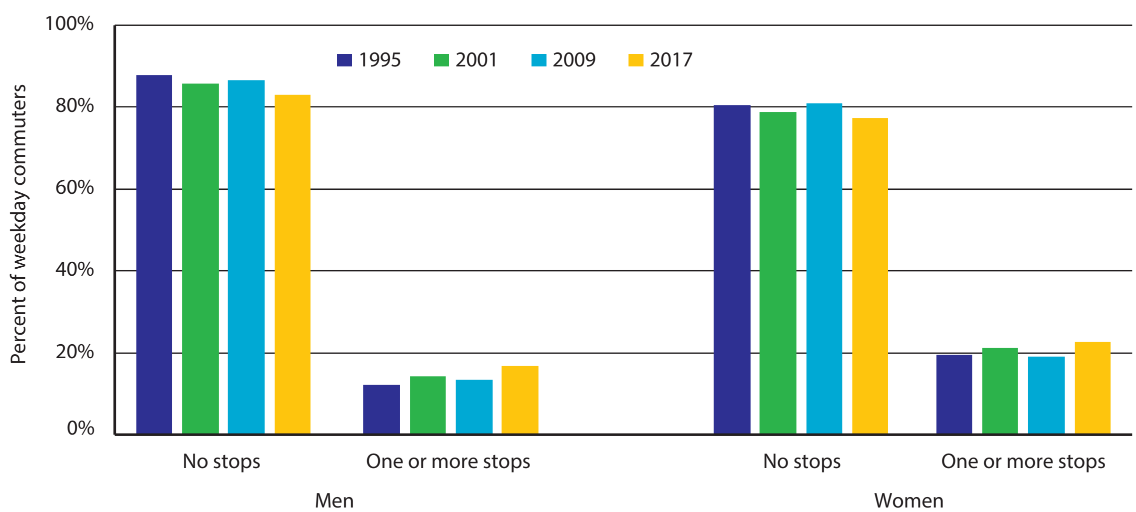
The 2017 NHTS shows a slight, but statistically significant, increase in the percent of commuters who stop during their commutes (figure 3-15). About 20 percent of weekday commuters make an incidental stop on the way to or from work [USDOT FHWA NHTS]. Nearly a quarter of women workers (23 percent) stop on their way to or from work compared to 17 percent of men workers. This reflects the greater number of trips women take, especially trips related to household maintenance and childcare.

Typical stops on the way to work or from work are for shopping and errands, followed by dropping off/picking up a passenger [USDOT FHWA NHTS]. Stops for meals or coffee are the third largest category, followed by stops to visit a friend or relative or for a medical appointment (figure 3-16).

Special Populations

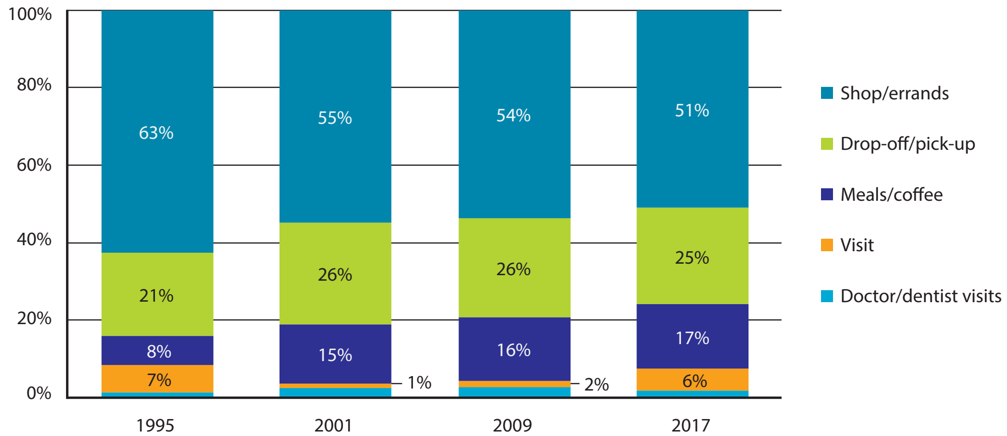
This section looks at travel behavior of the aging population, younger people, people without access to a personal vehicle, and people with mobility impairments (travel disabilities).

FIGURE 3-15 Percent of Weekday Commuters Who Travel Directly to Work or Make a Stop on the Way: 1995 NPTS and 2001, 2009, and 2017 NHTS



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

FIGURE 3-16 Purposes of Stopping While Commuting: 1995 NPTS and 2001, 2009, and 2017 NHTS



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

Aging Population and Young Drivers

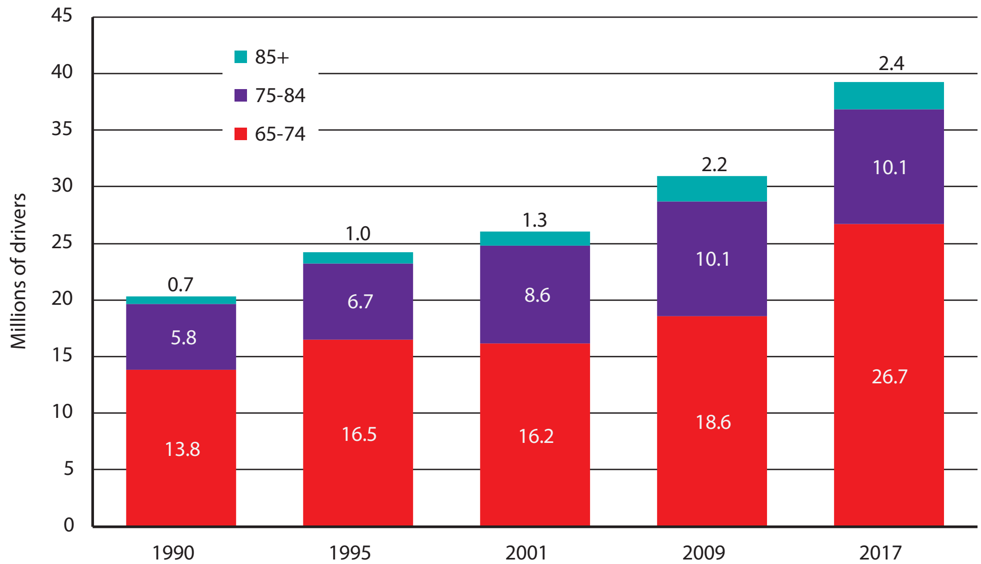
By 2016 the population 65 years and over was 15.6 percent of the population, about 50 million people. It is estimated that by 2030 the older population will likely outnumber children for the first time in history, growing to nearly 74 million people—an increase of almost 50 percent from 2016. By 2050 people aged 65 and older are projected to represent nearly a quarter of the U.S. population, 94 million individuals [USDOC CENSUS 2018].

As the population ages, the number of drivers aged 65 and older continues to grow (figure 3-17). The total number of drivers aged 65 and older nearly doubled between 1990 and 2017—rising from 20.3 to 39.3 million [USDOT FHWA NHTS].

Like other age groups, people 65 and older reported fewer vehicle trips in 2017 than in 2009. The vehicle-miles of travel (vmt) were statistically the same in 2017 compared to 2009. On the other hand, person trips and person-miles of travel both show significant increases for older individuals between 2009 and 2017. But the 2017 estimates are about the same as those in 2001, so while per person travel by older people may have declined during the recession, it is little different today than in 2001. However, as this population group grows so dramatically, more of the travel in the United States will be impacted by greater numbers of older individuals.

Overall, younger drivers (aged 16–24) report driving fewer miles per capita in 2017 compared to previous decades. In urbanized areas, where the majority of the U.S. population lives, the declines in vmt per day are notable for people aged 16–24 compared to 2001 but not 2009. Factors such as graduated driver licensing, a delay in getting a license, and changing attitudes toward driving may affect their choices. In any case, the percent of all people aged 16–24 without a license increased from 21 to 26 percent between 2009 and 2017.

FIGURE 3-17 Number of Drivers Aged 65 and Older: 1990, 1995 NPTS and 2001, 2009, and 2017 NHTS



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

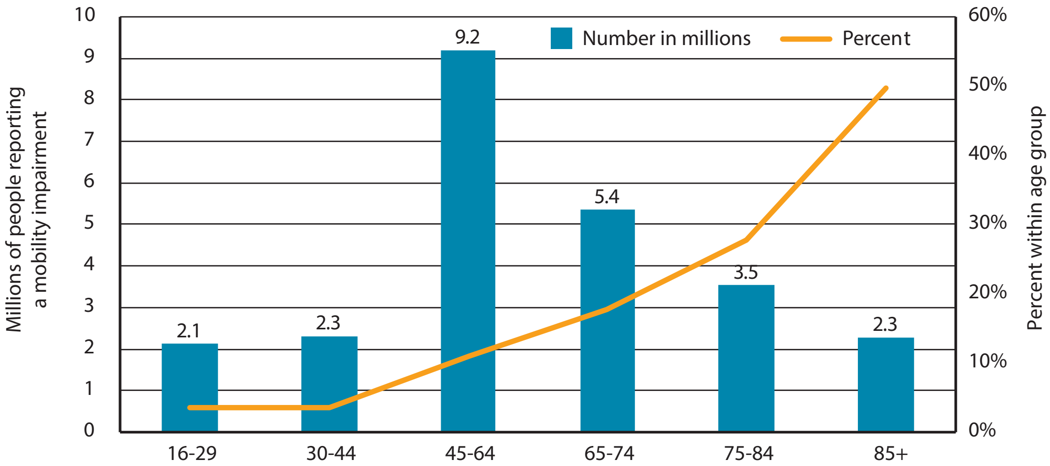
Travel by Persons with Disabilities

About 56.7 million people — 19 percent of the population — reported having a disability according to a broad definition of disability. More than half said their disability was severe [USDOC CENSUS 2012]. In the 2017 NHTS, an estimated 25.5 million people report having disabilities that make traveling outside the home difficult. Moreover, an estimated 3.6 million people with disabilities report not leaving their homes because they are disabled or housebound. About 1 out of 12 people aged 5 and older (8.5 percent) had a travel-limiting disability in 2017, which was the same as in 2001. In 2009 the proportion was just over 1 out of 10 [USDOT BTS 2018a].

The likelihood of having a travel-limiting disability rises with age. Figure 3-18 shows that while the greatest numbers of people with a travel-limiting disability are aged 45–64, half of the people aged 85 and over reported difficulty traveling [USDOT FHWA NHTS].

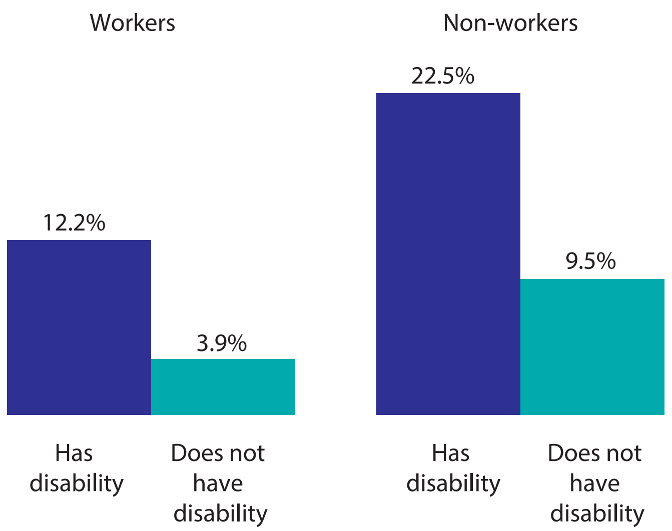
People with travel-limiting disabilities face mobility challenges because they have lower levels of vehicle ownership and vehicle access than people without disabilities. Among people age 18 to 64, 22.5 percent of non-workers with disabilities and 12.2 percent of workers with disabilities live in zero-vehicle households—compared to 9.5 percent of non-workers without disabilities and 3.9 percent of workers without disabilities living in zero-vehicle households (figure 3-19). People with disabilities are also less likely to drive even if they have vehicles: 91.7 percent of people age 18 to 64 drive if they do not have disabilities, but only 60.4 percent drive if they do [USDOT BTS 2018a].

FIGURE 3-18 Number and Percent of People Reporting a Mobility Impairment: 2017



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *2017 National Household Travel Survey*, available at https://nhts.ornl.gov as of October 2018.

FIGURE 3-19 People Living in Zero-Vehicle Households by Disability and Worker Status (age 18–64): 2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Travel Patterns of American Adults with Disabilities*, available at https://www.bts.gov as of September 2018.

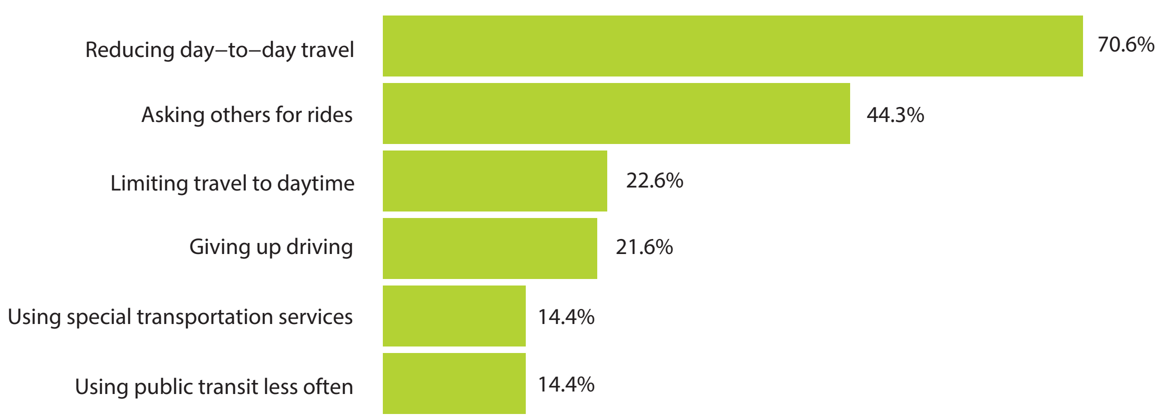
People with disabilities have lower household incomes and lower employment rates than people without disabilities; these differences affect their travel behavior as well. In 2017 over one-fifth (22.2 percent) of people age 18 to 64 with travel-limiting disabilities lived in households with annual household incomes under $10,000. One-fifth (20.2 percent) of respondents age 18 to 64 worked full- or part-time if they report having disabilities. In contrast, over three-quarters (76.6 percent) of people in this age group without disabilities worked [USDOT BTS 2018a].

People with disabilities take fewer daily trips than people without disabilities. People age 18 to 64 with disabilities make an average of 2.6 trips per day versus 3.6 trips for people without disabilities [USDOT BTS 2018a]. People age 65 and older with disabilities make an average of 2.1 trips per day versus 3.5 trips for people without disabilities [USDOT BTS 2018a].

Regardless of age, people with disabilities travel by personal vehicles—as drivers or as passengers—for a smaller share of trips than people without disabilities. People age 18 to 64 used personal vehicles for 74.8 percent of their trips if they had disabilities and 83.9 percent if they did not. People aged 65 and older used personal vehicles for 84.0 percent of their trips if they had disabilities and 86.1 percent if they did not [USDOT BTS 2018a].

People with disabilities use a range of strategies to compensate for their transportation limitations. The two most common strategies for dealing with a transportation disability are reducing day-to-day travel (70.6 percent) and asking others for rides (44.3 percent) [USDOT BTS 2018a]. Other strategies include driving only during the daylight hours, driving only on well-known local streets, or switching to other transport options, such as taxi and transit (figure 3-20).

FIGURE 3-20 Strategies for Dealing with a Travel Disability: 2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Travel Patterns of American Adults with Disabilities*, available at https://www.bts.gov as of September 2018.

Low-Income and Zero-Vehicle Households

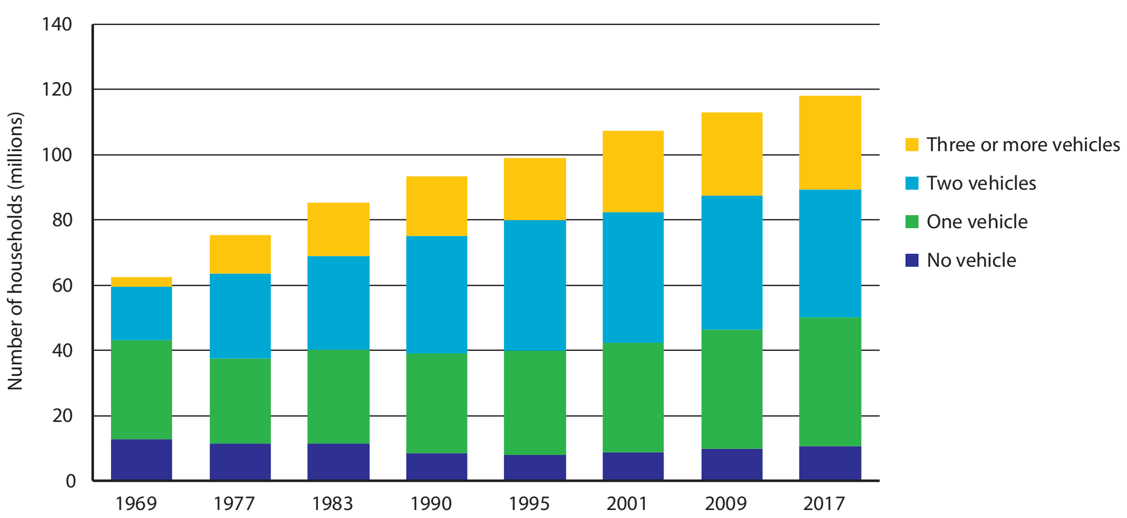
Out of the 120 million households in the United States, about 10.5 million are without a vehicle. The number of households with zero vehicles available remains virtually unchanged since 2001. On the other hand, since 1969 the number of households that owned three or more vehicles has grown by tenfold—from 2.9 million to nearly 29 million. The percentage of households with three or more vehicles has gone from 5 percent to nearly a quarter of all U.S. households (figure 3-21) [USDOT FHWA STT 2018].

Many people without access to a personal vehicle, especially people who are poor, have difficulty reaching stores, services, and workplaces outside of their immediate neighborhoods. In the most densely populated parts of cities (10,000 plus people per square mile), 26.8 percent of households had no vehicle in 2017 [USDOT FHWA NHTS 2017].

People living below the poverty level are less likely to own, or have access to, a personal vehicle to get to work than the population as a whole. Across the Nation the percentage of people in poverty was 12.3 percent in 2017, some 39.7 million people [USDOC CENSUS 2018].

Households with annual incomes less than $25,000 were 10 times more likely, on average, to be zero-vehicle households than households with annual incomes of $75,000 and above [USDOT FHWA NHTS 2017]. Of workers below the poverty level, 65 percent drive to work compared to 76 percent of workers overall in 2017. When they commute, people below the poverty level are more likely to carpool, take public transportation, walk, or use other transportation modes compared to overall averages.

FIGURE 3-21 Distribution of Households by Number of Household Vehicles: 1969–2015 NPTS and 2001–2017 NHTS



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Surveys* (multiple years), available at https://nhts.ornl.gov as of October 2018.

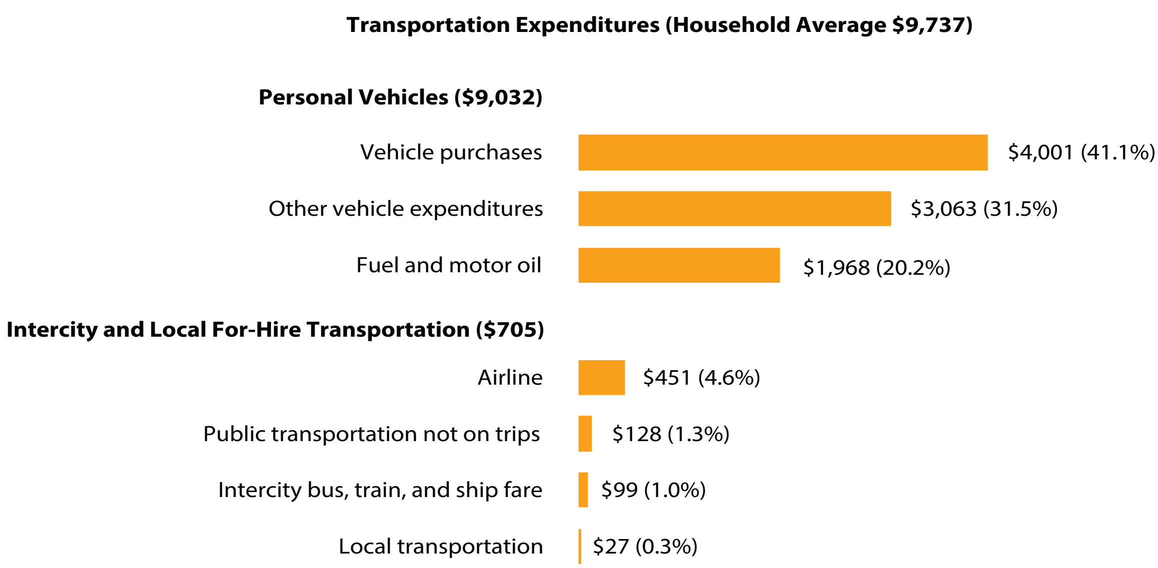
Households spend similar percentages of their income on transportation across all income categories except for the bottom fifth of households by income. On average, U.S. households spent just over $9,000 per year on personal vehicles (figure 3-22). However, households in the top income quintile spent over five times as much as households in the bottom income quintile in 2017—$18,190 versus $3,497. Higher income households spend more because they own more vehicles. Households in the top income quintile owned an average of 2.8 vehicles per household in 2017, while households in the bottom income quintile averaged 1.0 vehicles per household [USDOT BTS 2018b].

Long-Distance and International Travel

Americans primarily use personal vehicles and airplanes for their long-distance travel. Many people also travel by train—Amtrak—and by intercity bus or motor coach. A few travel in their own airplane, of which there are 220,000. There is sizable travel on cruise ships.

The majority of long-distance travelers in the United States are U.S. residents on business trips or on trips to visit family, vacation, and/or sight-see. Comprehensive data encompassing all modes of long-distance travel has not been collected since 1995. While BTS collects comprehensive

FIGURE 3-22 Average Individual Household Transportation Expenditures: 2017



NOTES: "Other vehicle expenditures" include vehicle insurance, vehicle parts, and maintenance and repair costs. "Public transportation not on trips" includes public transportation not taken as part of a trip or vacation. A trip or vacation includes trips to visit relatives or friends, business trips, recreational trips, other trips overnight or longer, and day trips of at least 75 miles away from home. "Local transportation" includes intracity mass transit and local for-hire taxicabs and ride-hailing services. Amounts are calculated by the Bureau of Transportation Statistics using public-use microdata and may differ slightly from amounts calculated using original data. Transportation expenditures include vehicle insurance.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey 2017 Microdata, available at www.bls.gov/cex as of September 2018.

data on the number and boarding location of air enplanements (no data on passenger characteristics), there is a large data gap for long-distance trips, such as the number and the type of long-distance trips by trip purpose, travel party size, and traveler characteristics. The growing air travel in the last decade or so suggested increasing long-distance travel, making this data gap critical to fill.

Air Travel

U.S. airlines and foreign airlines serving the United States carried a record high number of passengers in 2017— 965 million system wide (742 million domestic and 223 million international), 3.5 percent more than the previous record high of 933 million in 2016. U.S. airlines carried 3.0 percent more passengers on domestic flights and 3.5 percent more passengers on international flights in 2017 than in 2016, while 6.1 percent more passengers flew on foreign carrier flights to and from the United States.

Table 3-5 shows the top 10 U.S. airports with the most passenger enplanements, including Hartsfield - Jackson Atlanta International (50.3 million), Los Angeles International (41.2 million), and Chicago O'Hare (38.6 million). The top 50 airports accounted for 85.2 percent (about 726 million) of the U.S. passenger enplanements in 2017.

While the total enplanements for both domestic and international flights to and from the United States grew between 2005 and 2017, the number of passengers enplaning on international flights increased faster than domestic enplanements. International enplaned passengers became a larger share of the whole, increasing from 144 million (18 percent of all air passenger enplanements) in 2005 to 223 million (23 percent) in 2017.

TABLE 3-5 Enplanements at the Top 10 U.S. Airports: 2017

Rank	Airport	Enplaned Passengers (millions)
1	Hartsfield-Jackson Atlanta International	50.3
2	Los Angeles International	41.2
3	Chicago O'Hare International	38.6
4	Dallas/Fort Worth International	31.8
5	Denver International	29.8
6	John F. Kennedy International	29.5
7	San Francisco International	26.9
8	Las Vegas McCarran International	23.2
9	Seattle/Tacoma International	22.6
10	Charlotte Douglas International	22.0

NOTE: Includes passengers enplaned on U.S. carrier scheduled domestic and international service and foreign carrier scheduled international service from the United States.

SOURCE: U.S Department of Transportation, Bureau of Transportation Statistics, T-100 Market Data, available at www.transtats.bts.gov as of October 2018.

Along with the growth in international travel, foreign carriers have increased their share of passengers to and from the United States. For the second consecutive year in 2017, more passengers traveled on foreign airlines flights to and from the United States than on U.S. carriers' international flights. Foreign airlines carried 115.7 million passengers between the United States and foreign points, up 6.1 percent from 2016, while 107.7 million passengers traveled on U.S. carriers, a 3.5 percent increase from 2016. U.S. airlines carried less than half (49.5 percent) of passengers traveling between the United States and international points in 2017 [USDOT BTS 2018d].

Intercity Bus and Passenger Rail

During the 1990s the Nation's intercity bus industry was in the midst of a long-term decline in ridership. The industry grew rapidly in the 2008 to 2013 period, bolstered by advanced technologies (e.g., online ticket purchases) and high fuel prices that favored fuel-efficient bus operations compared with less efficient travel modes, such as cars (see box 3-B). Since then fuel prices have fallen and bus ridership has stabilized or fallen somewhat. However, express nonstop bus service between downtowns of major cities is common, and many bus companies provide service along routes with several alternative modes across the country [NAS TRB].

Box 3-B Business Models Prompt Resurgence in Intercity Bus Service

A new business model has prompted a resurgence of the intercity bus industry over the past decade. For example, because ticket purchases occur online, bus companies no longer pay for the overhead of real estate, stations, stops, ticketing agents, or baggage handlers. Reduced overhead makes extremely affordable intercity bus service possible [Cato]. Innovative trends brought about by the new business model continue to develop:

- Companies distinguish themselves from their competition by offering amenities such as free Wi-Fi and on-board entertainment [Cato]. Some customers pay premiums for comforts, such as leather seats and extra room [DePaul].
- New ticketing models rely on cost cutting [DePaul].
    - Yield management which makes frequent adjustments to the cost of a service based on demand and competition.
    - Crowd sourcing that enables customers to request service through web-based applications. If enough customers purchase tickets, the trip is scheduled. The trip is canceled, and money refunded, if there is not enough demand. This allows bus companies to react to demand in real-time.
    - Ticket aggregators who ease the burden of trip planning and ticket purchasing by selling seats for multiple bus companies from a single website.
    - Coordination of door-to-door journeys, with one-click bookings, by collaborating with transportation network companies (TNC) like Lyft and Uber.

Small carriers (those with fewer than 25 buses) dominate the motorcoach industry, accounting for over 90 percent of carriers. The average carrier operates 12 buses (often providing multiple services[3]). The number of passenger trips declined, from 604 million trips in 2014 to 596 million in 2015[4], a 1.2 percent decline, while passenger-miles increased 12.6 percent to 69.6 billion miles. This suggests people are traveling for longer distances on motorcoaches [ABA 2017][5].

Along with intercity bus, Amtrak serves a growing intercity travel market. Currently Amtrak operates about 300 regional and long-distance trains per day over about 21,000 miles of track. On an average day in 2017, Amtrak riders made nearly 87,000 trips for an annual total of 31.7 million trips, a record year. Amtrak operates long-distance trains on 15 routes, up to 2,728 miles, most of which are daily.

About 80 percent of the 457-mile Northeast Corridor (NEC) rail right-of-way linking Washington, New York, and Boston is owned by Amtrak, whereas most of the rest of the rail network on which Amtrak operates is owned by private freight operators. Because it has control over the right-of-way in the NEC, Amtrak has greater opportunity in this corridor than elsewhere in its system to complete with other interregional modes by increasing train frequencies during peak travel times and reducing schedule times off-peak. Since 1995 the average trip on Amtrak become shorter by 20 percent, while the average length of domestic air trips grew by 15 percent, perhaps suggesting people are more inclined to use Amtrak on shorter trips than air [USDOT NTS 2015].

In the NEC, more than 75 trains operate daily between New York, Philadelphia, Baltimore, and Washington, and nearly 50 others operate between New York, Providence, and Boston. In Philadelphia alone, nearly 100 trains stop per day to connect to markets farther north, south, and west. Numerous medium-size cities, such as Wilmington, Providence, and Trenton, which are situated along the routes connecting Boston, New York, Philadelphia, and Washington, benefit from these passing trains. Consequently, 33 of the 49 markets with the most frequent train service in the United States are in the Northeast [NAS TRB 2016].

Border Crossings

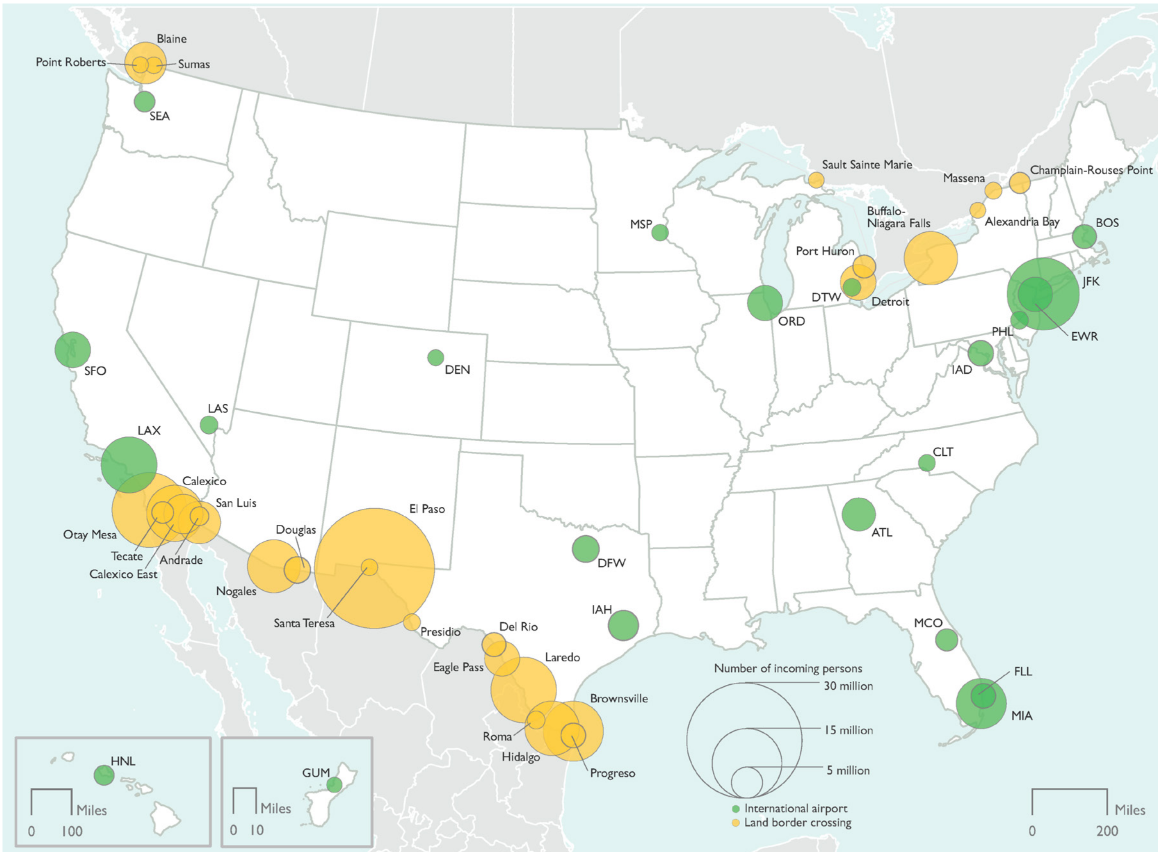
People enter the United States at land border crossings, U.S. airports, and water ports. Many more people pass through the land border checkpoints from Mexico and Canada on day trips compared to overnight/multiday stays [USDOC NTTO]. The land crossing checkpoints along the border with Mexico process about 3 million people entering the United States in an average week, including day workers. In 2017, 188 million people crossed these southwestern checkpoints into the United States (figure 3-23). The land border crossing stations with Canada are more numerous, but process fewer people—less than 53 million in 2017. U.S. airports with scheduled international flights serve as an entryway for 102.5 million people [USDOT

[3] Such as a packaged tour for sightseeing, airport shuttle service, and charter bus.

[4] May not include all intercity bus service.

[5] These numbers include Canadian as well as U.S. motor coach companies.

FIGURE 3-23 People Entering into the United States at Land Border Crossings and U.S. Airports with Scheduled International Service: 2017



NOTE: Truck crossings are not included because they are primarily freight-related.

SOURCES: **Person Crossings**: U.S. Department of Transportation, Bureau of Transportation Statistics, Border Crossing/Entry database; available at www.transtats.bts.gov of September 2018. **Air Passengers**: U.S. Department of Transportation, Bureau of Transportation Statistics, T-100 International Market (All Carriers): Available at: www.transtats.bts.gov as of September 2018.

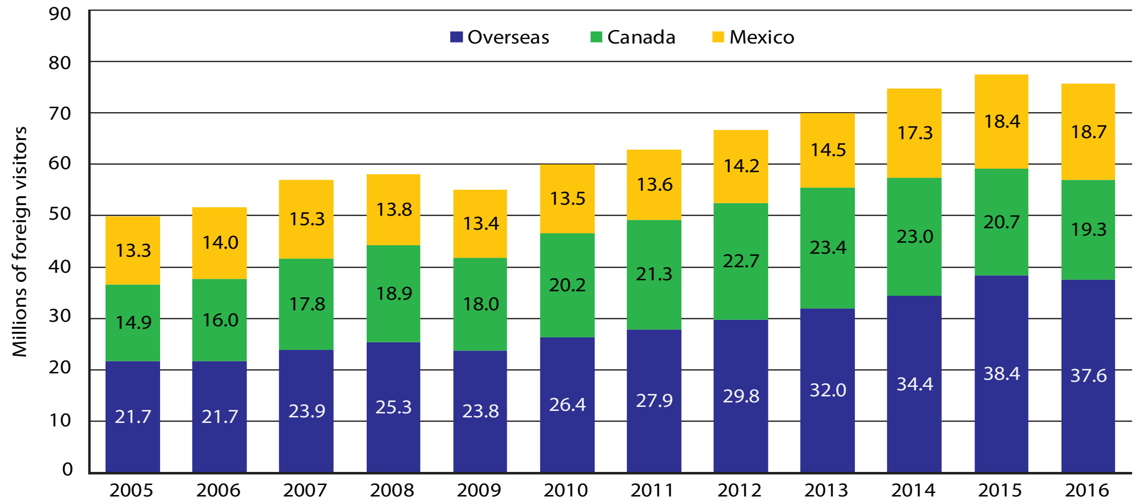
BTS 2018e], including returning U.S. citizens and residents. Several million people (both U.S. and foreign residents) enter and leave the United States at water ports, such as tourists on cruise ships and crew/workers on commercial vessels. An estimated 5.2 million cruise ship passengers made onshore visits in the United States in 2016, with 71 percent entering through ports in Alaska and Florida [CLIA]. Many do not stay overnight, but return to the cruise ship.

Foreign Visitors

An estimated 75.1 million foreign visitors stayed for at least one night in the United States in 2017, a decline from 75.9 million in 2016 and the peak of 77.5 million in 2015.[6] Figure 3-24 and 3-25 shows the trend in foreign visitors who stayed at least one overnight in the United States in 2016. That year the number of foreign visitors declined slightly after year-over-year growth since

[6] The 2017 number is a forecast.

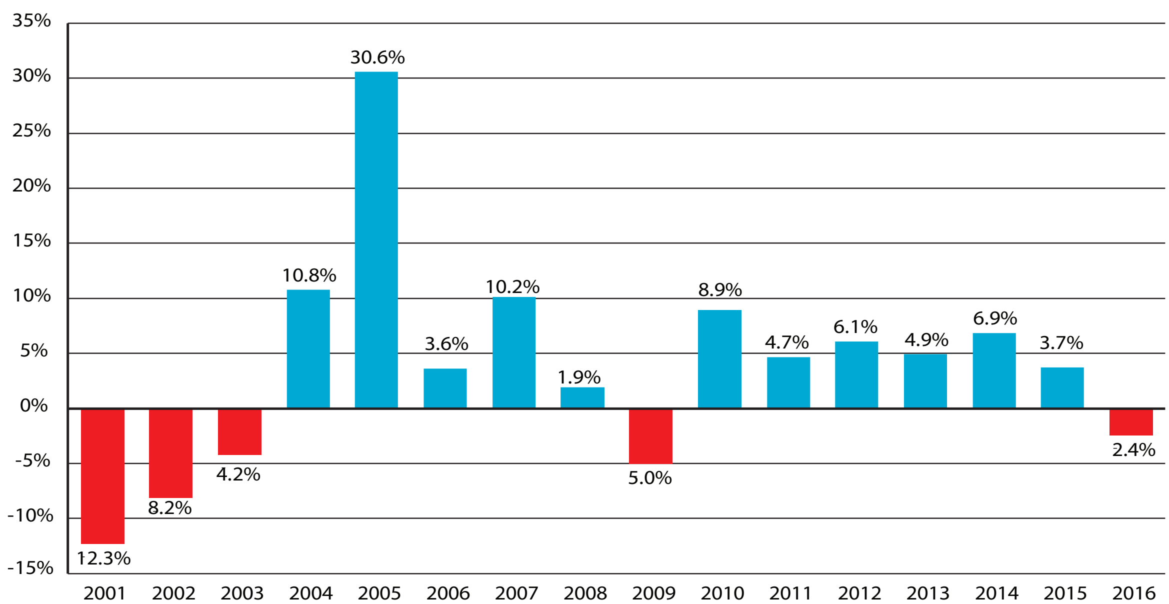
FIGURE 3-24 Number of Foreign Visitors by Main Market: 2005–2016



NOTE: These statistics count visitors staying in the United States at least one overnight.

SOURCE: U.S. Department of Commerce, Office of Travel and Tourism Industries, *U.S. Monthly Arrivals Trend Line: Overseas, Canada, Mexico & International*, available at: https://travel.trade.gov/ as of September 2018.

FIGURE 3-25 Percent Change from Previous Year in Total Foreign Visits: 2001–2016



NOTE: These statistics count visitors staying in the United States at least one overnight.

SOURCE: U.S. Department of Commerce, Office of Travel and Tourism Industries, *U.S. Monthly Arrivals Trend Line: Overseas, Canada, Mexico & International*, available at: https://travel.trade.gov/ as of September 2018.

2009, when there was a marked decrease during the Great Recession (December 2007 to June 2009). The number of foreign visitors is about a quarter (26.5 percent) of the total number of international entries at border crossings and U.S. international airports. The remainder are returning U.S. citizens and residents and day travelers.

Canada and Mexico together accounted for almost half of foreign visitors to the United States in 2016, maintaining their positions of sending the most travelers to the United States as they did in 2000 (table 3-6). The number of visitors from China has grown a remarkable 1,000 percent since 2000, when less than a quarter of a million Chinese visited. In 2016 there were nearly 3 million Chinese visiting the United States, moving up the list from 24th to 5th place. Australia also moved up the list from 12th to 10th place. Visitors from the United Kingdom and Japan have declined since 2000. [USDOC ITA].

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TABLE 3-6 Countries Sending the Most Travelers to the United States: 2000 v. 2016

	Thousands of travelers					
Country	**2000**	**Rank**	**Rank**	**2016**	**Country**	**Percent change, 2000 to 2016**
Canada	14,594	1	1	19,302	Canada	32.3
Mexico	10,322	2	2	18,730	Mexico	81.5
Japan	5,061	3	3	4,574	United Kingdom	-2.7
United Kingdom	4,703	4	4	3,577	Japan	-29.3
Germany	1,786	5	5	2,972	China	1091.8
France	1,087	6	6	2,035	Germany	13.9
Brazil	737	7	7	1,974	South Korea	178
South Korea	662	8	8	1,693	Brazil	144.5
Australia	540	12	9	1,628	France	49.8
China	249	24	10	1,346	Australia	149.5
Total	**50,890**			**75,621**	**Total**	**48.6**

NOTES: Arrivals for 2016 excludes Hong Kong. Beginning in 2014, overseas data include one-night stay travelers.

SOURCE: U.S. Department of Commerce, International Trade Administration, Office of Travel & Tourism Industries, International Visitation in the United States, available at travel.trade.gov/research/monthly/arrivals/index.asp as of October 2018.

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CHAPTER 4

Moving Goods

Highlights

- The freight transportation system moved nearly 17.7 billion tons of goods valued at more than $18.1 trillion, or an average of 54.7 tons of freight annually for every man, woman, and child in the United States in 2016.
- Trucks carry the largest share of goods shipped in the United States—62.7 percent of the tonnage and 61.9 percent of the value—and remain the primary mode for shipments moved less than 750 miles. Rail moves the most commodities by tonnage and ton-miles from 750 to 2,000 miles.
- Alaska and North Dakota, major oil producing states, were the leading net interstate exporters by value in 2016. Alaska was also the top net interstate exporter by tonnage, followed by Wyoming, a major coal producing state. Hawaii is the leading net interstate importer because of its distant location from the mainland and resource dependency.
- The value of total U.S.-international freight trade increased from nearly $2.5 trillion in 2000 to approximately $3.4 trillion in 2017—a 39.5 percent inflation-adjusted increase (2009 dollars).
- The Port of Los Angeles was the leading water gateway by value, followed by the Port of New York/New Jersey. John F. Kennedy International Airport was the leading air gateway by value, and Memphis International Airport was the leading air gateway by weight.
- While there are 467 ports of entry for international cargo, the top 25 handled more than $2.38 trillion (current dollars) or almost two-thirds of U.S.-international freight trade. Water is the leading transportation mode for U.S.-international freight trade by weight and value.
- Changes in global demand for U.S. energy commodities have affected the volume of inbound to outbound trade at bulk cargo ports. In recent years, coal exports have decreased and waterborne crude petroleum imports have fallen sharply while exports have risen considerably, and liquefied natural gas exports have surged.
- The substantial growth in E-commerce sales from 2000 to 2016 presents challenges to the freight transportation and logistics industry, such as increasing truck and delivery vehicle traffic in urban and residential areas.

This chapter provides an overview of freight movement on the U.S. transportation network. It highlights the volume and value of freight moved, examines the distance goods are carried, and identifies the modes used to transport commodities. The chapter also discusses U.S.-international freight trade, including trade with our North American neighbors, Canada and Mexico; the top freight gateways; and recent trends in energy commodities trade and how these trends are shaping freight transportation.

The U.S. freight transportation system moved nearly 17.7 billion tons of goods valued at more than $18.1 trillion in 2016, according to Freight Analysis Framework (FAF) (box 4-A) estimates (table 4-1). The freight transportation system carried, on average, about 48.3 million tons of goods worth $49.6 billion each day, or about 54.7 tons of freight annually for every man, woman, and child in the United States in 2016.

TABLE 4-1 Weight and Value of Shipments by Transportation Mode: 2012, 2016, and 2045

Weight	2012				2016				2045			
Millions of tons	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]
Total	**16,996**	**14,895**	**933**	**1,169**	**17,686**	**15,762**	**887**	**1,037**	**25,521**	**20,932**	**2,330**	**2,259**
Truck	10,098	9,893	115	90	11,086	10,882	101	103	14,836	14,226	304	306
Rail	1,625	1,481	57	87	1,575	1,418	66	90	1,926	1,588	112	226
Water	959	502	77	380	798	519	131	148	1,186	609	203	373
Air, air & truck	11	2	5	4	11	2	4	4	41	4	19	18
Multiple modes & mail	1,361	309	627	425	1,354	322	505	528	2,941	431	1,482	1,028
Pipeline	2,901	2,672	50	179	2,823	2,589	72	162	4,559	4,058	205	296
Other & unknown	42	37	2	3	39	29	9	1	32	16	5	11

Value	2012				2016				2045			
Billions of 2012 dollars	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]
Total	**17,729**	**13,965**	**1,545**	**2,219**	**18,142**	**14,341**	**1,542**	**2,259**	**37,064**	**22,469**	**6,511**	**8,084**
Truck	10,929	10,251	366	311	11,225	10,532	347	347	18,682	16,219	1,244	1,219
Rail	582	411	63	109	621	445	65	111	1,080	646	157	278
Water	631	270	73	288	527	279	98	151	1,031	340	281	411
Air, air & truck	1,067	135	461	472	1,081	132	447	502	5,221	324	2,544	2,354
Multiple modes & mail	3,246	1,746	552	947	3,315	1,784	487	1,044	8,981	3,393	2,123	3,465
Pipeline	1,233	1,150	13	70	1,282	1,169	31	81	1,744	1,546	88	110
Other & unknown	40	1	17	22	91	1	67	23	325	0	76	248

[1] Data do not include imports and exports that pass through the United States from a foreign origin to a foreign destination by any mode.

NOTES: Numbers may not add to totals due to rounding. The 2016 data are provisional estimates based on selected modal and economic trend data. Data in this table are not comparable to similar data in previous years because of updates to the Freight Analysis Framework. All truck, rail, water, and pipeline movements that involve more than one mode, including exports and imports that change mode at international gateways, are included in multiple modes & mail to avoid double counting. As a consequence, rail and water totals in this table are less than other published sources.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.4.1, 2018.

Box 4-A The Commodity Flow Survey and the Freight Analysis Framework

The Commodity Flow Survey (CFS) is conducted every 5 years (specifically in the years ending in 2 and 7) by the Bureau of Transportation Statistics (BTS) in partnership with the U.S. Census Bureau as part of the Economic Census. The CFS provides data for most of the U.S. economy on commodities shipped, their value and weight, mode of transport, and origin and destination within and between all U.S. regions. The survey covers about 75 percent of the value shipped from a domestic origin to a domestic destination.

The CFS is the foundation for the Freight Analysis Framework (FAF), a comprehensive dataset of all freight movements within the United States produced through a partnership between BTS and the Federal Highway Administration. The FAF incorporates domestic shipments collected in the CFS (covering mining, manufacturing, wholesale, and other selected industries), and augments the CFS data with foreign trade statistics from the U.S. Census Bureau, agricultural data from the Department of Agriculture, energy commodity data from the Department of Energy, and other sources.

The fourth generation of FAF (FAF4) is based on the 2012 CFS, which includes improvements to data collection, data editing, and an expanded number of geographic areas. Improvements were also made to the non-CFS components of FAF.

FAF provides tonnage and value estimates by – commodity types, modes, and origins and destinations; provides annual estimates for years in between the CFS; and presents long-range (30 year) forecasts in 5-year increments. It also includes an assignment of truck flows to the highway network for the CFS year and a 30-year forecast of flows to provide a picture of freight truck volumes. FAF forecasts are based on long-term U.S. economic forecasts, including real gross domestic product growth, nonfarm business productivity, population growth, and technological advancement [USDOT FHWA 2016]. While the FAF is more complete in coverage of freight flows, the CFS provides greater commodity detail, tabulations by industry, and additional shipment characteristics, such as hazardous materials class.

Detailed information on CFS data and methodologies are available at www.bts.gov/cfs. Information on FAF data and methodologies are available at https://www.bts.gov/faf.

FAF4 is updated as needed to reflect improvements in data quality and methodologies; thus, the latest data available online may not match the data in this chapter or previous editions of this report.

Population growth and economic activity continue to influence freight demand. As population increases and economic activity expands, more goods are needed and produced, resulting in additional freight movement. Between 2010 and 2017, the U.S. population increased by 5.3 percent [USDOC Census 2018c], and U.S. gross domestic product (GDP) grew by an inflation adjusted 15.7 percent, from $15.6 to $18.1 trillion [USDOC BEA 2018]. Although freight moves throughout the United States, the demand for freight transportation is driven by the geographic distribution of population and related economic activity. Both population and GDP have grown faster in the South and West than in the Northeast and Midwest, but the Northeast has the highest GDP per capita. Chapter 5, *Transportation Economics*, provides detailed information on the relationship between freight transportation services and the economy.

Changes in the composition of goods demanded and the rapid rise in online shopping and related package deliveries have also had an effect on what goods are moved, what modes are used to transport them, and where they are shipped. These changes not only reshape the retail landscape but also affect how freight companies do business.

Foreign trade is a major and growing component of U.S. freight movement. Respectively, U.S. exports and imports accounted for 5.0 and 5.9 percent of the weight and approximately 8.5 and 12.5 percent of the value of freight transported throughout the country in 2016. U.S. exports and imports are forecast to account for an even greater share of freight movements by 2045, reaching 18.0 percent of the weight and 39.4 percent of the value of goods shipped throughout the country [USDOT BTS and FHWA 2018].

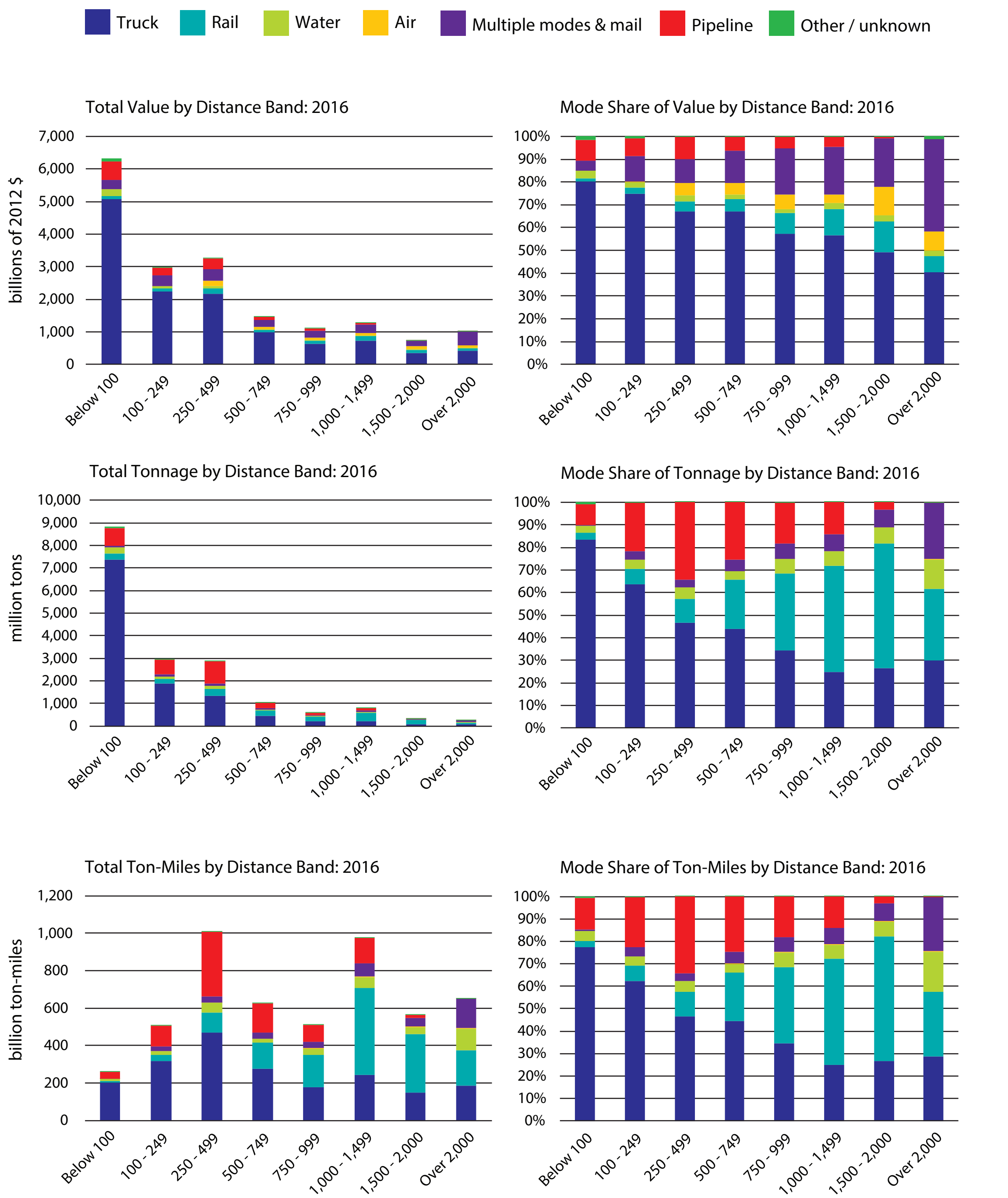
Domestic Freight Movement

The freight transportation industry moves goods over a network of truck routes, railroads, waterways, airports, and pipelines. The distance a shipment must travel and the cost to ship play a major role in determining what mode or mix of modes are used during any particular leg of a multimodal journey.

A large percentage of goods movement occurs close to home. Half of the weight and one-third of the value of goods were moved less than 100 miles between origin and destination in 2016 (figure 4-1). By contrast, 7.8 percent of the weight and 16.6 percent of the value of goods were moved 1,000 or more miles. Modal shares of freight vary considerably by distance. Trucks carry the largest shares by value, tons, and ton-miles of all goods shipped in the United States and are the predominant mode for shipments under 750 miles. Rail leads in tonnage and ton-miles for goods shipped from 750 to 2,000 miles. Air and multiple modes accounted for 49.0 percent of the value of shipments moving over 2,000 miles [USDOT BTS and FHWA 2018]. The multiple modes category is defined as freight that is transferred between two or more modes on the journey between an origin and destination.

Overall, trucks carry the highest percentages of goods by weight and value of goods in the United States, accounting for 11.1 billion tons of the weight (62.7 percent) and $11.2 trillion of the value (61.9 percent) in 2016 (table 4-1).

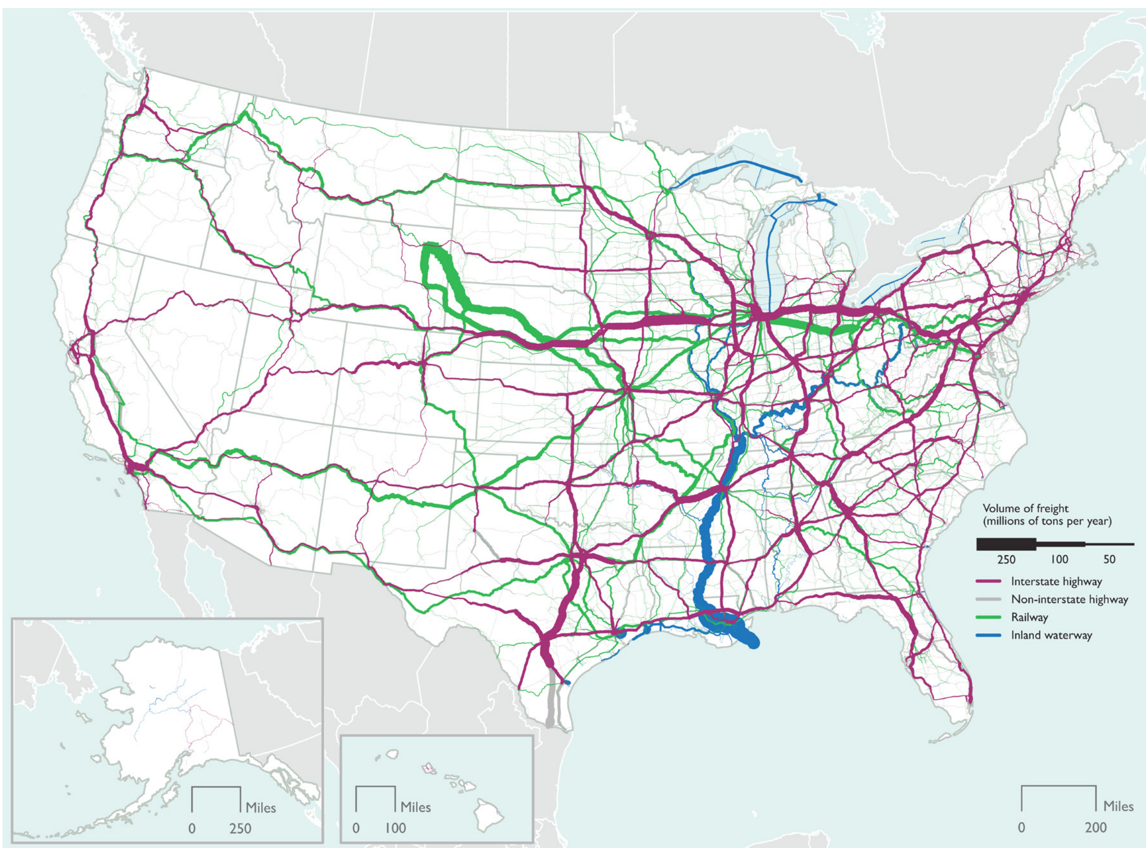
FIGURE 4-1 Value, Tonnage, and Ton-Miles by Distance Traveled: 2016



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.4.1, 2018.

However, railroads and inland waterways carry large volumes of bulk commodities over long distances. Figure 4-2 helps to visualize the large volume of coal moved by rail between the Powder River Basin in Wyoming and the Midwest, in addition to the grains and energy products moved by vessel and barge along the Lower Mississippi River. The sum of freight moved by rail and water combined accounted for 13.4 percent of the total tonnage and 6.3 percent of the total value of freight moved in the United States in 2016. Air carriers almost exclusively move high-value, low-weight products. This is underscored by the relatively high value-to-weight ratio of air cargo, which is nearly $100,000 per ton. In comparison, the overall value-to-weight ratio of cargo carried by all modes combined is about $1,026 per ton. In 2016 pipelines moved more than 2.8 billion tons of goods—mostly crude oil, petroleum products, and natural gas—valued at nearly $1.3 trillion ($454 per ton), while rail moved approximately 1.6 billion tons valued at $621 billion ($394 per ton) [USDOT BTS

FIGURE 4-2 Freight Flows by Highway, Railway, and Waterway 2016



NOTE: Highway flows depicted in this map are based on Freight Analysis Framework data for 2015.

SOURCES: **Highway**: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.3.1, 2016; **Rail**: Based on Surface Transportation Board, Annual Carload Waybill Sample and rail freight flow assignment done by Oakridge National Laboratory, 2018; **Inland Waterways**: U.S. Army Corps of Engineers, Institute of Water Resources, Annual Vessel Operating Activity and Lock Performance Monitoring System data, 2018.

AND FHWA 2018]. It is important to note that freight moved by more than one mode, including exports and imports that change modes at international gateways, is included in the "multiple modes and mail" category to avoid double counting. Thus, the rail and water totals are less than what they may be in other published sources.

Shipments moving by water are typically low-value, bulk products similar to those moved by rail.[1] In 2016 the water transportation industry moved 798 million tons[2] worth $527 billion ($660 per ton), representing 4.5 percent of the tonnage and 2.9 percent of the value of all freight shipments [USDOT BTS AND FHWA 2018]. In 2016 approximately 548 million short tons of cargo were moved by vessel along the inland waterways, including the Mississippi River—the Nation's busiest waterway [USACE WCSC 2017].

In comparison with the rail and water modes, air transport carries relatively high-value products, such as electronics, precision instruments, and pharmaceuticals, which require quick delivery. Of all modes, the value of air-freight shipments is projected to increase the fastest from 2016 to 2045, growing by more than 380 percent [USDOT BTS AND FHWA 2018]. In 2017 U.S. and international airlines[3] carried a record-breaking 75.9 billion revenue ton-miles. Of these, U.S. airlines handled 15.1 billion revenue ton-miles in domestic cargo [USDOT BTS 2018a].

The transportation system is increasingly interconnected. While freight moved to, from, and within the United States via multiple modes[4] accounted for 7.7 percent of freight tonnage, 18.3 percent of the value of goods was moved by multiple modes in 2016. FAF forecasts the total value of multiple modes and mail shipments to increase by more than two and a half times between 2016 and 2045, from $3.3 trillion in 2016 to nearly $9.0 trillion in 2045 [USDOT BTS AND FHWA 2018].

The growth in intermodal rail freight movement (e.g., containers moved by some combination of rail, truck, and water modes) is driven, in part, by global supply chain requirements. The Association of American Railroads reported a 52.2 percent increase in rail intermodal volumes between 2000 and 2017. Rail intermodal traffic accounted for 24 percent of U.S. Class I railroad revenue in 2017, more than any other single commodity group including coal, which had been the largest single source of rail revenue in previous years [AAR 2018]. With the growth in container trade, the rapid rise of E-commerce in recent years (see box 4-B), and improvements in information and logistics technologies, greater reliance on intermodal connections is expected to continue.

[1] Many shipments moving by rail or water are transferred to another mode for delivery to their final destination. In FAF, these shipments are counted under "multiple modes and mail." Thus the rail and water numbers discussed here may differ from those in other published sources.

[2] FAF numbers differ from previous editions of this report due to periodic changes in methodology.

[3] In all service classes (scheduled and non-scheduled).

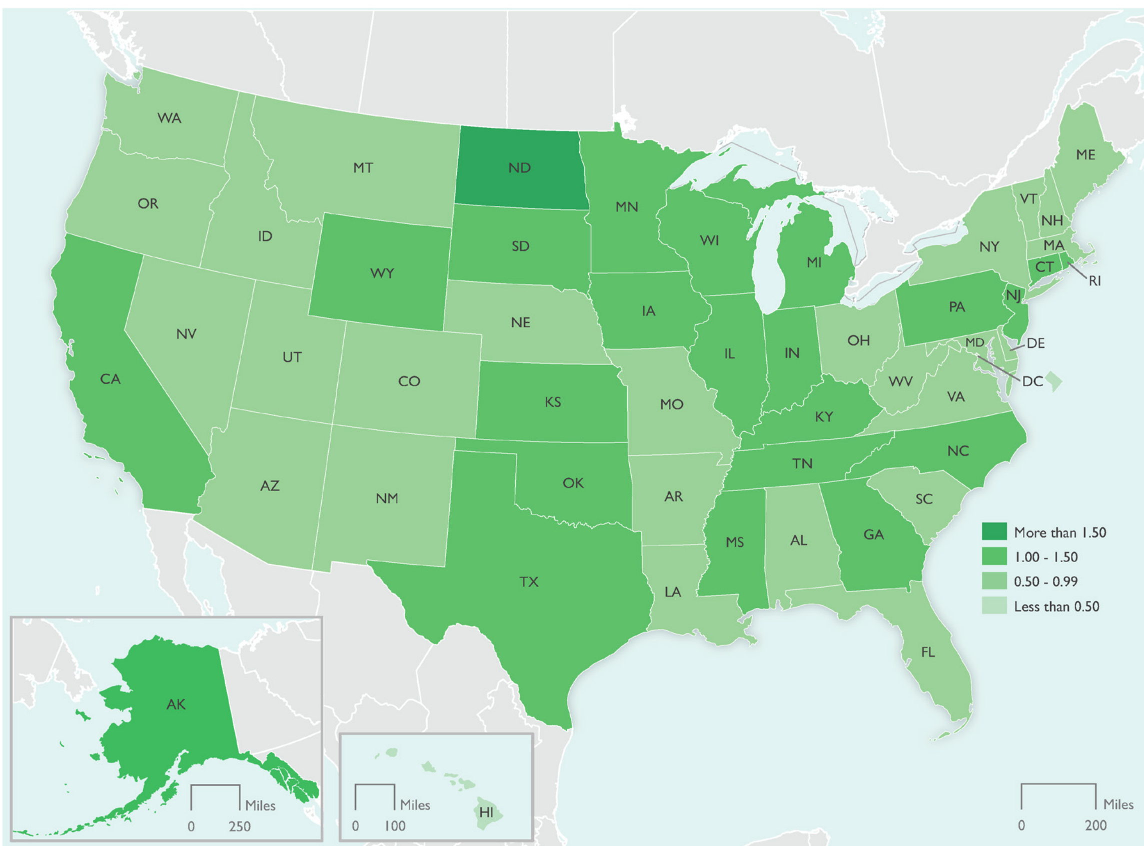
[4] The FAF category for multiple modes and mail includes all multimodal movements and is not limited to traditional intermodal services, such as trailer-on-flatcar and container-on-flatcar rail.

Value and Weight of Domestic Shipments by State

Figures 4-3 and 4-4 show the ratios of the value and weight of goods shipped to and from other states. A ratio of outbound-to-inbound shipments greater than 1.0 indicates that a state ships more good to markets in other states than it receives from other states; whereas a ratio less than 1.0 indicates that a state imports more goods from other states than it exports.

In terms of value, Alaska and North Dakota have the highest ratios of about 2.0, indicating that the value of their goods sent to other states is about two times greater than the value of the goods they receive from other states. Although both states have relatively small populations, they are major oil producers. According to the FAF, nearly all of the crude petroleum moving out of Alaska was transported by water, while pipeline and rail were the primary modes for moving oil out of North Dakota. Three

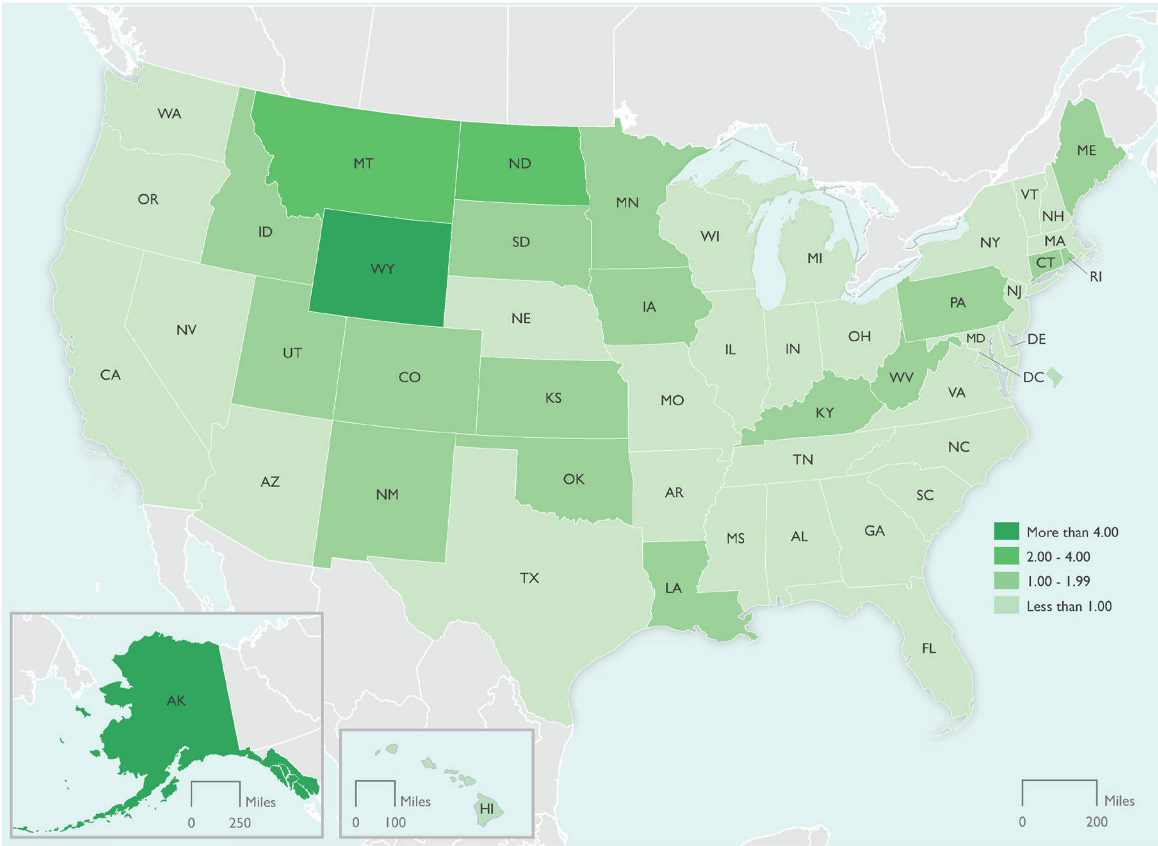
FIGURE 4-3 Ratio of Outbound to Inbound Domestic Shipments by Value 2016



NOTES: A ratio of outbound-to-inbound shipments greater than 1.0 indicates that a state ships more goods to markets in other states than it receives from other states; a ratio less than 1.0 indicates that a state imports more goods from other states than it exports.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.4.1, 2018.

FIGURE 4-4 Ratio of Outbound to Inbound Domestic Shipments by Weight 2016



NOTES: A ratio of outbound-to-inbound shipments greater than 1.0 indicates that a state ships more goods to markets in other states than it receives from other states; a ratio less than 1.0 indicates that a state imports more goods from other states than it exports.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.4.1, 2018.

other top states that exported more to other states than they imported were Connecticut, New Jersey, and California. In the case of Connecticut, mixed freight (e.g., groceries and convenience store goods, food for restaurants, office supplies, and hardware and plumbing items) topped the list. Electronics was the top outbound commodity group from California, due in part to technology manufacturing conducted within the Silicon Valley region. Pharmaceuticals were the top interstate export from New Jersey.

Hawaii had the lowest ratio of interstate outbound-to-inbound shipments by value at 0.17 because of its distant location from the mainland and resource dependency. Florida and New Hampshire also exported far less to other states than they imported from other states, reflecting demographics and other factors.

As for weight, all of the top five net interstate exporters are major producers of energy commodities: Alaska, Wyoming, North Dakota, Montana, and New Mexico. According

Box 4-B E-commerce and Transportation Impacts

E-commerce is changing many aspects of the freight transportation industry, particularly courier services. Historically, freight transportation companies moved consumer goods from manufacturers to warehouses and then delivered products to stores where consumers shopped. Today more consumers are ordering products online, specifying a location for delivery, and often opting to pay for faster deliveries.

E-commerce retail sales have grown rapidly since the early 2000s. The U.S. Census Bureau estimates that E-commerce retail sales increased by 14-fold from approximately $27.4 billion in 2000 to nearly $388.0 billion in 2016, while its share of total retail sales increased from 0.9 to 8.0 percent.[1] Over the same period, total retail sales grew 62.8 percent, increasing from $2,979.4 billion in 2000 to $4,841.5 billion in 2016 [USDOC Census 2018b]. The substantial increase in E-commerce sales is linked to the more than doubling of deliveries to households in an average month between 2009 and 2017, according to the latest National Household Travel Survey.

The reliance on express delivery to residences can result in an increase in vehicles needed per ton-mile, due to the need to carry smaller loads to meet delivery deadlines. Although it is already clear that E-commerce is affecting transportation, much of the data needed by transportation planners and decision makers to measure and assess the impact of rising E-commerce sales on local infrastructure and traffic is proprietary.

[1] The largest E-commerce merchandise category is clothing and clothing accessories, including footwear.

A 2017 Texas A&M Transportation Institute report indicates there are several possible impacts related to rapidly rising E-commerce sales:

1. an increase in the number and size of warehouses in urban areas, which in turn requires easy access to interstates and generates more truck traffic;
2. more and larger urban warehouses mean more employees, greater commuter congestion, and increasing need for transit services; and
3. an increasing number of trucks and greater use of personal vehicles for last-mile package deliveries [TTI].

Growth in Alternative Delivery Options

The use of drones and robots for package delivery is being explored by several large U.S. companies. However, due to security, safety, and privacy concerns, it is unlikely that package delivery by drone will be widespread in or around major metropolitan areas any time soon. A few companies are introducing small robots that operate on sidewalks to deliver pizzas, books, and other small items in some cities, although this is currently legal in only six states and the District of Columbia. As these alternative delivery options and other technologies, such as 3D printing, become more commonplace, information will be needed to identify and quantify their impacts on the freight transportation services industry and to plan for future infrastructure projects.

to the Energy Information Administration, Wyoming is the largest U.S. coal producer, while Montana is the seventh largest coal producer. For domestic markets, rail and barge are used to transport coal over long distances, primarily to power plants. New Mexico is in the top 10 for both oil and gas production.

Commodities Moved Domestically

Figure 4-5 shows the top 10 commodities moved on the U.S. transportation system in 2016. The leading commodities by weight, comprised mostly of bulk products, accounted for 66.1 percent of total tonnage but only 24.2 percent of the Nation's freight value. The top commodities by weight included natural gas and petroleum products, cereal grains, gravel, and nonmetal mineral products [USDOT BTS AND FHWA 2018].

The commodity mix is different when looking at the value of goods shipped. The leading commodities by value are mostly high-value-per-ton goods that often call for rapid delivery, including motorized vehicles, mixed freight, electronics, and pharmaceuticals. In 2016 the top 10 commodities by value accounted for 57.0 percent of total value but only 29.7 percent of total tonnage [USDOT BTS AND FHWA 2018].

As shown in figure 4-5, trucks are involved in the supply chain of all top 10 commodities by tonnage and value. Trucks moved more goods, especially high-value, time sensitive commodities, than any other mode in 2016.

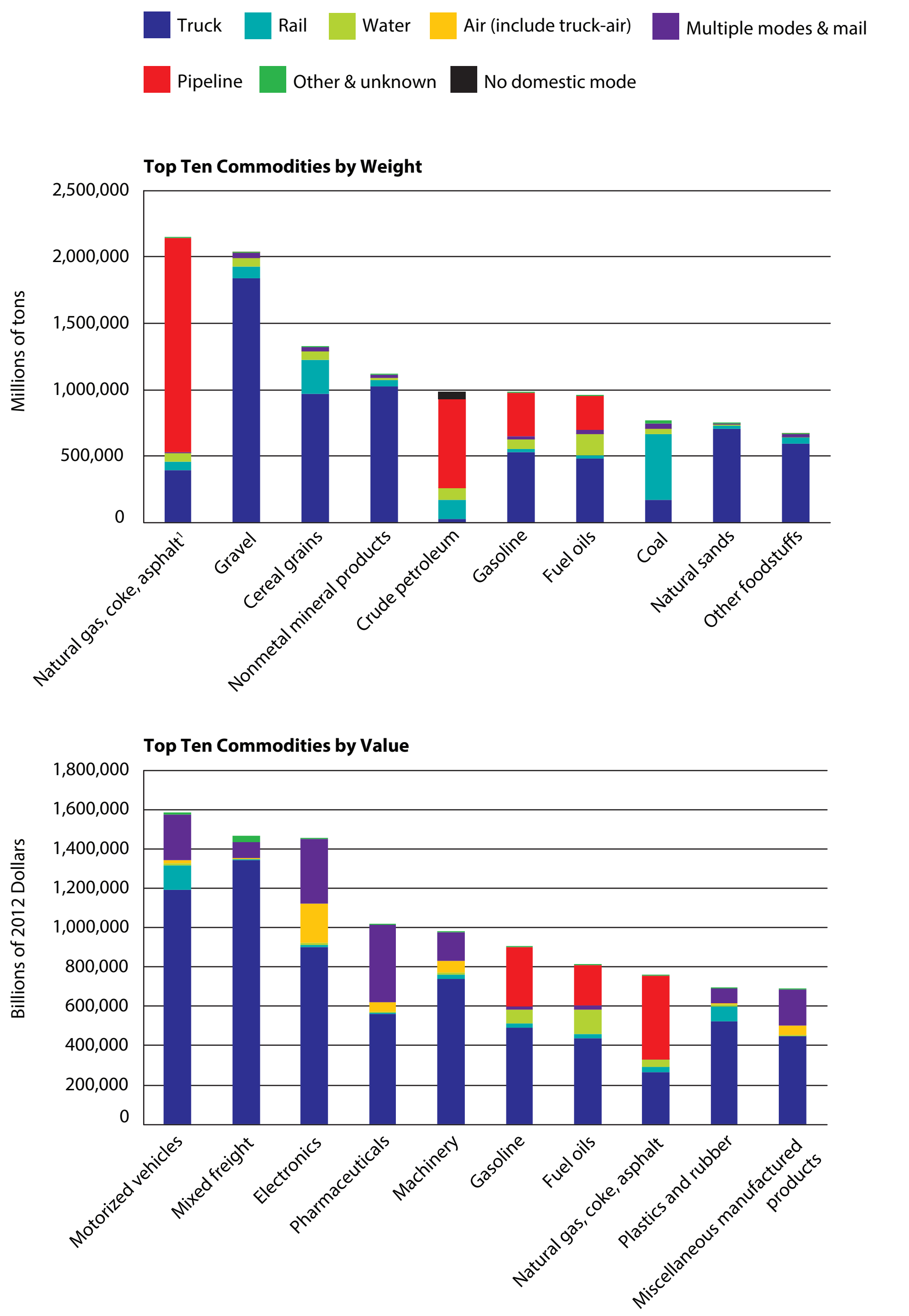
Trucks also were the primary mover of hazardous materials in the United States, transporting approximately three-fifths of both the tonnage and of the value. However, truck ton-miles of hazardous materials shipments accounted for a much smaller share, about one-third of all ton-miles, because such shipments travel relatively short distances. By contrast, rail accounted for only 4.3 percent of hazardous materials shipments by weight but 27.6 percent of ton-miles. Flammable liquids, especially gasoline, are the predominant hazardous materials transported in the United States, accounting for 86.4 percent by value, 85.4 percent by weight, and 66.5 percent by ton-miles. The next largest class of hazardous materials, in terms of ton-miles, is corrosive material at 12.3 percent, followed by gases at about 10.8 percent [USDOT BTS and USDOC Census 2015]. Chapter 6 discusses the safety record of hazardous materials transportation.

International Freight

The value of total U.S.-international freight increased from nearly $2.5 trillion in 2000 to approximately $3.4 trillion in 2017—a 39.5 percent inflation-adjusted increase (in 2009 dollars) [USDOC Census FTD 2018a]. Table 4-2 shows total U.S.-international freight by mode and geography. The water and air modes are used in freight trade with Asia and Europe, while truck is the primary mover between the United States and Canada and Mexico [USDOC FTD 2018a].

In 2016 vessels carried more than $1.6 trillion in freight to and from the United States [USDOC Census FTD 2018a]. Container ports provide a link between the global and domestic freight network, utilizing intermodal barge, truck, and rail connections to transport containers filled with consumer goods to their final destinations. U.S. retailers increasingly

FIGURE 4-5 Weight and Value of Top Ten Commodities by Tansporation Mode: 2016



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.4.1, 2018.

TABLE 4-2 Value of U.S.-International Freight Flows by Geography and Transportation Mode: 2017 (millions dollars)

	Mode					
Geography	**Truck**	**Rail**	**Pipeline**	**Air**	**Vessel**	**Other**
Canada	336,094	94,199	61,616	27,170	22,878	40,490
Mexico	384,734	79,944	3,627	16,657	52,756	19,316
Asia	NA	NA	NA	544,121	894,610	105,394
Europe	NA	NA	NA	403,136	361,174	74,703
Other	NA	NA	NA	77,509	270,783	17,326

KEY: NA = Not Applicable.

NOTE: Transportation mode in this table represents the mode by which freight arrived to or departed from the United States, therefore truck, rail, and pipeline are only available for U.S. freight flows with Canada and Mexico.

SOURCE: **Truck, Rail, and Pipeline**: U.S. Department of Transportation, Bureau of Transportation Statistics, TransBorder Freight Data, available at www.bts.gov/transborder; **Air, Vessel, and Other**: U.S. Department of Commerce, Census Bureau, *USA Trade Online*, https://usatrade.census.gov/ as of August 2018.

depend on the U.S. transportation system to move goods from manufacturers to warehouses and stores, particularly those that build up their inventories in October in anticipation of holiday sales in November and December.

U.S.–North American Freight Transportation

Our North American neighbors, Canada and Mexico, accounted for 29.3 percent (approximately $1.14 trillion) of the value of U.S.-international freight in 2017. Over the 2000 to 2017 period, combined freight value (adjusted for inflation) with Canada and Mexico increased 29.3 percent[5] [USDOC Census FTD 2018a]. In recent years, the gap in the total values of U.S.-Canada and U.S.-Mexico freight flows has shrunk. For the first 8 months of 2018, U.S.-Canada freight flows totaled $415.5 billion, and U.S.-Mexico freight flows totaled $405.1 billion.

In both July and August 2018, the value of goods traveling between the United States and Mexico were greater than the value of goods traveling between the United States and Canada. Previously, U.S.-Mexico freight flows had only exceeded U.S.-Canada freight flows during October of 2015, 2016, and 2017, the peak month for electrical machinery shipments between the United States and Mexico.

By value, every mode carried more U.S. freight with Canada and Mexico in 2017 than in 2016, rising by 6.6 percent overall. An increase in the year-over-year price of crude oil in 2017 played a key role in the annual increase in the dollar value of goods moved by pipeline (up 31.3 percent) and vessel (up 29.6 percent) [USDOT BTS 2018b][6].

Trucks are the primary mover of goods to and from both Canada and Mexico, accounting for

[5] The percent increase was calculated by adjusting the 2000 trade data using the Consumer Price Index Inflation Calculator.

[6] Average monthly prices of crude and refined petroleum are available from the Energy Information Agency at www.eia.gov.

63.3 percent of the value and 26.3 percent of the tonnage in 2017. Pipelines moved as many tons as trucks, while rail carried the second highest percentage of goods by value (15.3 percent) (table 4-3). Vehicles and parts (other than railway vehicles and parts) was the top commodity transported between the United States and both Canada and Mexico. Truck and rail accounted for the vast majority of these commodity movements, moving $104.4 billion and $93.6 billion, respectively, in 2017. On the U.S.-Mexico border, electrical machinery was the second most shipped commodity, accounting for $100 billion dollars. Electrical machinery was also the top commodity moved by air between the United States and both Canada and Mexico. Mineral fuels were the top commodity moved by pipeline and vessel between the United States and both Canada and Mexico [USDOT BTS 2018b].

Michigan, which accounts for 13.0 percent of U.S.-Canada border mileage, was the top state freight gateway with Canada. Border crossing/entry ports are located between Detroit, Port Huron, and Sault Ste. Marie and Ontario; both Michigan and Ontario have a high concentration of automakers. Freight flows through Michigan amounted to $222.8 billion or 38.3 percent of total U.S. freight with Canada in 2017 [USDOT BTS 20187b].

Texas, which accounts for 64.2 percent of the U.S.-Mexico border mileage, is home to 11 border crossing/ports-of-entry. In total, there are 85 ports-of-entry along the U.S.-Canada border and 25 on the U.S.-Mexico border. Texas led all U.S.-Mexico border states as a gateway, handling 70.0 percent ($390.1 billion) of freight moved between the United States and Mexico in 2017 [USDOT BTS 2018b].

TABLE 4-3 Value and Weight of U.S. Freight Flows with Canada and Mexico by Transportation Mode: 2000, 2010, 2016, and 2017

(Billions of current U.S. dollars and millions of short tons)

	2000		2010		2016		2017	
Mode	**Value**	**Weight**	**Value**	**Weight**	**Value**	**Weight**	**Value**	**Weight**
Truck[1]	429	NA	560	188	700	213	721	223
Rail[1]	94	NA	131	134	166	163	174	170
Air	45	<1	45	<1	42	<1	44	<1
Water	33	194	81	210	58	194	76	210
Pipeline[1]	24	NA	65	106	50	209	65	223
Other[1]	29	NA	37	11	54	33	60	20
TOTAL[1]	**653**	**NA**	**921**	**650**	**1,069**	**814**	**1,139**	**848**

KEY: NA = not available.

[1] The U.S. Department of Transportation, Bureau of Transportation Statistics estimated the weight of exports for truck, rail, pipeline, and other modes using weight-to-value ratios derived from imported commodities.

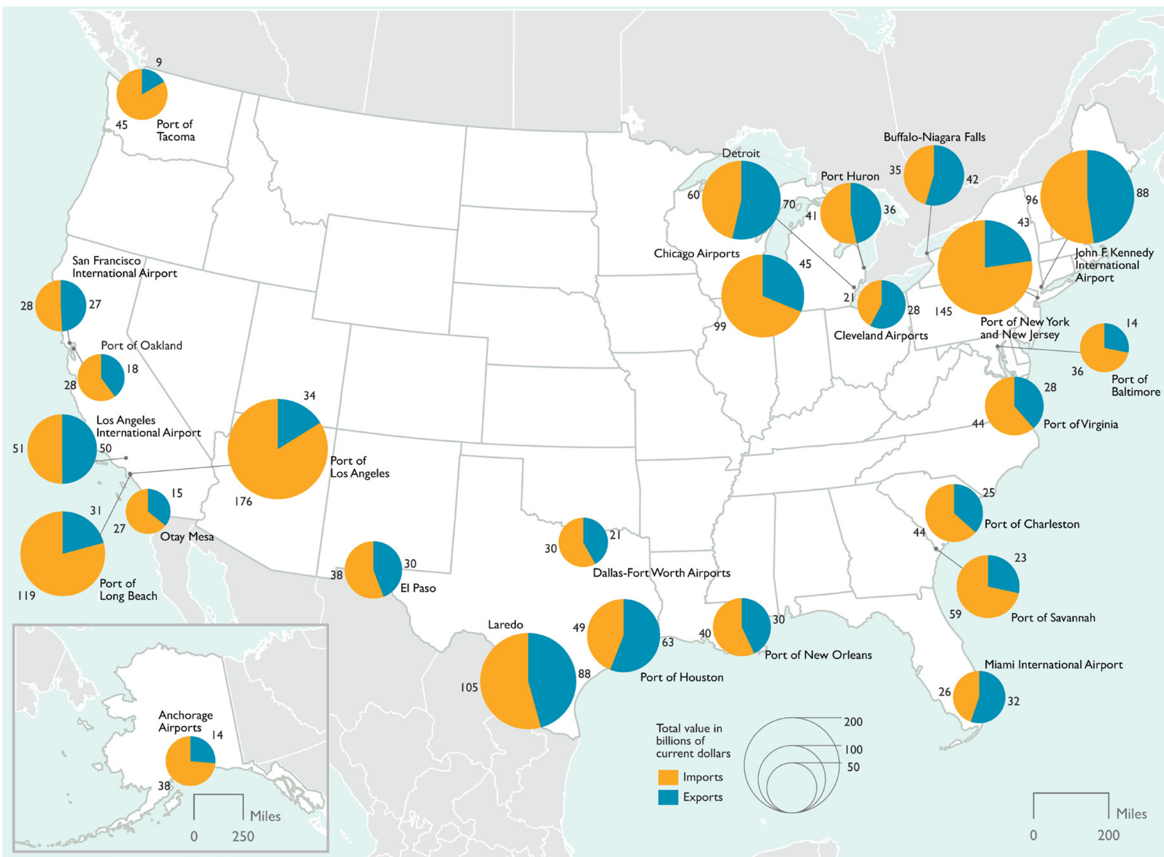
NOTES: Numbers may not add to totals due to rounding. 1 short ton = 2,000 pounds. "Other" includes shipments transported by mail, other and unknown modes, and shipments through Foreign Trade Zones. Totals for the most recent year differ slightly from the Freight Analysis Framework (FAF) due to variations in coverage and FAF conversion of values to constant dollars.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, TransBorder Freight Data, available at www.bts.gov/transborder as of September 2018. **2000**: U.S. Department of Commerce, Census Bureau, FT-920 U.S. Merchandise Trade (December 2000).

Freight Transportation Gateways

A large volume of U.S.-international freight passes through a relatively small number of gateways—the entry and exit points between the United States and other countries. According to the U.S. Census Bureau, there are 467 ports of entry, including airports, land border crossings, and seaports, that handle international cargo [USDOC Census FTD 2018a]. The latest available data show that in 2016, the top 25 gateways handled 61.3 percent of U.S.-international freight by value—about $2.38 trillion of the $3.89 trillion (in current dollars) (figure 4-6). Twenty of the top 25 gateways handled more imports than exports in 2016.

FIGURE 4-6 Top 25 U.S.-International Freight Gateways by Value of Shipments 2016

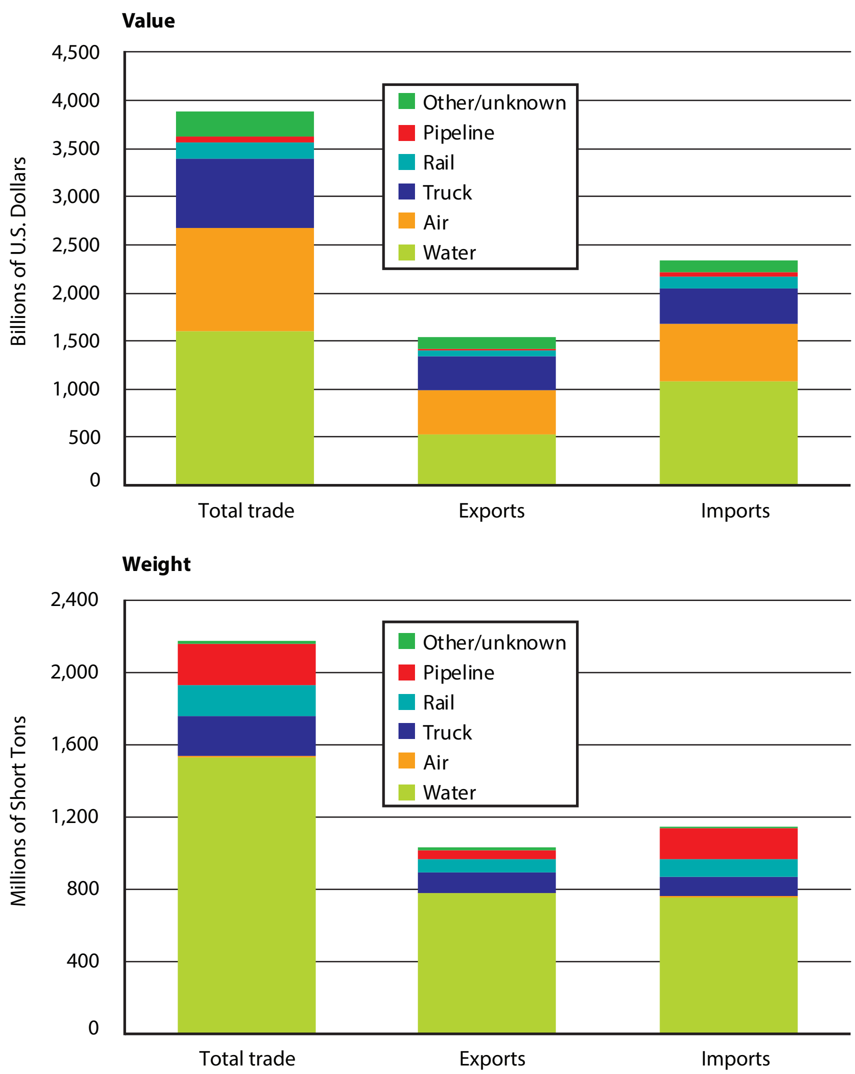


NOTES: **All data**: Flows through individual ports are based on reported data collected from U.S. trade documents and does not include low-value shipments. (In general, these include imports valued at less than $1,250 and exports that are valued at less than $2,500). Numbers may not add to total due to rounding. **Air**: Data for all air gateways are reported at the port level and include a low level (generally less than 2%-3% of the total value) of small user-fee airports located in the same region. Air gateways not identified by airport name (e.g., Chicago, Il and others) include major airport(s) in that geographic area in addition to small regional airports. In addition, due to U.S. Census Bureau confidentiality regulations, data for courier operations are included in the airport totals for JFK International Airport, Chicago, Los Angeles, Miami, New Orleans, Anchorage, and Cleveland.

SOURCES: **Air**: U.S. Department of Commerce, Census Bureau, Foreign Trade Division, USA Trade Online, as of October 2017. **Land**: U.S. Department of Transportation, Bureau of Transportation Statistics, TransBorder Freight Data, available at www.bts.gov/transborder/ as of October 2017. **Water**: U.S. Army Corps of Engineers, Navigation Data Center, special tabulation, December 2017, as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 1-51.

Water is the leading transportation mode for U.S.-international freight trade both in terms of weight and value. Ships moved 41.2 percent of freight value ($1.6 trillion) and 70.3 percent of the total freight weight (more than 1.5 billion tons) in 2017 (figure 4-7). By value, the Port of Los Angeles on the Pacific coast was the leading U.S. water gateway, handling more than $209.8 billion in freight, while the Port of New York/New Jersey, on the Atlantic

FIGURE 4-7 Value and Weight of U.S.-International Freight Flows by Transportation Mode: 2017



NOTES: Numbers may not add to totals due to rounding. 1 short ton = 2,000 pounds. The U.S. Department of Transportation, Bureau of Transportation Statistics estimated the weight of exports for truck, rail, pipeline, and other modes using weight-to-value ratios derived from imported commodities. "Other/unknown" includes shipments transported by mail, other and unknown modes, and shipments through Foreign Trade Zones. Totals for the most recent year differ slightly from the Freight Analysis Framework (FAF) due to variations in coverage and FAF conversion of values to constant dollars.

SOURCES: **Total, Air, and Water**: U.S. Department of Commerce, Census Bureau, *USA Trade Online*, available at https://usatrade.census.gov/; **Truck, Rail, Pipeline, and Other/unknown**: U.S. Department of Transportation, Bureau of Transportation Statistics, *TransBorder Freight Data*, available at www.bts.gov/transborder as of August 2018.

coast, was the second leading water gateway, handling more than $187.3 billion in cargo, also mostly imports (figure 4-6).

Air handles less than one-half of one percent of international freight weight but 27.5 percent of freight value, due to its focus on high-value, time-sensitive, and perishable commodities. In 2016 New York City's John F. Kennedy International airport was the top U.S.-international air gateway by value, handling $183.9 billion in exports and imports—a slight decrease from 2015—followed by Chicago area airports ($143.5 billion) and Los Angeles International ($101.2 billion) (figure 4-6). By freight tonnage, Memphis International, TN, Ted Stevens Anchorage International, AK, and Louisville International, KY, were the top U.S.-international air gateways, handling about 11.9, 8.4, and 6.4 million short tons of cargo, respectively, in 2016 [USDOT FAA].

Trucks haul an appreciable share of imports and exports between the United States and its neighbors, Canada and Mexico. In 2017 trucks carried 18.5 percent of the value of total U.S.-international freight and 10.3 percent of the tonnage (figure 4-7). Laredo, TX, continues to be the top land-border crossing, handling $193.2 billion in freight between the United States and Mexico, while Detroit, MI, ranked second with $130.1 billion (figure 4-6).

Waterborne Freight Transportation

The number of container vessels calling at U.S. ports has increased in recent years. The latest data from the U.S. Maritime Administration indicate that vessel calls at U.S. seaports increased by 38.3 percent, from 59,328 in 2010, at the beginning of the recovery from the Great Recession,[7] to 82,044 in 2015. In 2015 tankers accounted for 40.4 percent of the vessel calls, followed by containerships with 22.8 percent [USDOT MARAD 2016].

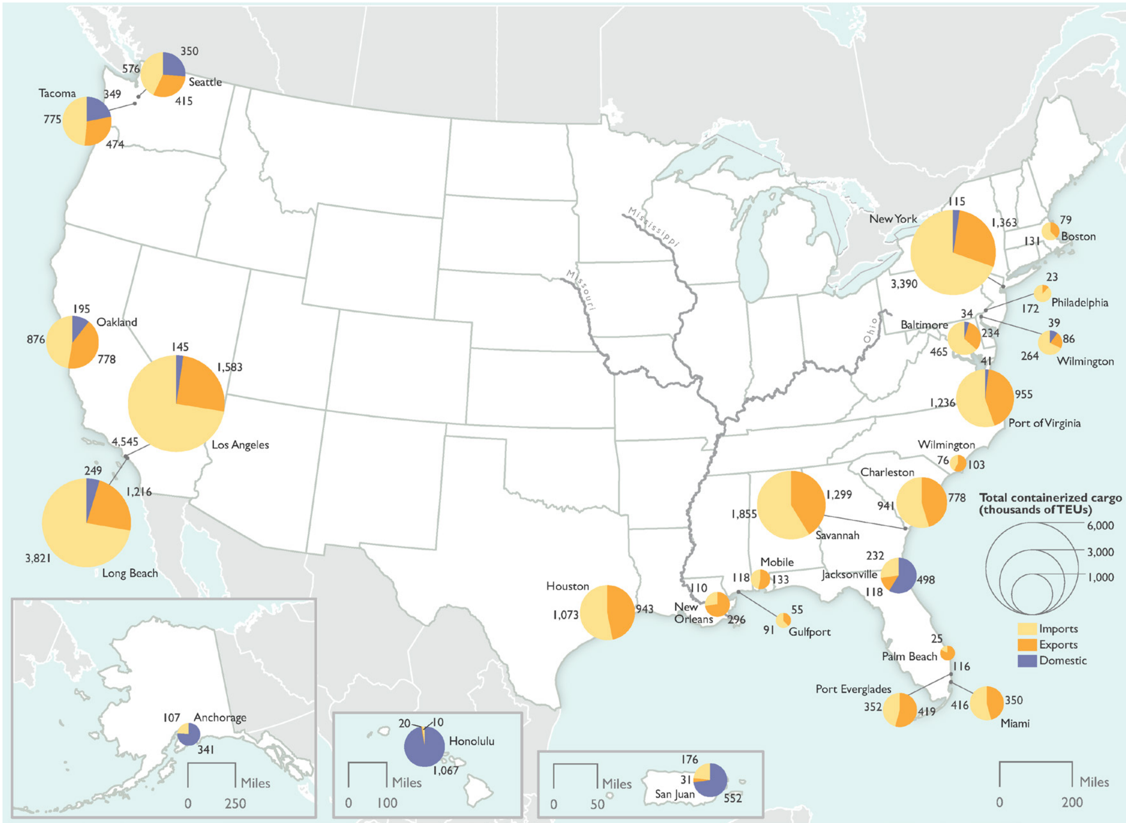
The size of containerships calling at U.S. ports also has increased in recent years, due in part to intense competition within the shipping industry, the recent expansion of the Panama Canal locks to accommodate larger vessels, and efforts by ship owners to minimize costs. The trend toward larger containerships has led to a concentration of liner service[8] at ports with a deep water draft, ample overhead clearance, and intermodal connections, such as double-stack rail service. In 2017 U.S. seaports handled approximately 38.2 million twenty-foot equivalent units (TEUs) of containerized cargo [USACE WCSC 2018]. The ports of Los Angeles and Long Beach on the Pacific coast and the port of New York and New Jersey on the Atlantic coast are the leading container ports. As shown in figure 4-8, container ports are concentrated along the Pacific and Atlantic coasts.

The latest data available indicate that by the end of 2016, 392 vessels with a capacity of 10,000 TEU and larger accounted for 25.8 percent of the total available TEU capacity, while vessels of this size represented 6.2 percent of total container fleet TEU in 2010. Although the increased size of vessels results in fewer calls to move the same number of containers, the greater volume of cargo that these larger ships unload during a single call

[7] December 2007 to June 2009.

[8] A vessel advertising sailings on a specified trade route on a regular basis. It is not necessary that every named port be called on every voyage.

FIGURE 4-8 Top 25 Water Ports by TEU 2017



KEY: TEU = Twenty-Foot Equivalent Unit.

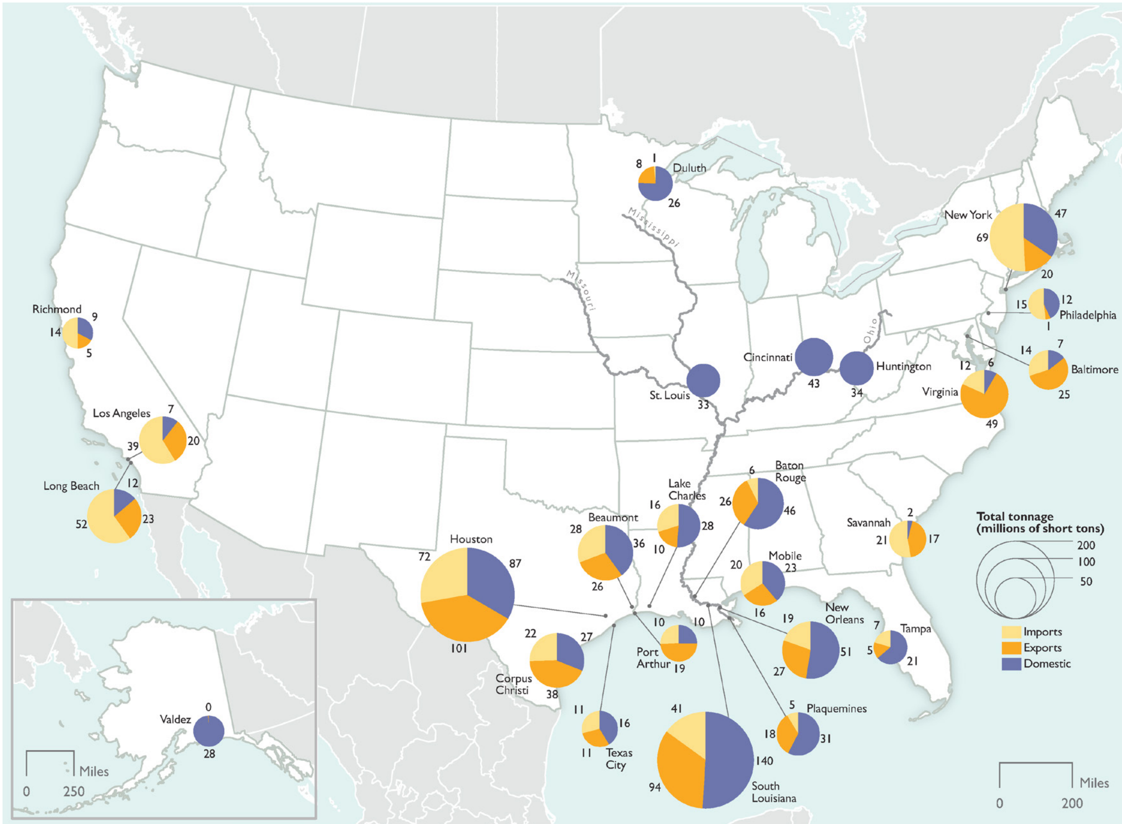
SOURCE: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, *TEUs for Selected Ports in 2017*, available at https://www.iwr.usace.army.mil/ as of September 2018.

can challenge terminal throughput and capacity and affect road and rail systems near the port.

The Bureau of Transportation Statistics established the *Port Performance Freight Statistics Program* in 2015. The goal of this program is to provide nationally consistent measures of performance of the Nation's largest ports, and to report annually to Congress on port capacity and throughput. The ongoing program produces an annual report that contains data and statistics on capacity and throughput at the top 25 ports by tonnage, 20-foot equivalent unit (TEU), or dry bulk tonnage; and nationally consistent port performance metrics. The report also includes detailed information on U.S. maritime ports and discussions of throughput and capacity measures to provide a more complete picture of port activity and to place the statistics in context [USDOT BTS2018c]. The most recent annual report is available on the BTS website at https://www.bts.gov/ports.

Bulk cargo, such as coal, crude petroleum, and petroleum products, moves predominantly through ports on the gulf coast and the inland waterway system (figure 4-9). The top 25 water

FIGURE 4-9 Top 25 Water Ports by Tonnage 2017



NOTES: 1 short ton = 2,000 pounds.

SOURCE: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, *Tonnage for Selected Ports in 2017*, available at http://www.navigationdatacenter.us/ as of July 2018.

ports by tonnage handled 69.2 percent of the weight of all domestic and foreign goods moved by water in 2016. The Port of South Louisiana was the top water gateway by weight, handling 261.9 million short tons, followed by the Port of Houston, moving 248.0 million short tons [USACE WCSC 2018]. A considerable portion of the tonnage moved through these two ports included crude oil and petrochemicals.

In recent years bulk cargo ports have been affected by changes in global demand for U.S. energy commodities. U.S. coal exports, handled primarily by Atlantic and gulf coast ports, have decreased since 2012, although they remain higher than they were in 2007. Waterborne crude petroleum imports fell sharply from 522 million tons in 2007 to 280 million tons in 2016, a 46.3 percent drop, while exports over the same period surged from 83,000 tons to 18 million tons [USDOT BTS 2018c]. Most natural gas produced in the United States is used domestically, but the U.S. export market for liquefied natural gas (LNG) is also surging, driven by increases in U.S. natural gas supplies and expansion of LNG production capacity (box 4-C).

Box 4-C U.S. Liquefied Natural Gas Exports and Imports

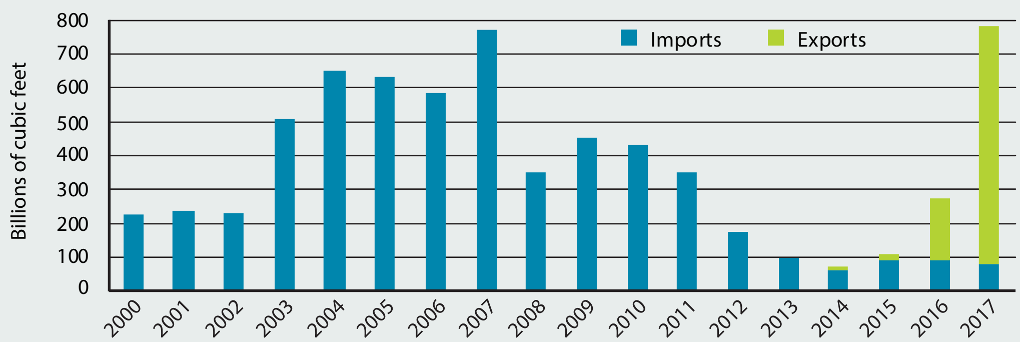
Liquefied natural gas (LNG) is natural gas that has been cooled to a liquid state at -260 °F. The volume of natural gas in its liquid state is about 600 times smaller than its volume as a gas making it easier to move over long distances when pipeline transport is not feasible. LNG is shipped in specially designed cryogenic vessels that can handle the extremely low LNG temperature, reduce the risk of damage or leaks, and limit evaporation during transport.

The United States began exporting LNG in 2014, when a total of 13.3 billion cubic feet (Bcf) were shipped. In 2017 LNG exports reached 707.54 Bcf, up from 186.8 Bcf in 2016 (figure 4-10). All U.S. LNG exports in 2017 originated from the expanded Sabine Pass terminal in Louisiana, which has both liquefaction and regasification capabilities. A new liquefaction terminal at Cove Point, MD, began production in January 2018, and four more facilities are scheduled to come online in the next two years. New pipelines also are being built to move the LNG to these new terminals. Rail transportation of LNG is forbidden by the Federal Railroad Administration (aside from a demonstration plant in Alaska) [USDOT BTS 2018d]. These six facilities will increase total U.S. LNG capacity to approximately 3,504 billion cubic feet by the end of 2019 [USDOE EIA 2018].

U.S. LNG exports in 2017 were shipped to 25 countries, with over half going to three countries: Mexico, South Korea, and China. Mexico received the largest share at 20 percent of the 2017 total [USDOE EIA 2018]. As a result of increasing growth in LNG supplies, particularly from the United States and Australia, the number of LNG carriers in the global fleet has risen from 360 in 2010 to 439 at the end of 2016. An additional 121 tankers are expected to be delivered to the global fleet by 2022 [IGU 2017 and IGU 2010].

The United States also imports a small amount of LNG, mostly to New England, where it is converted to a gas at regasification terminals and transported by pipeline to distribution companies, industrial consumers, and power plants [USDOE EIA 2017].

FIGURE 4-10 Waterborne Import and Export of LNG: 2000–2017



KEY: LNG = liquefied natural gas.

SOURCES: U.S. Department of Energy (USDOE), Energy Information Administration (EIA), U.S. Natural Gas Exports and Re-Exports by Country and USDOE, EIA, U.S. Natural Gas Imports by Country, available at https://www.eia.gov/ as of June 2018.

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CHAPTER 5

Transportation Economics

Highlights

- The demand for transportation grew 0.2 percent from 2015 to 2016 (the last available year) — the slowest growth since the end of the Great Recession. The slow growth resulted from a 7.3 percent decline in private investment — the first year of decline in private investment since steadily rising from the 2009 low.
- Total freight movement reached an all-time high in June 2018, with rail intermodal growing the fastest since the end of the Great Recession.
- Since 2009 transportation has contributed positively to economic growth. However, transportation's average annual contribution to economic growth from 2009 to 2016 is below its pre-recession level.
- In 2016 the wholesale and retail trade sector used the largest amount of transportation services, at $277.9 billion, and required the most transportation services to produce one dollar of output.
- Transportation and transportation-related industries employ over 13.3 million people, accounting for 9.1 percent of workers in the United States.
- Workers with transportation occupations overall earned, at $31,600, a lower median annual wage than workers of all occupations ($37,690) in 2017.
- From 1990 to 2016, air transportation experienced the largest increase in labor productivity, at 159.2 percent, followed by rail transportation, at 100.9 percent.
- Total national expenditures on transportation accounted for $1.2 trillion of all personal expenditures in 2017, making it the fourth largest personal expenditure category (excluding other) after healthcare, housing, and food.
- The amount received for producing air, rail, and truck transportation services (an indicator of the prices faced by households and businesses purchasing the services) declined between 2014 and 2016 before rising in 2017.

Transportation Economics

Transportation plays a vital role in the American economy; it makes economic activity possible and is as a major economic activity in its own right, contributing directly and indirectly to the economy. Households, businesses, and the government directly consume transportation goods (e.g., vehicles and motor fuel) and services (e.g., passenger and freight air transportation). Transportation indirectly contributes to the economy by enabling the production of goods and services (e.g., by connecting producers to the raw materials for baking bread) and employing workers in transportation occupations in both the transportation and non-transportation industries. Public (government) and private expenditures on transportation facilities, infrastructure, and systems contribute to the economy by enabling the movement of both people and goods domestically and internationally. Transportation not only enables international trade but also is a major good and service traded. This chapter examines each of these roles of transportation in the economy. The full scope of transportation's role in the economy is available in the Bureau of Transportation Statistics' (BTS') *Transportation Economic Trends* report.

Transportation's Contribution and Role in the Economy

Transportation's Contribution to GDP

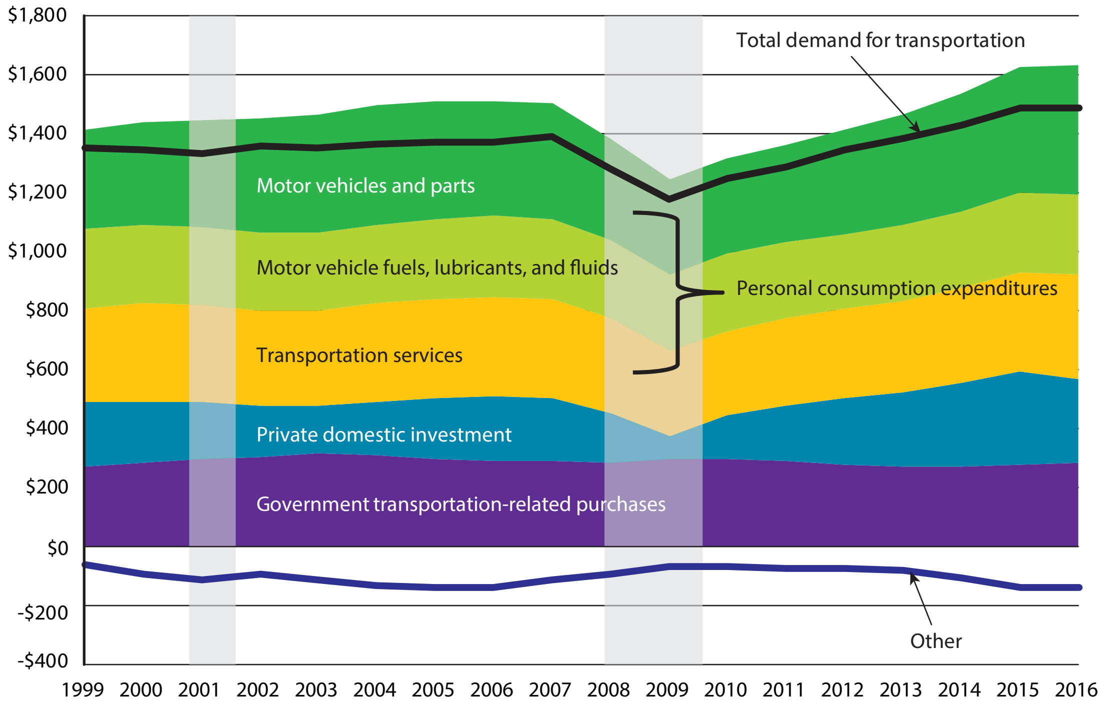
Transportation's contribution to the economy can be measured by its contribution to gross domestic product (GDP). GDP is an economic measure of all goods and services produced and consumed in the country. Transportation's contribution to GDP can be measured in terms of expenditures on transportation goods and services (collectively known as the demand for transportation) or the transportation services produced by the transportation sector.[1] The demand for transportation ($1,489.7 billion) accounted for 8.9 percent of U.S. GDP (as measured in chained 2009 dollars) in 2016 (figure 5-1), which included:

- personal consumption expenditures on transportation, such as vehicle and motor fuel purchases ($1,059.5 billion, or 71.1 percent of the demand for transportation);
- private domestic investment in transportation structures and equipment ($289.0 billion, or 19.4 percent);
- government purchases of transportation goods and services ($282.3 billion, or 19.0 percent);
- net exports (exports minus imports) related to transportation goods and services (-$149.9 billion, or -10.1 percent); and
- the change in retailers' inventories of motor vehicles and parts ($8.8 billion, or 0.6 percent).

The demand for transportation fell 15.6 percent from $1,392.6 billion to $1,175.6 billion (in chained 2009 dollars) during the Great

[1] The two approaches yield different values. For more information, see U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Economic Trends, chapter 2, available at: https://www.bts.gov/product/transportation-economic-trends as of November 2018.

FIGURE 5-1 Components of the Demand for Transportation, 1999–2016 (billions, chained 2009 dollars)



NOTES: Shaded areas indicate economic recessions. "Other" is the sum of the change in retail dealer inventories of motor vehicles and parts and net exports of transportation-related goods and services. 2016 data are latest available.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts Tables, tables 1.1.6, 2.3.6, 2.4.6, 3.11.6, 3.15.6, 4.2.6, 5.4.6, 5.5.6. 5.7.6B, available at http://www.bea.gov/National/nipaweb/SelectTable.asp?Selected=N as of June 2018.

Recession,[2] falling to its lowest level since 1999 in 2009.[3] The sharp decline during that recession effectively erased 10 years of growth in the demand for transportation.

The demand for transportation increased following the Great Recession, surpassing the 2007 peak in 2014 and continued to climb through 2016. However, it grew only slightly from 2015 to 2016, at 0.2 percent, which marked a sharp contrast to the growth of 2.9 percent or more following the Great Recession. The slow growth between 2015 and 2016 resulted from a 7.3 percent decline in private investment — the first year of decline in private investment since steadily rising from the 2009 low.

Transportation's contribution to the economy alternatively can be measured as the contribution of transportation services to the economy. The U.S. Bureau of Economic Analysis (BEA) produces the U.S. Input-Output (I-O) accounts, which show the contribution of for-hire transportation services

[2] The Great Recession was from December 2007 to June 2009.

[3] Percentages in this chapter are calculated using unrounded data when available and may therefore differ from those percentages calculated using the rounded values.

to GDP.[4] In 2017 for-hire transportation and warehousing contributed $589.0 billion (3.0 percent) to U.S. GDP (2016 dollars) [USDOC BEA 2018a]. While for-hire transportation contributes less to the economy than other industries, for-hire transportation delivers the raw materials other industries need to produce finished products and delivers finished products to wholesale and retail outlets.

Measuring only for-hire transportation services understates the transportation component of GDP. Many industries carry out their own transportation services (called in-house transportation) that, with few exceptions, are not included in the for-hire measure. BTS developed the Transportation Satellite Accounts (TSAs) to estimate the contribution of in-house transportation services to the economy.[5] The TSAs also show the contribution of transportation carried out by households using household vehicles.

In 2016, the latest year for which comprehensive data are available, transportation's total (for-hire, in-house, and household) contribution to GDP was $1,066.9 billion. For-hire transportation contributed $562.4 billion (3.0 percent) to an enhanced U.S. GDP of $19.0 trillion.[6] Transportation services (air, rail, truck, and water) provided by non-transportation industries for their own use contributed an additional $172.3 billion (0.9 percent) to GDP. Household transportation, measured by the depreciation cost associated with households owning motor vehicles, contributed $332.2 billion (1.8 percent). Total household transportation's contribution to GDP was larger than any of the other transportation modes. Trucking contributed the second largest amount, at $288.2 billion. In-house truck transportation operations contributed $141.0 billion, while for-hire truck transportation services contributed $147.2 billion (figure 5-2).

Use of Transportation Services by Industries

Transportation indirectly contributes to the economy by enabling the production of goods and services by non-transportation industries. Specifically, industries rely on transportation services as well as transportation infrastructure, such as roadways and rail lines, to access supplies and customers. Additionally, workers in each industry use transportation to reach their workplace.

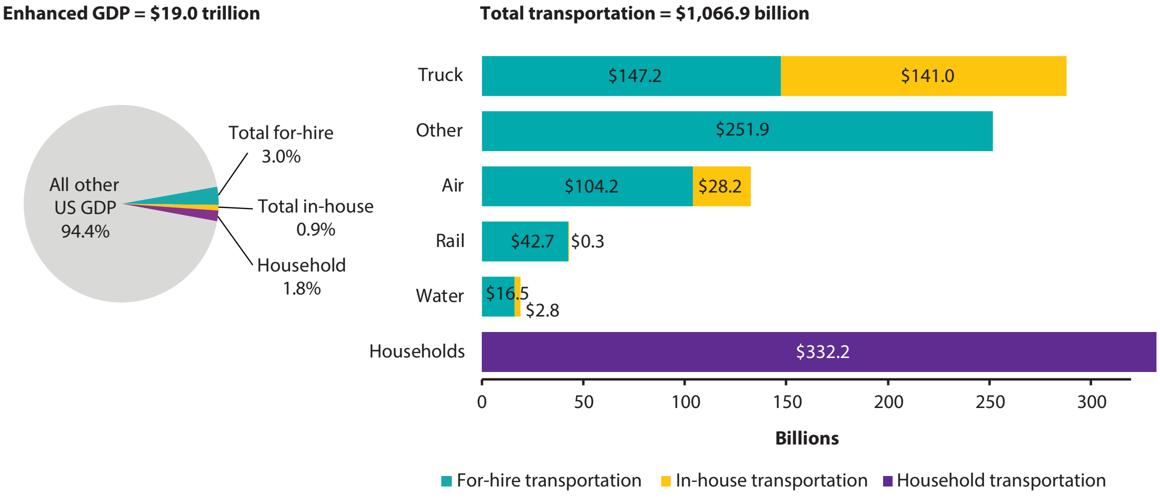
Industry Snapshots: Uses of Transportation summarizes the transportation services and related resources used by the seven major sectors to produce their goods and services [USDOT BTS 2018a]. Some sectors use more transportation than others. In 2016 the wholesale and retail trade sector used the largest amount of transportation services at

[4] For-hire transportation services consist of air, rail, truck, passenger and ground transportation, pipeline, and other support services that transportation firms (e.g., transit agencies and common carrier trucking companies) provide to industries and the public on a fee basis.

[5] For more information about the Transportation Satellite Accounts, see U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Economic Trends, chapter 2, available at: https://www.bts.gov/product/transportation-economic-trends as of July 2018.

[6] Enhanced GDP is the sum of the GDP published in the National Accounts plus the contribution of household transportation. Household transportation covers transportation provided by household for their own use through the use of a motor vehicle.

FIGURE 5-2 Gross Domestic Product (GDP) Attributed to Transportation by Mode, 2016 (billions)



NOTES: For information on the methodology behind the Transportation Satellite Accounts (TSAs), see https://www.bts.gov/satellite-accounts. The GDP value in the TSAs (referred to as enhanced GDP) is larger than the GDP value published in the National Accounts, because it includes the contribution of household transportation. "Household transportation" covers transportation that households provide for themselves with vehicles. "Other" includes: pipeline, transit, and ground passenger transportation, including State and local government passenger transit; sightseeing transportation and transportation support; courier and messenger services; and warehousing and storage). Enhanced GDP = U.S. GDP $18,624.5 billion + contribution of household transportation $332.2 billion. 2016 data are latest available.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at www.bts.gov as of June 2018.

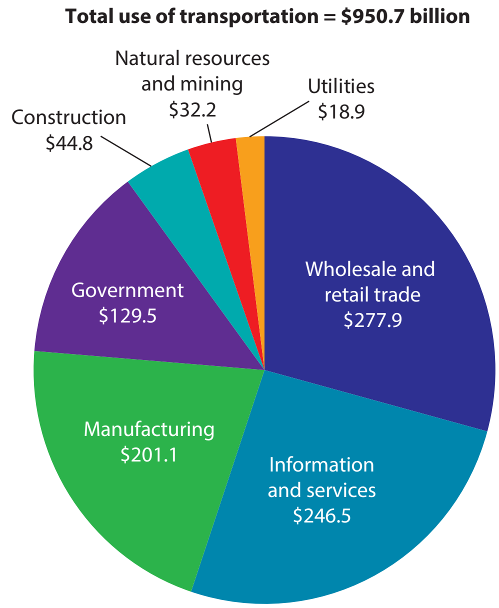
$277.9 billion, followed by the information and services sector at $246.5 billion, and the manufacturing sector at $201.1 billion (figure 5-3).

Looking at the amount of transportation required to produce each dollar of output shows how much a sector depends on transportation services. In 2016 the wholesale and retail trade sector continued to require more transportation services, at 9.0 cents (4.6 cents of in-house transportation operations and 4.4 cents of for-hire transportation services), to produce one dollar of output than any other sector (figure 5-4). The utilities sector continued to be the smallest user of transportation services but the second most dependent on transportation services, requiring 4.9 cents of transportation services to produce one dollar of output (0.1 cents of in-house transportation and 4.7 cents of for-hire transportation).

Transportation as an Economic Indicator

Transportation activities have a strong relationship to the economy. BTS developed the Transportation Services Index (TSI) to measure the volume of freight and passenger transportation services provided monthly by the for-hire transportation sector in the United States. BTS research shows that changes in the TSI occur before changes in the economy, making the TSI a potentially useful economic indicator [USDOT BTS 2014]. This relationship is particularly strong for freight traffic as measured by the freight TSI.

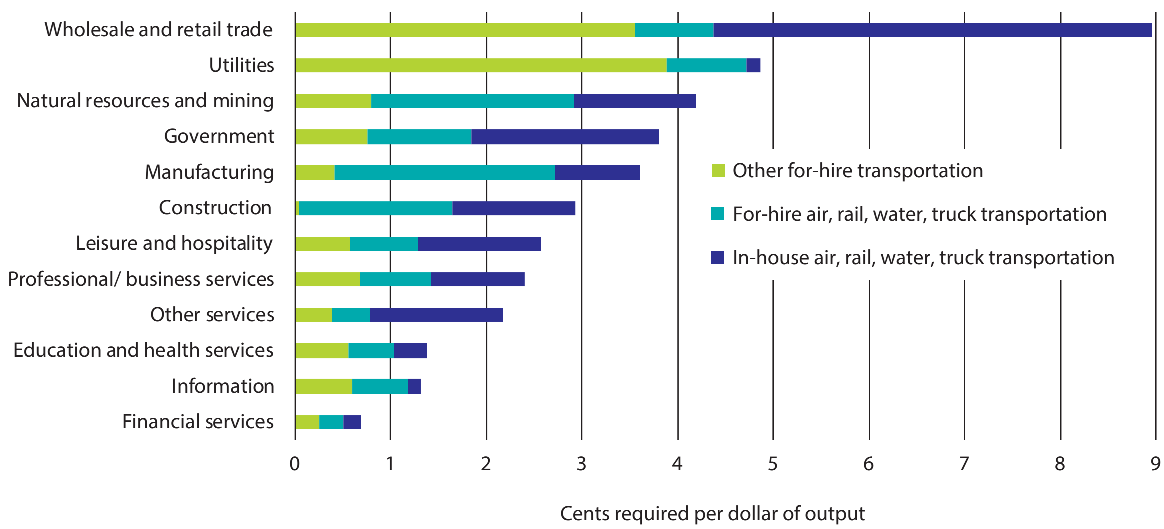
FIGURE 5-3 Use of Transportation by Sector, 2016 (billions of dollars)



NOTES: Includes for-hire and in-house transportation. 2016 data are latest available.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at http://www.bts.gov as of June 2018.

FIGURE 5-4 Transportation Required Per Dollar of Output by Sector, 2016



NOTES: Other for-hire transportation includes: pipeline, transit and ground passenger transportation, including State and local government passenger transit; sightseeing transportation and transportation support; courier and messenger services; and warehousing and storage). 2016 data are latest available.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at http://www.bts.gov as of June 2018

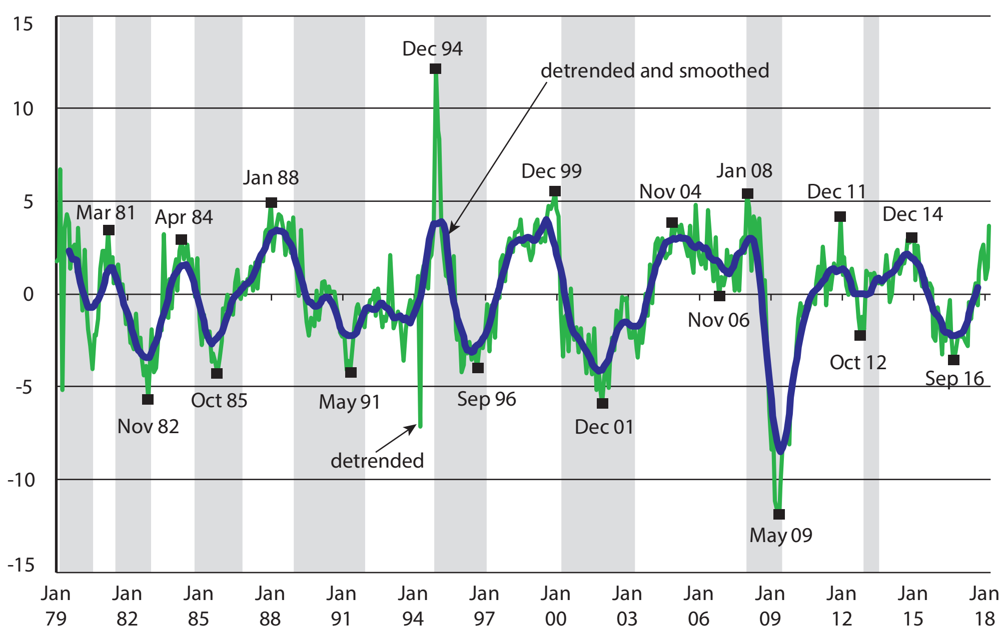
Figure 5-5 illustrates the relationship between the freight TSI and the national economy from January 1979 to May 2018. The dashed green line shows the freight TSI detrended to remove long-term changes. The solid blue line shows the freight TSI detrended and smoothed to remove month-to-month volatility as well. The shaded areas represent economic slowdowns, or periods when economic growth slows below normal rates and unemployment tends to rise as a result. The peaks and troughs marked in figure 5-5 show that the freight TSI usually peaks before a growth slowdown begins and hits a trough before a growth slowdown ends.

Two economic accelerations followed the Great Recession, the first from June 2009 (marking the end of the recession) to December 2012 and the second from July 2013 to December 2014 [USDOT BTS 2017a]. The freight TSI led both of these accelerations.[7]

The freight TSI climbed to record levels in 2017, and reached a new all-time high in June 2018. As of August 2018 (the latest available data), the freight TSI was slightly below the June 2018 peak. The freight index rose 6.8 percent in 2017, the biggest annual gain since the post-recession recovery year of 2010. Monthly freight transportation services, as

[7] For more information about the Transportation Services Index and its relationship to the economy, see U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Economic Trends*, chapter 1, available at: https://www.bts.gov/transportation-economic-trends/tet-2018-chapter-1-summary as of November 2018.

FIGURE 5-5 Freight Transportation Services Index and the Economic Growth Cycle, January 1979–March 2018



NOTES: Detrending and smoothing refer to statistical procedures that make it easier to observe changes in upturns and downturns of the data. Detrending removes the long-term trend and smoothing eliminates month-to-month volatility. Shaded areas indicate decelerations in the economy (growth cycles). Economic deceleration begun December 2014 not shown because more years of data are needed to determine the endpoint.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Services Index, available at www.bts.gov as of July 2018.

measured by the freight TSI, reached a new all-time high in June 2018 — 0.3 percent above the previous all-time high in May 2018 and 2.3 percent higher than the pre-2018 high reached in December 2017 [USDOT BTS 2018b].

Figure 5-6 shows the changes in freight movement by the transportation modes included in the freight TSI from January 2000 to August 2018. Rail intermodal grew the fastest, rising 51.9 percent from June 2009 (the end of the economic recession) to August 2018. Competitive pricing, track upgrades, and investment in rail intermodal terminals and other infrastructure contributed to the rapid growth of rail intermodal traffic.[8] Trucking grew the second fastest, from June 2009 (the end of the Great Recession) to August 2018, at 51.7 percent, followed by air freight at 43.6 percent, pipeline at 37.1 percent, waterborne at 29.0 percent, and rail carloads at 1.2 percent. Rail intermodal, trucking, and pipeline have grown steadily since June 2009, while waterborne showed little growth after initial recovery. Rail carloads initially declined before growing through early 2018. Data from the Association of American Railroads suggest that the decline in rail carload shipments from 2009 to early 2016 is due to reductions in coal shipments and recent increases in coal shipments contributed to growth in rail carloads in 2016 and 2017.[9]

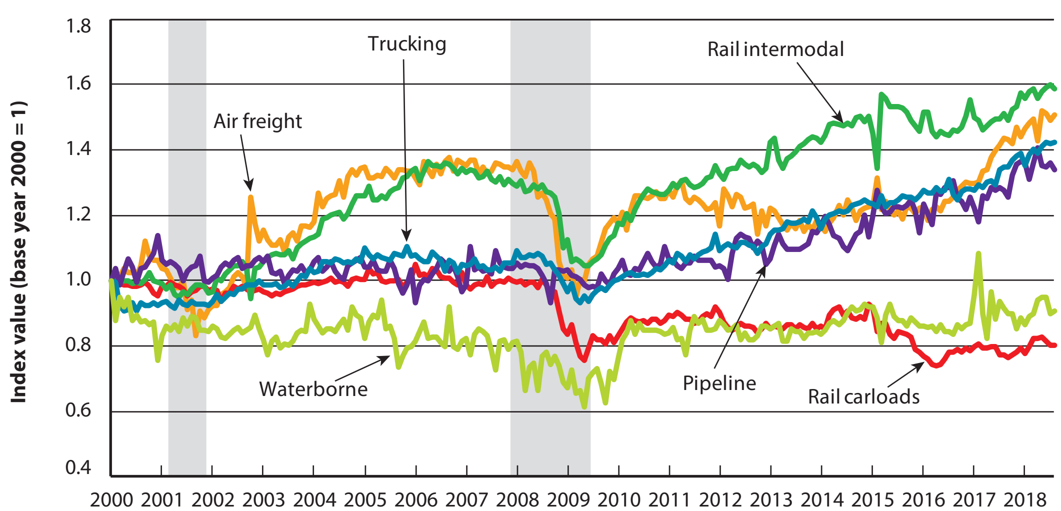
Transportation-Related Employment and Wages

Industries in the transportation and warehousing sector and related industries

[8] See "Railroad Intermodal Keeps America Moving," May 2016, available at www.aar.org/BackgroundPapers/Rail%20Intermodal.pdf.

[9] See "Railroads and Coal," May 2018, available at https://www.aar.org/wp-content/uploads/2018/05/AAR-Railroads-Coal.pdf.

FIGURE 5-6 Freight Transportation Services Index Modal Data, January 2000–August 2018



NOTE: Shaded areas indicate economic recessions. Pipeline is a weighted average of petroleum pipeline and natural gas movement.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, seasonally adjusted transportation data, available at www.bts.gov as of October 2018.

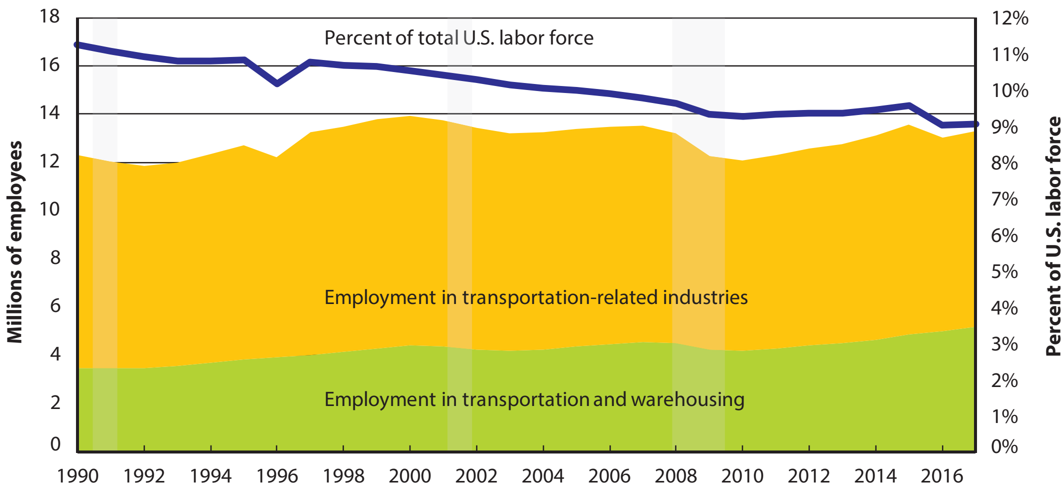
outside the sector employed over 13.3 million people in 2017 in a variety of roles, from driving buses to manufacturing cars to building and maintaining ports and railroads. Figure 5-7 shows the number and percentage of workers in transportation and transportation-related industries from 1990 to 2017.[10] The number of American workers in transportation and transportation-related industries rose to a high of 13.9 million workers in 2000 but declined to 13.2 million in 2003 following the 2001 recession. Employment declined further to a low of 12.1 million in 2010 due to the Great Recession. After the Great Recession, employment rose steadily from 2011 to 2015, reaching 13.6 million in 2015 and exceeded the prerecession (2007) level of 13.5 million for the first time, employment then declined to 13.3 million in 2017. The percentage of American workers employed in transportation and transportation-related industries declined from 11.2 percent of the U.S. labor force in 1990 to 9.1 percent in 2017 (figure 5-7).

The transportation and warehousing sector directly employed 5.2 million workers in the United States in 2017—3.5 percent of the Nation's labor force (figure 5-7). Employment in this sector includes transportation and non-transportation occupations and covers a diverse set of skills. Transportation-related industries outside the transportation and warehousing sector employed 8.1 million workers.

A notable shift in transportation-related employment occurred between 1990 and 2017 (figure 5-8). From 1990 through 2001, transportation equipment manufacturing employed the most people of all transportation-

[10] "Transportation industries" refers to industries in the transportation and warehousing sector such as air, rail, water, and truck transportation. "Transportation-related industries" refers to related industries outside the sector such as motor vehicle parts manufacturing.

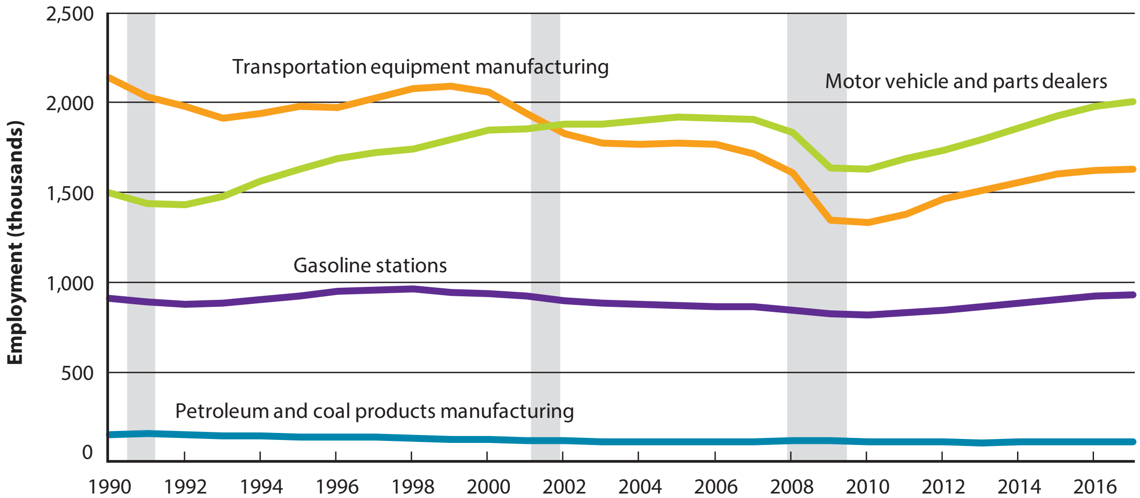
FIGURE 5-7 Transportation-Related Labor Force Employment in the United States, 1990–2017



NOTE: Shaded areas indicate economic recessions.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, Table 3-23 Employment in For-Hire Transportation and Selected Transportation-Related Industries (NAICS basis), available at www.bts.gov as of July 2018.

FIGURE 5-8 Employment in Selected Transportation-Related Industries, 1990–2017



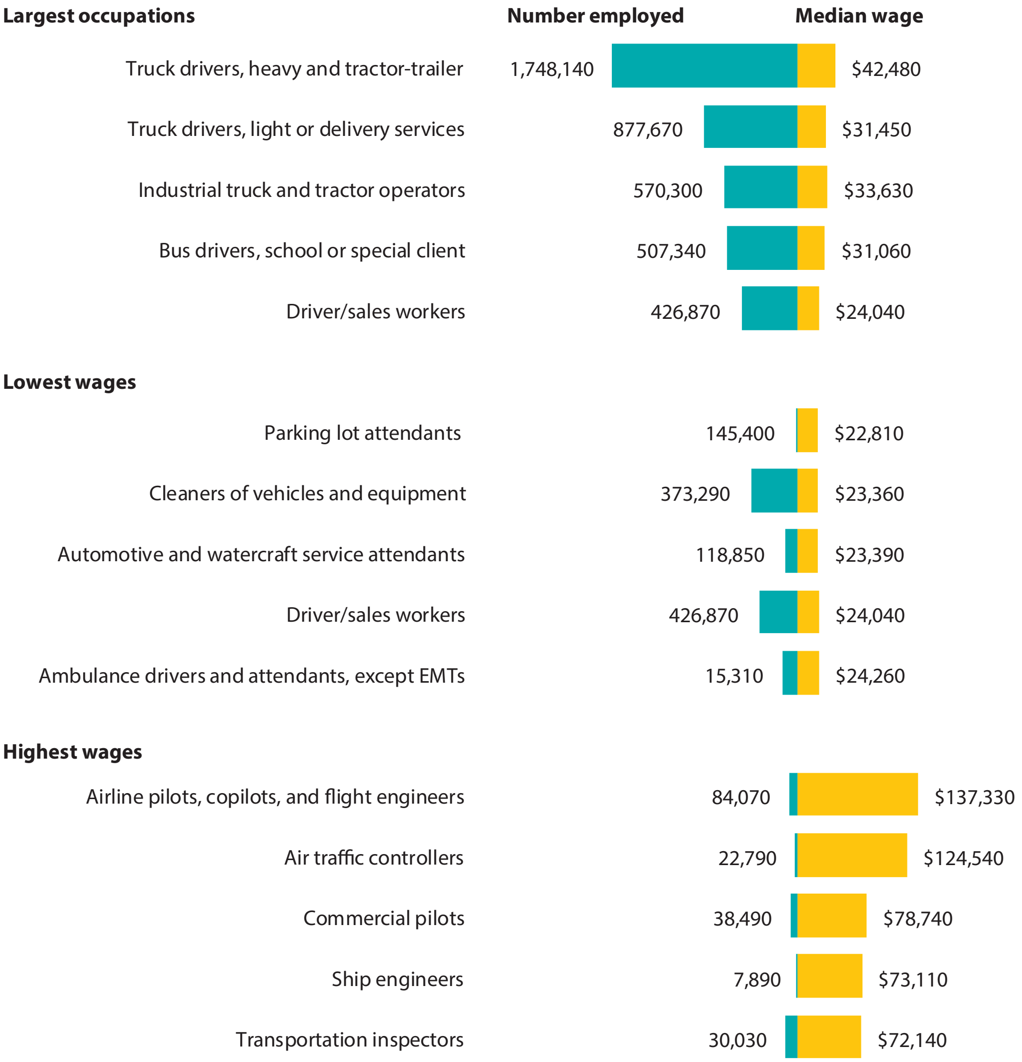
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, Table 3-23, available at www.bts.gov.

related industries. However, as employment in transportation equipment manufacturing experienced a prolonged decline, motor vehicle and parts dealers became the largest industry in 2002. Employment in motor vehicle and parts dealers grew by 34.4 percent from 1990 to 2017 (from 1.5 to 2.0 million employees), while employment in transportation equipment manufacturing declined 23.6 percent (figure 5-8).

Workers with transportation occupations overall earned, at $31,600, a lower median annual wage than workers of all occupations ($37,690) in 2017 [USDOL BLS 2018b]. Annual wages for the largest, the lowest-paid, and the highest-paid transportation occupations in the United States in 2017 are illustrated in figure 5-9. Annual wages vary widely, from an average of over $100,000 for airline pilots and air traffic controllers to an average of $22,810 for parking lot attendants. While the five highest-wage occupations employ 183,270 workers, the five lowest-wage transportation-related occupations collectively employ almost 6 times more workers at 1.1 million.

The number employed and the wages earned are indicators of the demand for an occupation. Recent growth in freight activity, as indicated by the freight TSI reaching record highs in 2017, increased the demand for truck drivers. The number employed as truck drivers across all industries rose from 2004 to 2017, increasing 5.3 percent—from 2.9 to 3.1 million. The most substantial change occurred in the number of heavy and tractor-trailer truck drivers, which rose 12.5 percent from 1.6 to 1.7 million from 2004 to 2017, with a 2.6 percent growth from 2016 to 2017. The 2016 to 2017 growth equaled the average annual growth experienced since the end of the 2007 through 2009 recession [USDOL BLS 2018b]. According to the American Trucking

FIGURE 5-9 Employment and Wages in Select Transportation and Transportation-Related Occupations, 2017



NOTES: Based on analysis of occupation groups classified as detailed and with Standard Occupation Code (SOC) 53-000 (transportation and material moving occupations). Material moving occupations not included if transportation not directly involved, such as packers and packagers. Figure not comparable to previous versions which included occupations with SOCs other than 53-000.
Airline pilots typically fly on scheduled air carrier routes to transport passengers and cargo, while commercial pilots fly on non-scheduled air carrier routes. "Commercial pilots" includes charter pilots, air ambulance pilots, and air tour pilots.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Occupational Employment and Wages, available at http://www.bls.gov/oes as of July 2018.

Association (ATA), the trucking industry faced an estimated 50,000 shortage of drivers at the end of 2017, and that number is projected to increase. Strong demand for truck drivers sometimes causes wages to increase to attract workers, particularly when companies face a shortage in drivers to move goods.

Transportation Productivity

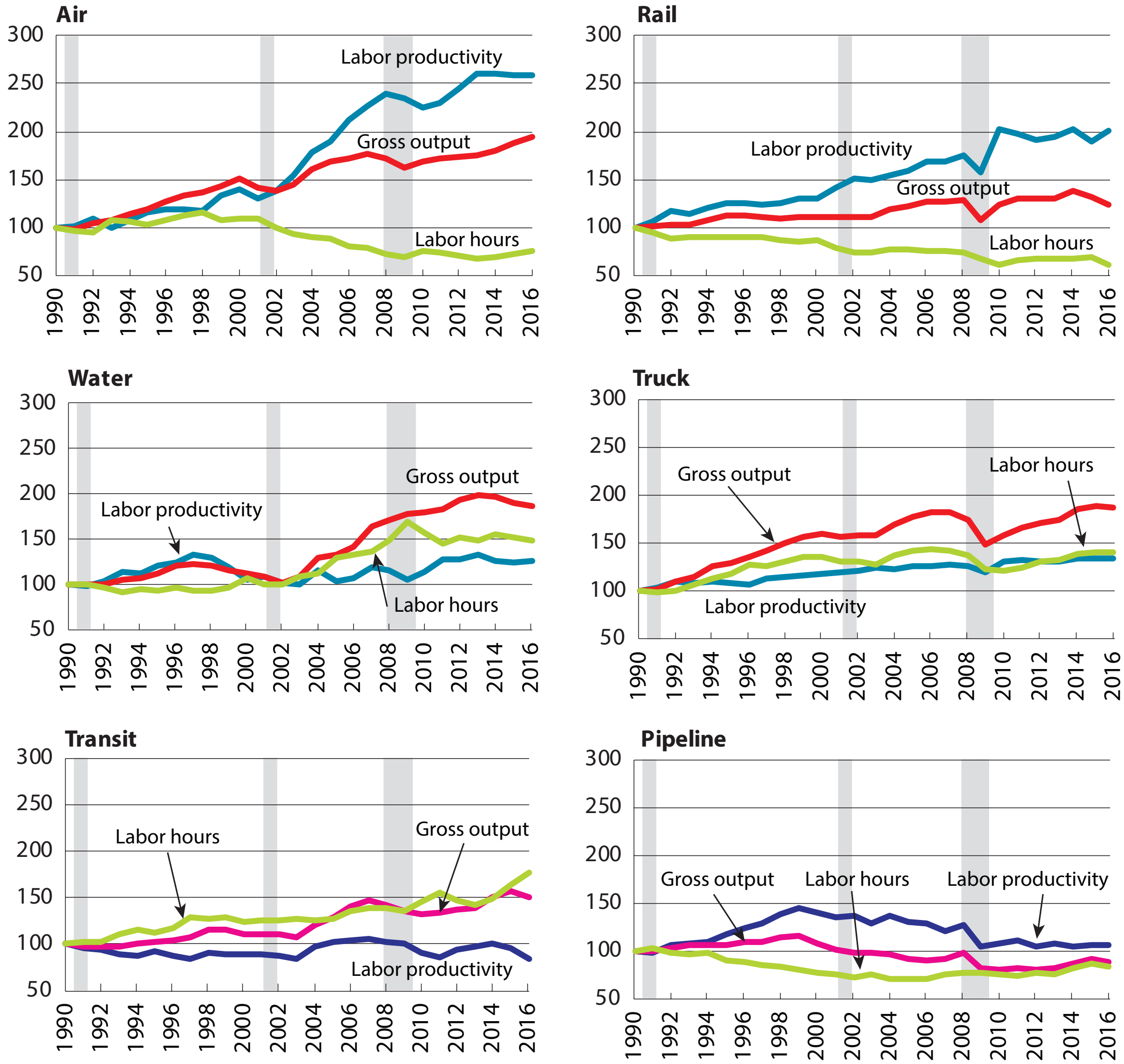
The size of the transportation workforce depends on the demand for transportation and on firms' utilization of the workforce relative to other inputs, such as capital, energy, materials, and services. Economists measure how efficiently firms use inputs through economic productivity. Economic productivity is the ratio of total output to the inputs used in the production process. Productivity increases when a business produces the same output using fewer (or lower cost) inputs. The reverse is also true. Productivity decreases when a business produces the same output using more (or higher cost) inputs. In instances of productivity increases, the business may choose to produce more output, lower prices, invest in the business, or return income to shareholders.

The two main measures of transportation productivity are labor (single-factor) productivity and multifactor productivity (MFP). Labor productivity measures the output per unit of labor input, while MFP measures the output per unit as a weighted average of multiple factors, such as fuel, equipment, and materials.

Labor productivity continues to have broad appeal because it is both simple to understand and, in many instances, labor is the major driver in changes to productivity. Figure 5-11 illustrates changes in labor productivity for selected transportation sectors from 1990 to 2016. Air transportation experienced the largest increase in labor productivity among all transportation modes, increasing 159.2 percent from 1990 to 2016 (figure 5-10). Air transportation's labor productivity grew most notably between 2001 and 2008. The gains during this period come from legacy carriers adopting aggressive labor-saving initiatives and from large output gains among low-cost carriers [USDOL BLS 2017]. Rail transportation experienced the second largest gains in labor productivity, increasing by 100.9 percent. These gains are the result of labor-saving technologies automating operational and administrative tasks [Kriem n.d.]. Labor-saving initiatives in air and rail resulted in a decline in labor hours required per unit of output over the 1990 to 2016 period. During the same period, smaller labor productivity increases occurred in truck (33.6 percent) and water (26.2 percent) transportation. Labor productivity in pipeline transportation grew 5.7 percent, despite declining output and labor hours from 2000 through 2016. Labor productivity in transit declined 15.2 percent due to the amount of labor hours required to produce output rising faster (76.6 percent) than output (49.8 percent).

From the perspective of output per unit of multiple inputs (e.g., fuel, equipment, and materials), air transportation experienced the largest increase in MFP from 1990 to 2016, growing 107.3 percent (figure 5-11). Rail and water transportation experienced the next largest increases in MFP, growing 33.7 and 33.0 percent from 1990 to 2016, respectively.

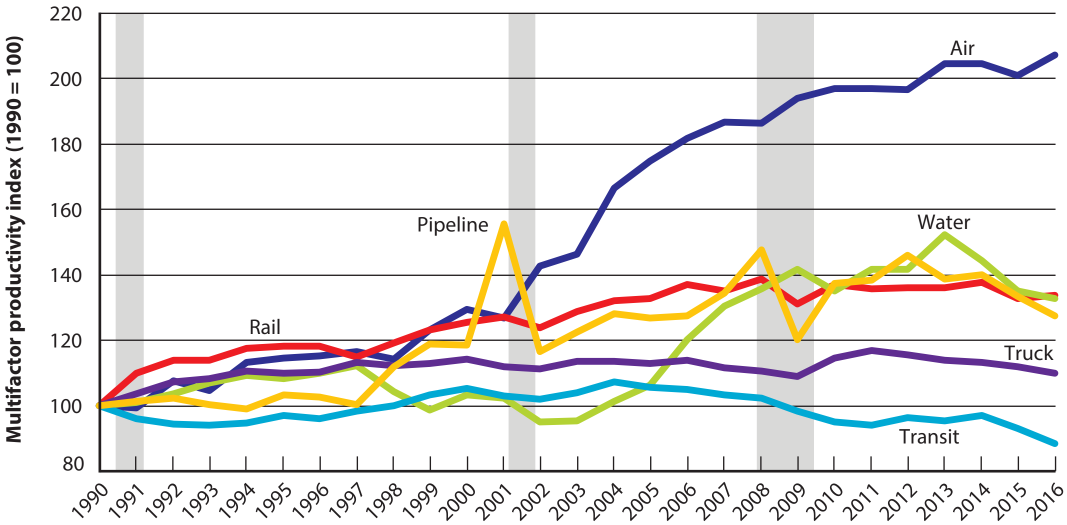
FIGURE 5-10 Labor Productivity Indexes of Transportation Sectors, 1990–2016 (index 1990 = 100)



NOTES: Shaded areas indicate economic recessions. Labor hours is the total number of number of hours worked by all workers in a sector to produce gross output. Gross output is the total value of goods and services produced by the sector. Gross output includes the value of the goods and services used to produce the sector output. Labor productivity measures a sector's output per unit of labor input.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Major Sector Productivity, http://www.bls.gov as of July 2018.

FIGURE 5-11 Multifactor Productivity Indexes for Transportation Sectors, 1990–2016 (index 1990 = 100)



NOTES: Shaded areas indicate economic recessions. Scenic and sightseeing transportation (NAICS 487), support activities for transportation (NAICS 488), postal Services (NAICS 491), couriers and messengers (NAICS 492), and warehousing and storage (NAICS 493) are not included in this figure.

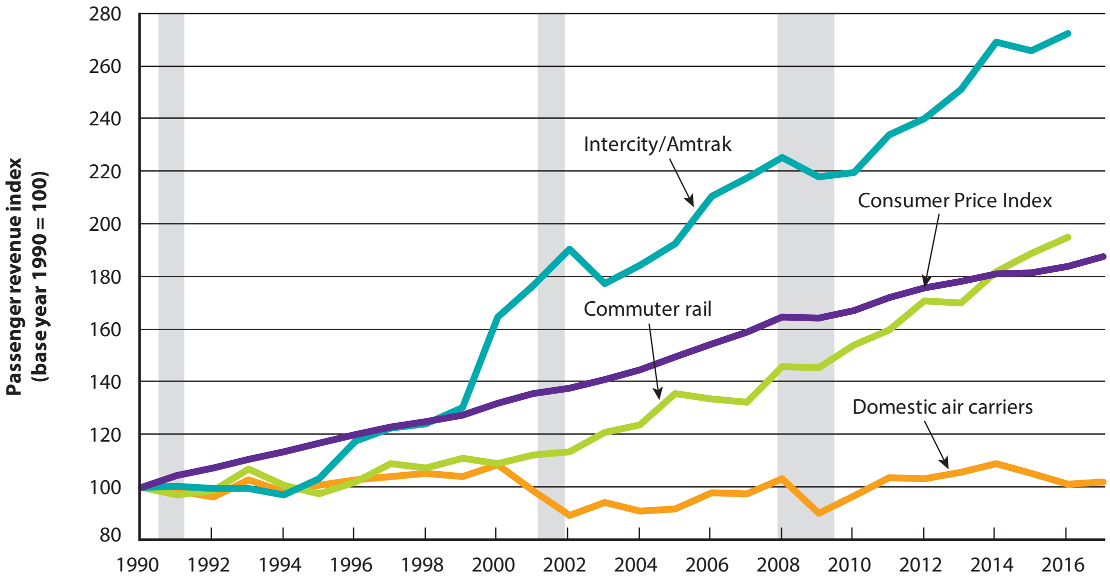
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Major Sector Productivity, http://www.bls.gov as of July 2018

Unlike air and rail transportation MFP, the MFP of water transportation declined from 1997 to 2003 — due to a decline in the output of water transportation services — and then began to rise (figure 5-11). MFP in pipeline transportation had a smaller increase of 27.6 percent from 1990 to 2016 and showed more year-to-year variation than other modes.

Labor productivity and MFP measure productivity from the industry perspective. What users pay for each unit of the produced services can be thought of as a productivity measure from the user perspective. For for-hire passenger transportation, the average revenue per passenger-mile measures what travelers pay per mile of purchased transport services. For for-hire freight transportation, the average freight revenue per ton-mile measures what freight shippers pay per ton-mile of purchased transport. For modes where users do not typically pay per use, like driving a personal vehicle, data are difficult to obtain.

Figure 5-12 shows nominal changes in revenue per passenger-mile relative to the Consumer Price Index (CPI) for three industries: domestic air carriers, commuter rail, and Amtrak/intercity rail. Amtrak/intercity rail experienced the largest growth in revenue per passenger-mile, increasing 172.1 percent between 1990 and 2016, and commuter rail increased 94.7 percent during the same time period. Both Amtrak/intercity rail and commuter rail experienced steady growth. In contrast, domestic air carrier revenue per passenger-mile fell after the September 2001 terrorist attacks, began to rise after reaching a low in

FIGURE 5-12 Average Revenue per Passenger-Mile Indexes, 1990–2017 (index 1990 = 100)



NOTE: Domestic air carrier revenue includes baggage fees and reservation change fees. Data for commuter rail and intercity/Amtrak available only through 2016. Shaded areas indicate economic recessions.

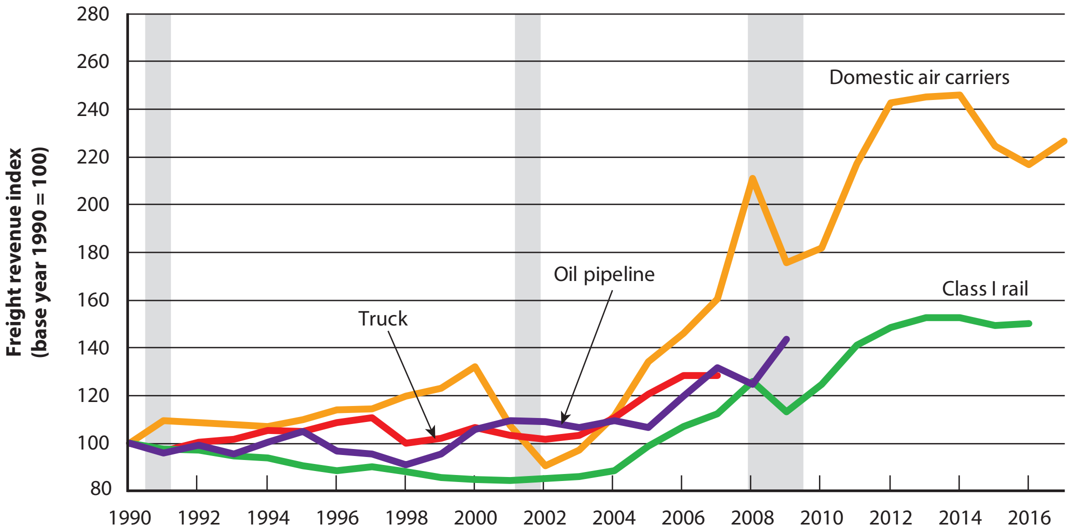
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 3-20, available at www.bts.gov as of October 2018.

2002, and then fell again during the Great Recession to its 2002 level in 2009. Between 2009 and 2014, domestic air carrier revenue per passenger-mile rose 21.0 percent but then fell 6.6 percent between 2014 and 2017.

Comparing revenue per passenger-mile to the CPI shows whether revenue per passenger-mile is rising slower or faster than inflation. From 1990 to 2017, air revenue per passenger-mile grew more slowly than the CPI, suggesting air carriers received less revenue per passenger-mile over time after accounting for inflation (figure 5-12). In contrast, revenue per passenger-mile of Amtrak/intercity rail grew faster than the CPI, suggesting Amtrak/intercity rail received increasing revenue per passenger-mile over time after accounting for inflation.

Figure 5-13 shows the average freight revenue per ton-mile for air, truck, rail, and pipeline. Nominal freight revenue per ton-mile increased for all freight modes. Domestic air carriers experienced the largest increase in revenue per ton-mile, increasing 145.9 percent from 1990 to 2014 before falling 11.6 percent that level between 2015 and 2016. Revenue per ton-mile for domestic air carriers increased 4.5 percent from 2016 to 2017. Class I railroads experienced a smaller increase in revenue per ton-mile of 50.1 percent from 1990 to 2016 due to an initial decline.

FIGURE 5-13 Average Freight Revenue per Ton-Mile Indexes, 1990–2017 (index 1990 = 100)



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 3-21, available at www.bts.gov as of October 2018. **Producer Price Index**: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index-Commodities (WPUFD49207), available at http://www.bls.gov/ppi/ as of Aug. 14, 2018.

Sources of Economic Growth

The BEA/BLS Integrated Production Accounts show the contribution of labor, capital, and MFP to economic growth. Based on the accounts, transportation's contribution has been smaller than other sectors. Between 2003 and 2007, transportation, with an average annual growth rate of 0.14 percent, contributed significantly less than manufacturing, services, and finance, which all had average annual growth rates in excess of 0.50 percent (table 5-1). Almost all sectors, including transportation, experienced negative growth during the Great Recession. Since 2009 transportation has contributed positively to economic growth. However, transportation's average annual contribution to economic growth from 2009 to 2016 (the latest available year) is below its pre-recession level at 0.05 percent.

Transportation Expenditures and Revenues

Household Spending

In 2017 total national expenditures on transportation by and on behalf of U.S. households amounted to $1.20 trillion, making it the fourth largest household expenditure category (excluding other) after healthcare, housing, and food (figure 5-14). Expenditures to purchase, operate, and maintain personal vehicles accounted for most of the transportation expenditures—$1.1 trillion in 2017, or 87.9 percent of total transportation expenditures [USDOC BEA 2018b].

Transportation expenditures by or on behalf of households increased 54.6 percent, from $794.8 billion in 2000 to $1.2 trillion in 2017. Total household expenditures increased

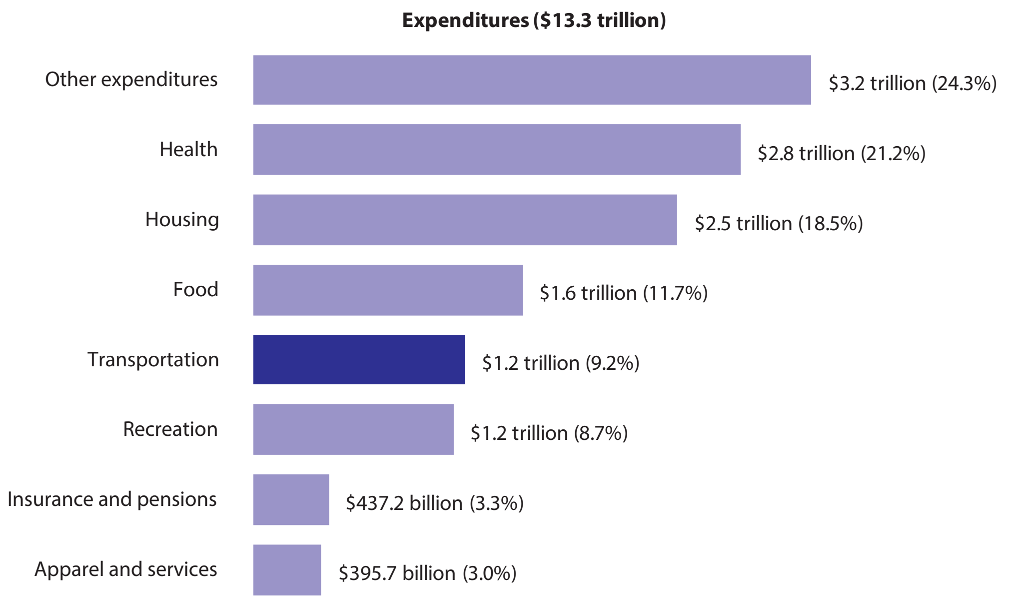
TABLE 5-1 Sources of Economic Growth (average annual growth rate, percent)

Industry	2003-2007	2007-2009	2009-2016
All	2.71	-1.56	1.91
Finance	0.58	0.03	0.34
Services	0.56	-0.12	0.60
Manufacturing	0.51	-0.66	0.17
Information	0.32	0.03	0.17
Government	0.26	0.17	0.09
Trade	0.28	-0.61	0.29
Transportation	0.14	-0.11	0.05
Mining	0.07	0.17	0.08
Utilities	0.02	-0.05	0.02
Agriculture	0.00	0.09	0.03
Construction	-0.03	-0.48	0.06

NOTE: Finance includes: Finance and insurance and Real estate rental and leasing. The service sector includes: Professional and business services; Education and health services; Leisure and hospitality; and Other services (NAICS 54-81).

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, Integrated Industry-Level Productivity Account, http://www.bea.gov as of September 2018.

FIGURE 5-14 Total National Household Expenditures (Major Expenditure Categories), 2017



NOTES: "Other expenditures" include alcoholic beverages purchased for off-premises consumption; furnishings, household equipment, and routine household maintenance; education; accommodations; financial services (excluding pension funds); other goods and services; net foreign travel and expenditures abroad by U.S. residents; and final consumption expenditures of nonprofit institutions serving households.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts Tables, table 2.4.5U, available at http://www.bea.gov/iTable/index_nipa.cfm as of August 2018.

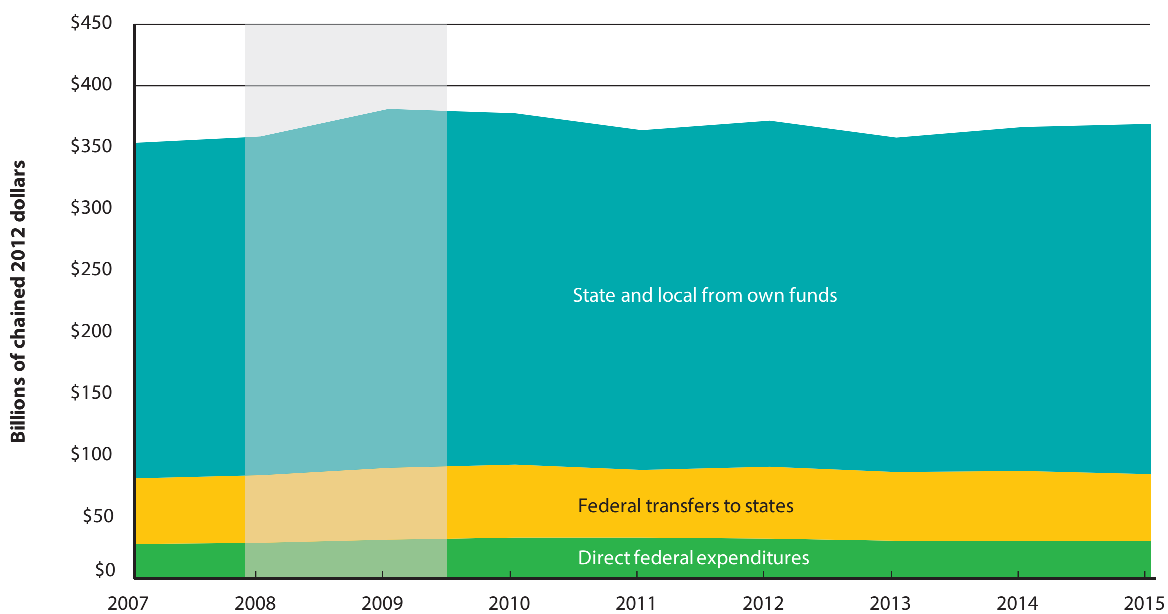
97.0 percent from $6.8 to $13.3 trillion over the same period, outpacing the growth in transportation expenditures. Expenditure growth for healthcare (155.0 percent), housing (102.9 percent), and food (93.3 percent) also outpaced expenditure growth for transportation [USDOC BEA 2018b].

Public and Private Sector Expenditures and Revenue

Expenditures

Most government spending on transportation takes place at the state and local levels, although state and local capital expenditures are often paid for in part with federal funds. In 2015 state and local governments spent $297.3 billion, including expenditures paid for with federal transfers, such as the Federal-Aid Highway Program and the Airport and Airway Trust Fund. The Federal Government spent $32.3 billion directly on transportation, excluding federal transfers to states. In real 2012 dollars, transportation expenditures at all levels of government have increased since 2007 (figure 5-15). Real direct federal expenditures increased by 8.4 percent (from $28.5 to $30.8 billion in 2012 dollars). Real federal transfers to states increased 2.6 percent (from $53.2 to $54.5 billion in 2012 dollars), while real state and local expenditures (excluding expenditures paid for with federal funds) increased by 4.4 percent (from $272.0 to

FIGURE 5-15 Federal, State, and Local Government Expenditures, 2007–2015 (billions of chained 2012 dollars)



NOTE: Shaded vertical bar indicates economic recession.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at www.bts.gov as of January 2019.

$283.9 billion in 2012 dollars).[11] Governments increased transportation spending following the Great Recession to stimulate the economy. In 2009 the Federal Government enacted the American Recovery and Reinvestment Act (ARRA) of 2009, which authorized $48.1 billion in transportation spending. As a result, transportation expenditures by the Federal Government (direct federal expenditures and federal transfers to states) reached a peak in 2010 at $93.4 billion (in chained 2012 dollars). By 2014 ARRA spending was substantially complete and no longer impacted the pattern of growth in transportation spending.

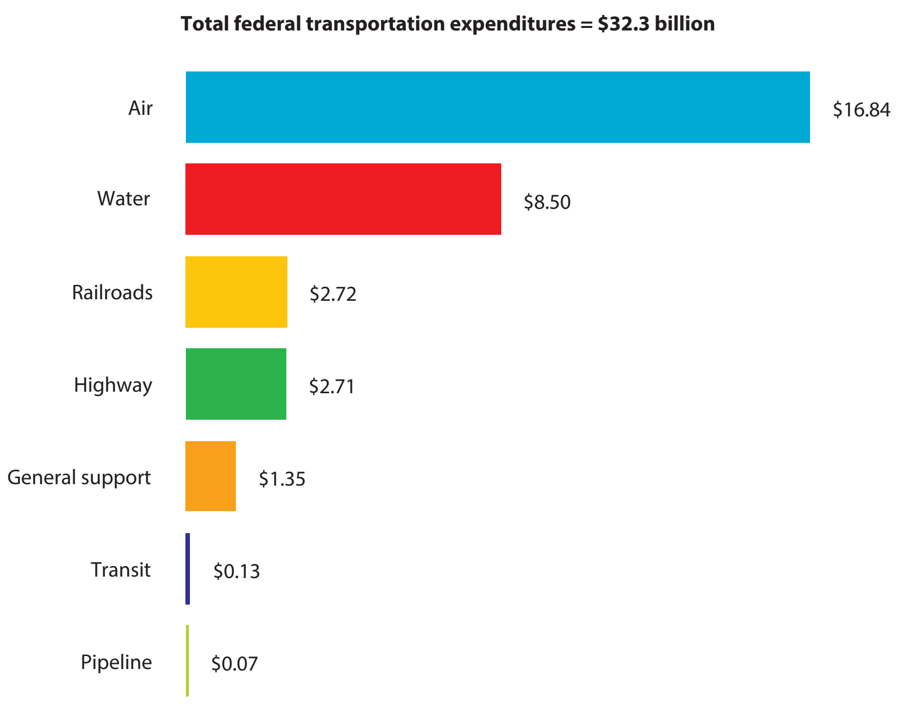
[11] Data revised from earlier editions of TSAR.

Most federal transportation spending in 2015, excluding federal grants to states, was for aviation ($16.8 billion in 2015, or 52.1 percent), followed by water ($8.5 billion, or 26.3 percent), railroads ($2.7 billion, or 8.4 percent), and highway ($2.7 billion, or 8.4 percent) (figure 5-16).

In 2015, 68.7 percent ($204.2 billion) of state and local spending on transportation, including expenditures paid for with federal grants, went to highways and 21.6 percent ($64.1 billion) went to transit (figure 5-17).

In 2017 private and public spending on new transportation construction and improvements totaled $134.0 billion (figure 5-18). The

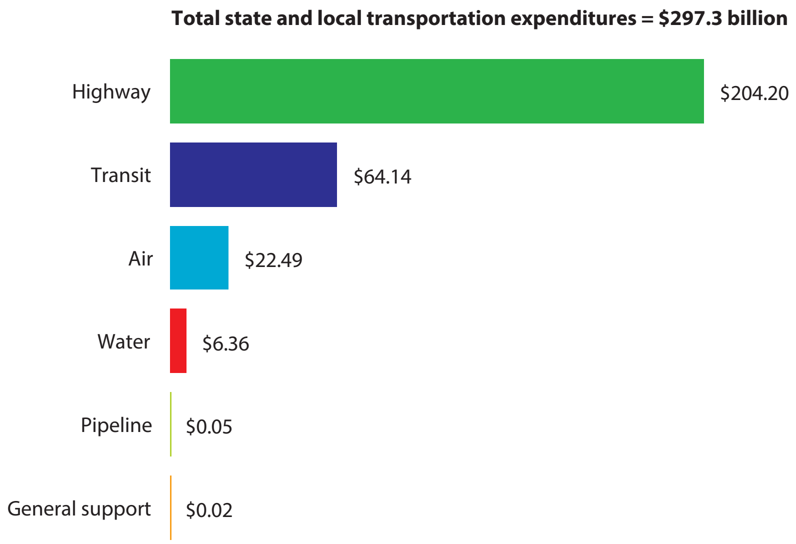
FIGURE 5-16 Federal Transportation Expenditures by Mode, 2015 (billions of 2015 dollars)



NOTE: Federal expenditure includes direct federal spending, excluding grants to state and local governments.

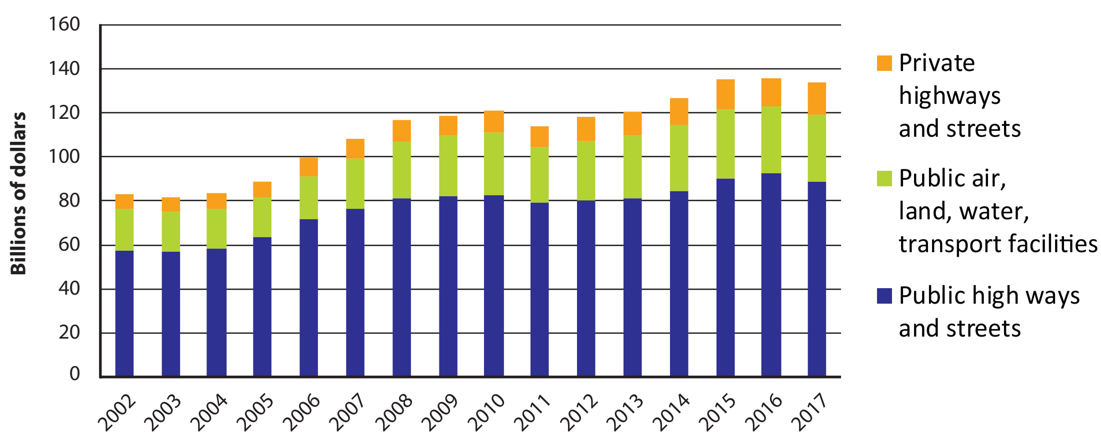
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at www.bts.gov as of January 2019.

FIGURE 5-17 State and Local Expenditures by Mode, 2015 (billions of 2015 dollars)



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at www.bts.gov as of January 2019.

FIGURE 5-18 Value of Transportation Construction Put in Place, 2002–2017 (billions of current dollars)



SOURCE: U.S. Department of Commerce, Census Bureau, Value of Construction Put in Place, Not Seasonally Adjusted (2002–2016), available at http://www.census.gov/ as of July 2018.

public sector generally funds transportation infrastructure construction, especially for streets and highways. In 2017 public transportation construction accounted for 89.0 percent of that amount ($119.3 billion), and private transportation construction accounted for the remaining 11.0 percent ($14.8 billion). Highway and street construction accounted for 74.5 percent of public spending on transportation construction ($88.9 billion), and construction for air, land, and water transportation facilities accounted for the remaining 24.5 percent ($30.4 billion). Although the amount and composition of construction varies from year to year, the value of new transportation construction and improvements put in place has increased an average of 3.3 percent per year since 2002, dropping slightly in 2011 when transportation stimulus funding from the American Recovery and Reinvestment Act (ARRA) of 2009 ended [USDOC CENSUS 2018].

Revenue

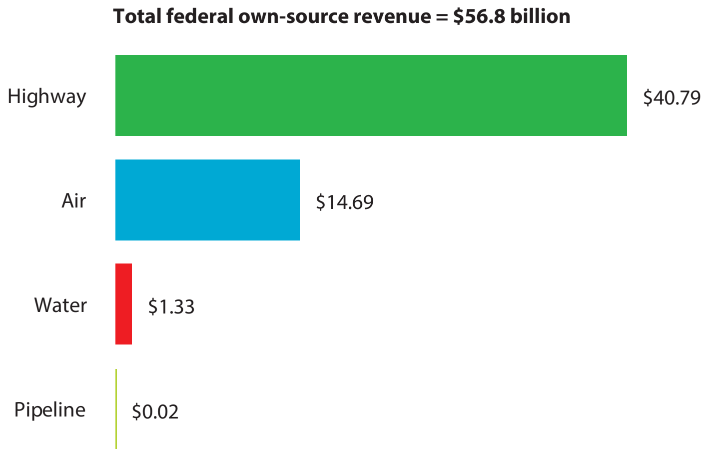
Government transportation revenue comes from user taxes and fees, such as gasoline taxes and tolls, air ticket taxes, and general revenues, as well as income from investing transportation funds and receipts from fines and penalties. In 2015 government revenue collected and dedicated to transportation programs totaled $337.8 billion (in 2015 dollars). Over half of the revenue ($194.3 billion, or 57.5 percent) came from taxes and charges levied on transportation-related activities. The remaining $143.5 billion (42.5 percent) came from non-transportation-related activities that support transportation programs, such as state or local sales or property taxes used to finance transportation projects. In inflation-adjusted dollars, total revenue collected by the government and dedicated to transportation programs increased by 10.0 percent, from $299 billion in 2007 to $329 billion in 2015 [USDOT BTS 2018c].

Highway and aviation, which have trust funds supported by dedicated taxes, accounted for 97.6 percent of the $56.8 billion in federal transportation revenue in 2015. The Federal Government collected $40.8 billion (71.8 percent) in highway revenues and $14.7 billion (25.9 percent) in aviation revenues, as well as $1.3 billion (2.3 percent) in water transportation revenues and $0.02 billion (0.04 percent) in pipeline revenues (figure 5-19). In real 2012 dollars, Highway Trust Fund revenues decreased by 14.3 percent from 2007 to 2015 [USDOT BTS 2018c]. Real revenues have declined in part because the Federal Government has not increased the federal taxes for gasoline and diesel—18.4 cents per gallon for gasoline and 24.4 cents per gallon for diesel—since October 1997. Revenues also declined because vehicle gas mileage improved by 13.8 percent from 2007 to 2014 for new passenger cars and because vehicle-miles traveled declined by 2.7 percent from 2007 to 2011 due to the Great Recession. Highway revenues have remained stable since the recession.

State and local governments collected $241.9 billion of the $337.8 billion (71.6 percent) in government revenues. Of this revenue, the state and local governments collected $137.5 billion from transportation-related activities, of which:

- $93.0 billion, (67.6 percent of transportation revenue in 2015) came from

FIGURE 5-19 Federal Own-Source Revenue by Mode, 2015 (billions of 2015 dollars)



NOTE: Own-source refers to taxes and charges levied on transportation-related activities and used specifically for transportation purposes

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at www.bts.gov as of January 2019.

highway revenue sources, such as fuel taxes, motor vehicle taxes, and tolls;

- $19.8 billion (14.4 percent) came from transit revenue – almost entirely from fares; and
- $19.6 billion (14.3 percent) came from aviation-related revenue such as landing fees and terminal area rental (figure 5-20).

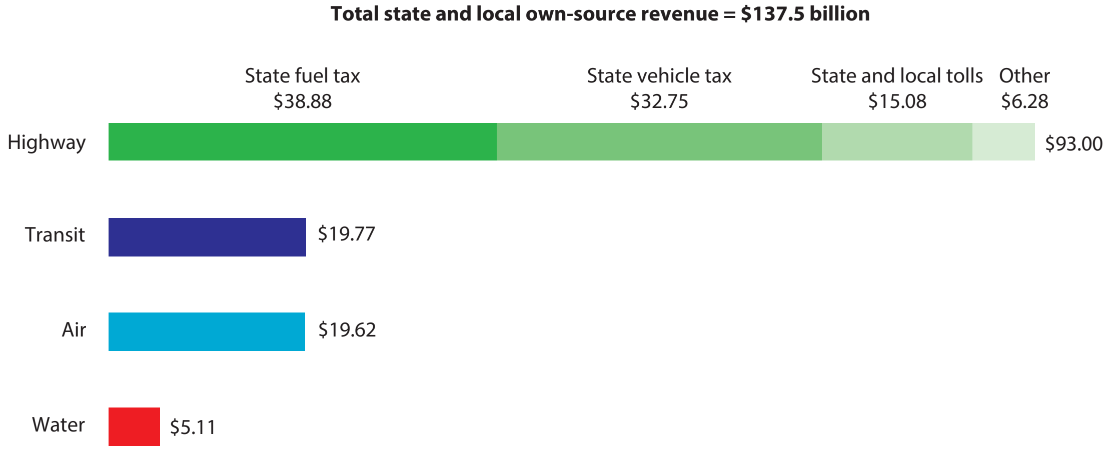
Transportation revenue includes the revenue collected from transportation activity (i.e., own source revenues) as well as supporting revenue from other sources like general funds. Own source transportation revenue continues to fall short of government transportation expenditures. In 2015 own source transportation revenues covered 59.0 percent of expenditures. When including supporting revenue, transportation revenue has exceeded expenditures since 2010 (figure 5-21).

Transportation Investment

Government, private sector, and households all invest in transportation assets. Transportation investment is defined as spending on transportation assets that take more than a year to consume. The investment may be in transportation infrastructure (referred to as structures in national data on investment) like highways and streets, which have a fixed location, or in transportation equipment like motor vehicles, aircraft, ships, and boats.

Transportation assets represent a small but important share of total public and private investment in the United States. In 2017 public and private investment in transportation infrastructure and equipment totaled $412.9 billion, or 14.1 percent of the $2,931.1 billion in investment in all infrastructure and equipment (figure 5-22). Public and private investment in new transportation infrastructure accounted for $128.6 billion (4.4 percent), and

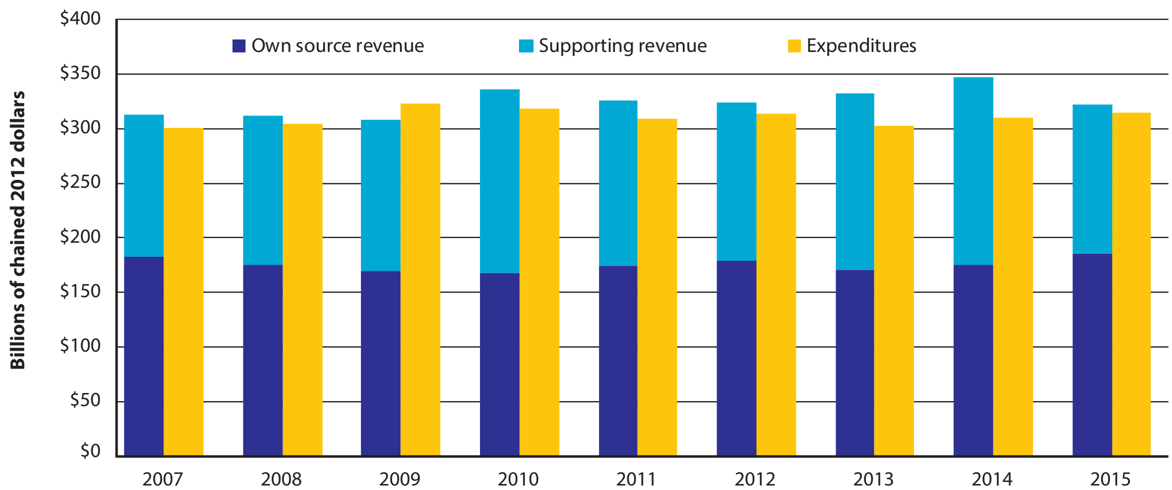
FIGURE 5-20 State and Local Own Source Revenue by Mode, 2015 (billions of 2015 dollars)



NOTE: Own-source refers to taxes and charges levied on transportation-related activities and used specifically for transportation purposes. Totals may not sum due to rounding.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at www.bts.gov as of January 2019.

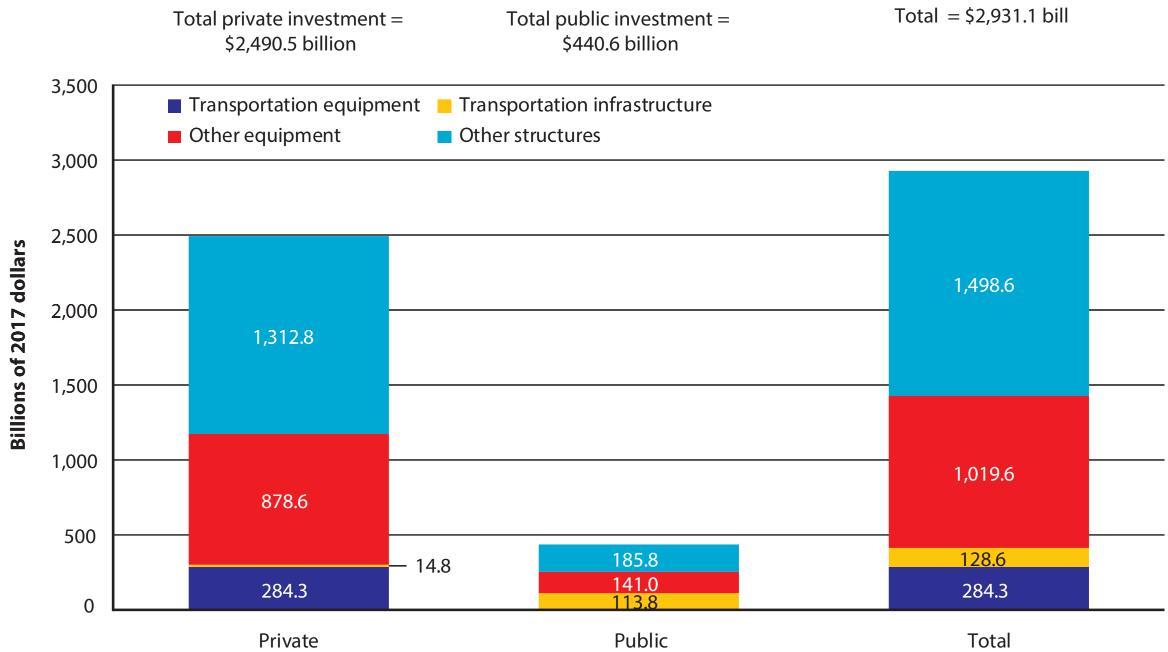
FIGURE 5-21 Government Transportation Revenue and Expenditures, 2007–2015 (billions of chained 2012 dollars)



NOTE: Revenue includes own-source revenue and supporting revenue. 2010 numbers revised.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at www.bts.gov as of January 2019.

FIGURE 5-22 Public and Private Fixed Investment, 2017 (billions of 2017 dollars)



NOTE: Intellectual property products such as software and research and development excluded from public investment total.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Account Tables, Private Fixed Investment in Structures by Type (Table 5.4.5 millions), Private Fixed Investment in Equipment by Type (Table 5.5.5 millions), and Gross Government Fixed Investment by Type (Table 5.9.5B millions), available at https://www.bea.gov/iTable/index_nipa.cfm as of August 2018.

private transportation equipment accounted for $284.3 billion (9.7 percent). Data for public investment in transportation equipment are not available.

Cost of Transportation

The *cost* to produce transportation services stems from the resources it requires—labor, equipment, fuel, and infrastructure. Firms purchase these resources to produce transportation services. For example, airlines pay for pilots, commercial jets, and jet fuel to provide air transportation services. The cost of the resources used by producers of transportation services influences the prices they charge businesses and households for transportation services.

Costs to Produce Transportation Services

The major inputs to produce transportation services include transportation equipment, fuel, labor, and other materials and supplies.

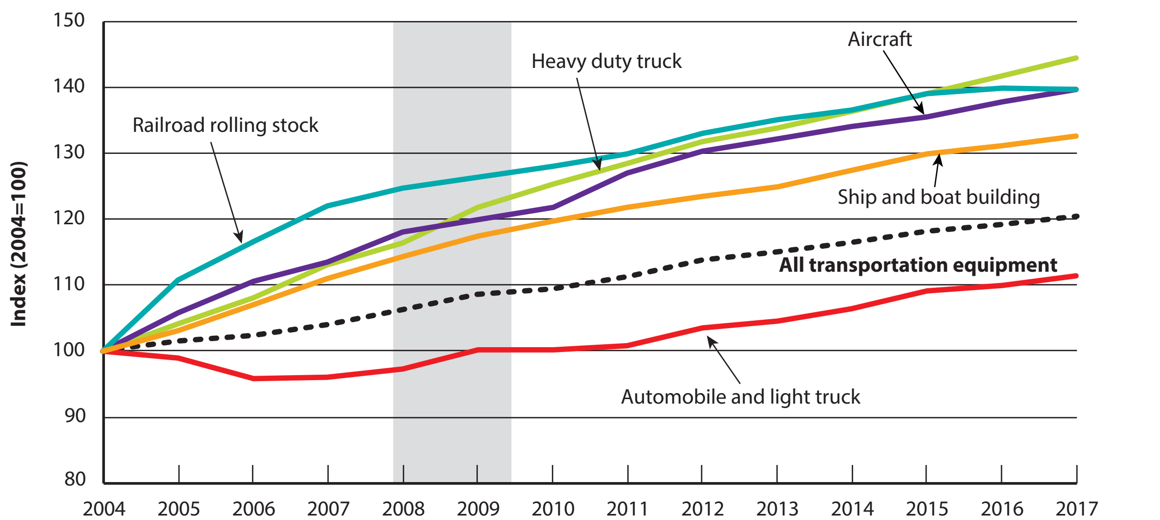
Different modes of transportation purchase and use different equipment, for example, airlines use aircraft to move people and goods while households primarily use motor vehicles to travel. The amount that firms receive for producing transportation equipment is an indicator of the prices faced by purchasers, for example, if the amount firms receive rises, the prices faced by purchasers will likely increase.

The amount received by producers of transportation equipment increased continuously between 2004 and 2017, except for automobiles and light-duty motor vehicles (figure 5-23). In contrast, the amount received by producers of automobiles and light-duty vehicles declined from 2004 to 2006, rose slightly in 2007 through 2009 (remaining below its 2004 level until 2009), leveled off in 2010, and finally increased in 2011 through 2017. The increase in equipment prices may have affected the profitability and purchase decisions of transportation sectors, the costs for transportation users, and prices along the economic supply chain in other sectors that use transportation services, such as wholesale, retail, and warehousing and storage industries.

Fuel prices also are a cost to industries that produce transportation services. These industries embed the costs in the price they charge businesses and households— in the transportation services they provide for a fee or for goods they produce with transportation services. Average annual fuel prices for all classes of transportation fuels, except aviation gasoline and railroad diesel fuel, peaked in 2012 and then declined to between their 2004 and 2005 level. Fuel prices for many modes show recent increases. The average annual fuel price for gasoline peaked at $3.64 in 2012, declined 41.2 percent to $2.14 in 2016 (figure 5-24), and then rose 12.4 percent (from the 2016 price) to $2.41 in 2017. The most recent data for aviation gasoline shows little change in price between 2012 and 2015, and railroad diesel fuel fell continuously from 2012 to 2016 (the most recent year for which data are available).

The cost of labor is an additional cost to produce transportation services. When faced with higher labor costs, companies often increase the price they charge for goods and services to offset the

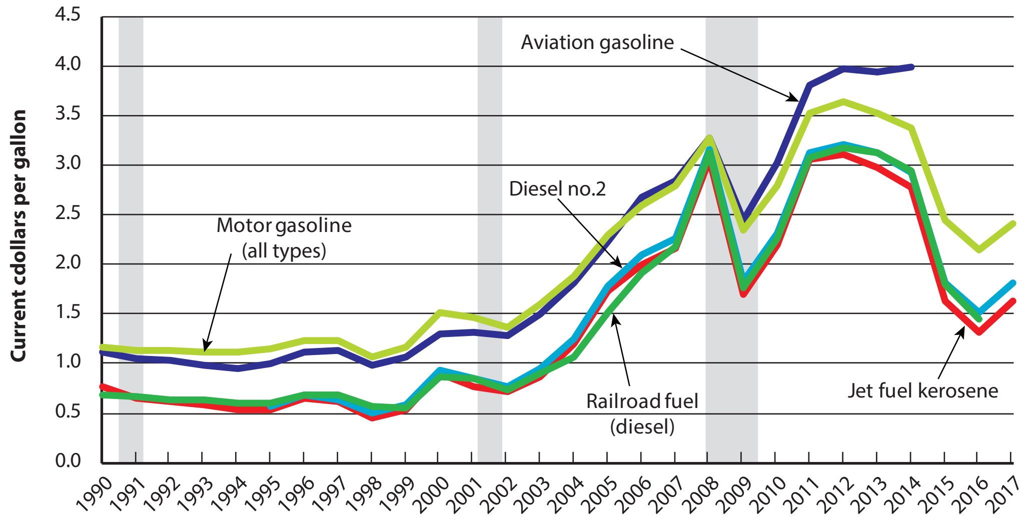
FIGURE 5-23 Average Change in Amount Received for Producing Transportation Equipment: 2004–2017



NOTES: Annual averages. Rebased to 2004. 2016 data are prelimary and subject to revision. Aircraft are civilian aircraft only. Shaded areas indicate U.S recessions, as defined by the National Bureau of Economic Research.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index Industry Data, available at http://www.bls.gov as of June 2018.

FIGURE 5-24 Sales Price of Transportation Fuel to End-Users (Dollars / gallon), 1990–2017



NOTES: Aviation gasoline data through 2014 and railroad fuel data through 2015. Shaded areas indicate U.S recessions, as defined by the National Bureau of Economic Research.

SOURCES: All data except railroad fuel: U.S. Department of Energy, Energy Information Administration, Monthly Energy Review (Washington, DC: April 2016), tables 9.4 and 9.7, available at http://www.eia.doe.gov/emeu/mer/prices.html as of June 2018. **Railroad fuel**: Association of American Railroads, Railroad Facts (Washington, DC: Annual Issues), p. 61.

decline in profit from paying more for labor. Recent data show an increase in the cost of labor, as shown in the Employment Cost Index (ECI).[12] The ECI shows that compensation costs for all civilian workers grew 2.6 percent from 2016 to 2017— more than in all years following the Great Recession (figure 5-25). Wages and salaries (which make up about 70 percent of compensation costs[13]) contributed to this growth, rising more in 2017 than in all years following the Great Recession. Data for the first and second quarter of 2018 show growth marginally higher than growth in the first two quarters in 2017. Private surveys suggest higher labor costs reduced profits of some U.S. companies— those unable to increase their prices to offset the higher cost of labor [Chemtob 2018].

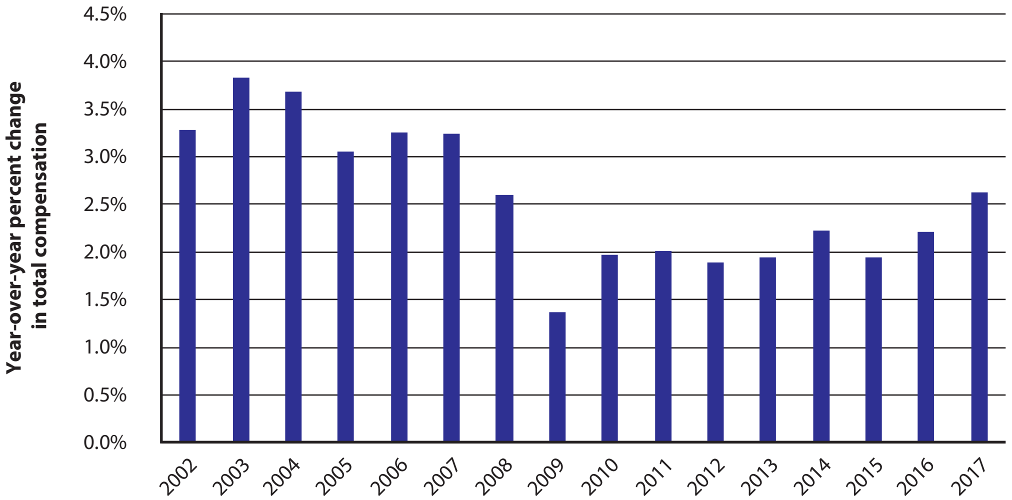
Prices Faced by Businesses Purchasing Transportation Services

The amount received by producers for selling their transportation services, for example, airfare, are an indicator of the prices faced by households and businesses for purchasing transportation services. Despite periods of modest decline, the amount received for producing transportation services rose between 2004 and 2017 (figure 5-26). During that

[12] The ECI measures the change in the cost of labor, free from the influence of employment shifts among occupations and industries.

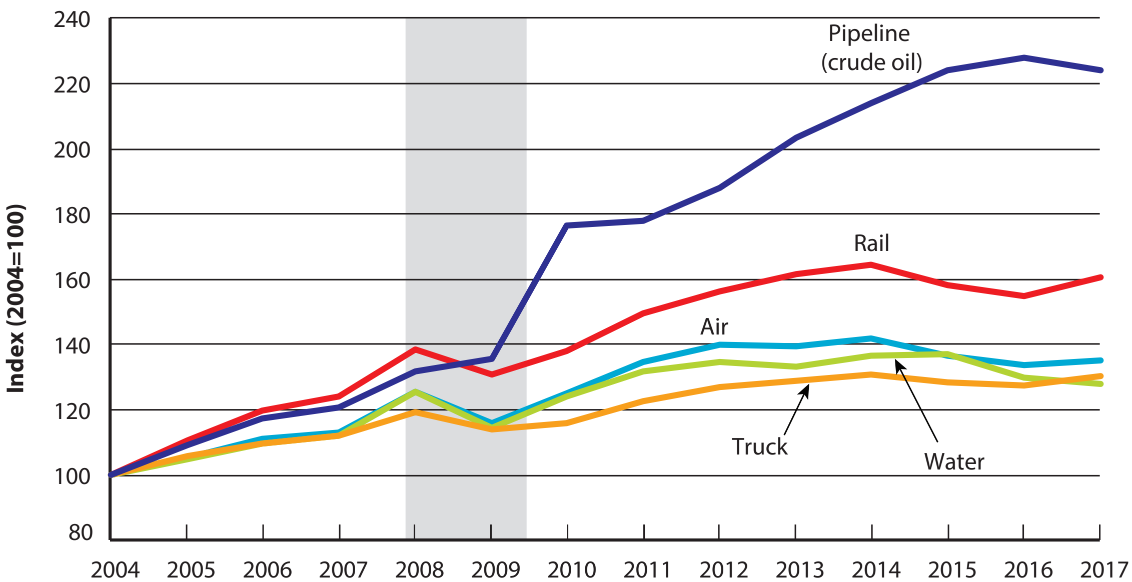
[13] See U.S. Department of Labor, Bureau of Labor Statistics, News Release USDL-18-1238, Employment Cost Index – June 2018, available at https://www.bls.gov/news.release/pdf/eci.pdf as of August 2018.

FIGURE 5-25 Year-Over-Year Percent Change in Total Employee Compensation (All Civilian Workers)



SOURCE: U.S. Bureau of Labor Statistics, Employment Cost Index: Total compensation: All Civilian [ECIALLCIV], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/ECIALLCIV, August 23, 2018.

FIGURE 5-26 Average Change in Amount to Produce Transportation Services: 2004–2017



NOTE: Annual averages. Rebased to 2004. Shaded areas indicate U.S recessions, as defined by the National Bureau of Economic Research.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index Industry Data, available at http://www.bls.gov as of June 2018.

time the amount received for producing rail transportation services grew more rapidly than any other transportation mode, at 60.4 percent, except pipeline, which grew 124.0 percent.

Prices Faced by Households

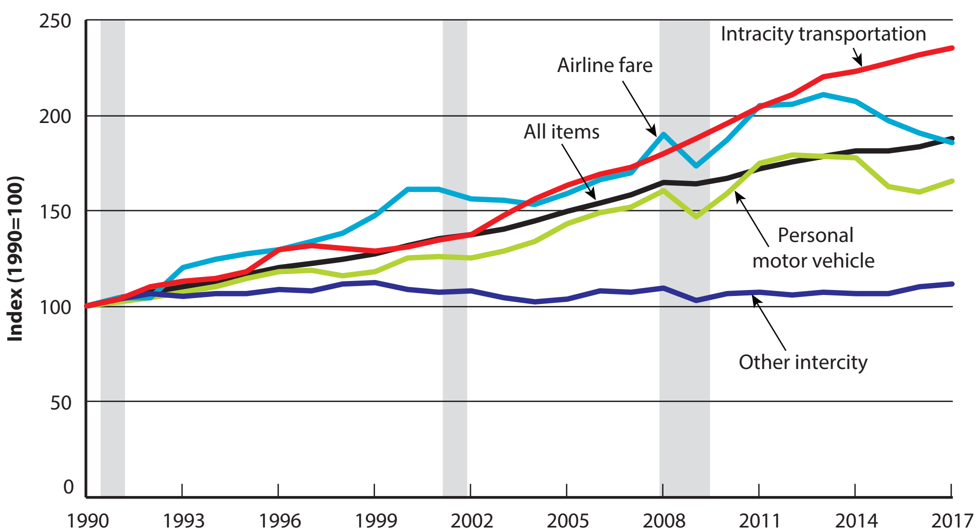
Households pay for travel in two ways. First, they pay to own and operate vehicles for their own use. Second, they pay fares to use for-hire passenger transportation services (e.g., air, transit bus, and rail services) for their travel.

According to the Consumer Price Index for Urban Consumers (CPI-U), the average price of owning and operating a personal motor vehicle grew less (at 65.5 percent) than public transportation (at 84.5 percent) between 1990 and 2017 [USDOL BLS 2018a].[14] The prices for public transportation rose more than the average price for all items. Intracity transportation[15] prices, which rose 135.4 percent, drove the growth in the overall price for public transportation between 1990 and 2017. Airfare contributed to the growth in public transportation prices from 1990 to 2013. It has since declined, while intracity transportation prices continued to rise (figure 5-27).

[14] The Consumer Price Index for Urban Consumers (CPI-U) measures the change in prices paid by urban consumers for particular goods and services, such as ones related to transportation.

[15] Intracity transportation includes intracity (local) mass transit (bus, street car, trolley, subway and commuter train), taxi fare, and car and vanpools. See BLS Handbook of Methods, Consumer Price Index, ch. 17, available at: https://www.bls.gov/opub/hom/pdf/homch17.pdf as of December 2018.

FIGURE 5-27 Average Changes to Transportation Prices Paid by Urban Consumers, 1990–2017 (index 1990 = 100)



NOTES: Annual averages. Rebased to 1990. Intracity transportation includes intracity (local) mass transit (bus, street car, trolley, subway and commuter train), taxi fare, and car and vanpools. Shaded areas indicate U.S recessions, as defined by the National Bureau of Economic Research.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index (CPI-U) Data, available at http://www.bls.gov as of July 2018.

Transportation as a Component of International Trade

Transportation and Trade

Transportation enables the export of American goods and services and connects U.S. businesses to sources of raw materials and consumers to imported goods. An efficient and reliable domestic transportation system with good connections to the international transportation system supports the United States in the global marketplace. Transportation not only enables international trade but also is a major good and service traded.

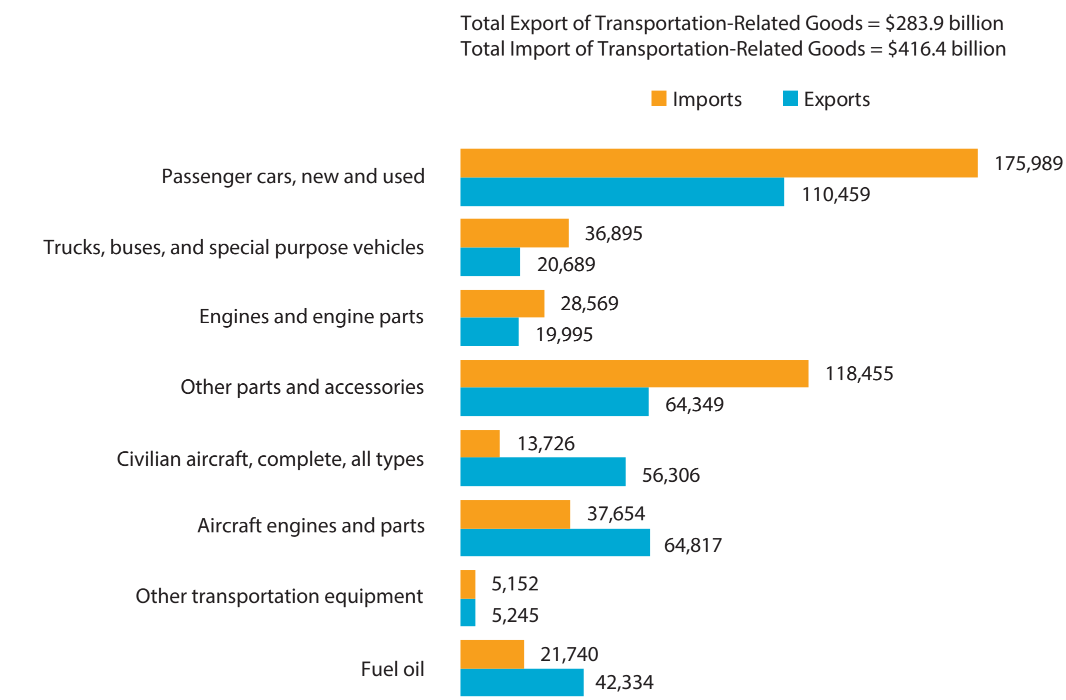
In 2017, 17.9 percent ($700.4 billion) of the $3.9 trillion goods traded internationally were related directly to transportation.[16] Fuel oil comprised an additional 1.6 percent of all goods traded in 2017 [USDOC BEA 2018c]. Across all goods traded related to transportation, new and used passenger cars accounted for the largest share. In 2017 imports of transportation-related goods exceeded exports except for civilian aircraft, aircraft engines and parts, and fuel oil (figure 5-28).[17]

Transportation services are used to move goods from and to the United States. In 2017, $187.8

[16] Includes automotive vehicles, parts, and engines; civilian aircraft, engines, and parts; and other transportation equipment.

[17] Fuel oil is a petroleum product used, for example in engines.

FIGURE 5-28 U.S. Trade of Transportation-related Goods, 2017 (millions of 2017 dollars)



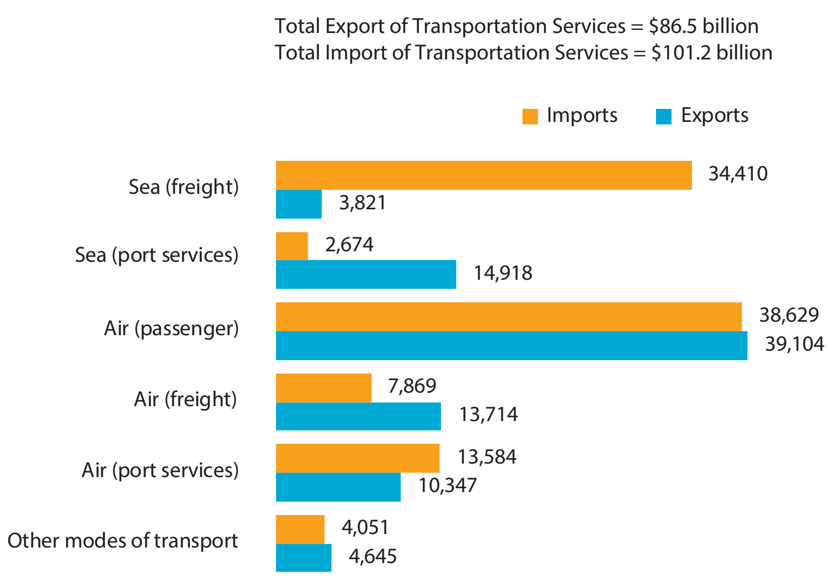
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, International Transactions (ITA), Table 2.1 U.S. International Trade in Goods. Interactive, Annual. Available at http://www.bea.gov/itable/ as of May 2018.

billion (14.2 percent) of all services traded were related directly to transportation [USDOC BEA 2018d]. The value of transportation services traded capture the following:

1. passenger fares paid by U.S. residents to foreign airline carriers and foreign vessel operators as well as the passengers fares paid by foreign residents to U.S. airline carriers and U.S. vessel operators,
2. the freight charges for moving goods from and to the United States, and
3. the expenses that transportation companies incur in foreign ports (i.e., goods and services procured by foreign carriers in U.S. ports and by U.S. carriers in foreign ports) [USDOC BEA 2018e]

The fares and fees received by U.S. carriers to move goods and people to foreign countries exceeds the fares and fees received by foreign carriers bringing goods and people to the United States. Air passenger transportation accounted for the largest share of the total fares and fees paid to move goods and people to and from the United States, followed by sea freight transportation. For all modes except sea freight transportation, the fares and fees paid to move goods and people to foreign countries nearly equaled the fares and fees received by foreign carriers bringing goods and people to the United States. For goods moved by sea, the fares and fees received by foreign-operated vessels to bring goods to the United States exceeded the fares and fees paid to move goods to foreign countries (figure 5-29).

FIGURE 5-29 U.S. Trade of Transportation Services, 2017 (millions of 2017 dollars)



NOTE: Port services are the expenses that transportation companies incur in foreign ports (i.e., goods and services procured by foreign carriers in U.S. ports and by U.S. carriers in foreign ports), excluding purchases of fuel which are counted in the goods exports and imports account.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, International Transactions (ITA), Table 3.1 U.S. International Trade in Services. Interactive, Annual. Available at http://www.bea.gov/itable/ as of May 2018.

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CHAPTER 6

Transportation Safety

Highlights

- Transportation-related accidents claimed 39,032 lives in 2017, and 37,133 of those deaths were due to highway crashes. 2017 experienced a 16 percent increase in deaths among occupants of large trucks.

- In 2017, 2,093 died from aviation, boating, railroad (including transit rail), and other nonhighway modes. This was about one-fourth fewer fatalities than in 2000. 2017 was the fourth year in a row with no fatalities on U.S. air carriers, although 330 died in general aviation crashes—the fewest fatalities since at least 1970.

- Highway fatalities remain the second largest cause of unintentional injury death in the United States, but dropped from 7th to 13th place on the list of causes of death in the United States between 2000 and 2016.

- The fatality rate on rural highways is 2.5 times higher than in urban areas. Still, the number of fatalities decreased 18 percent on rural highways while increasing 17.4 percent on urban roads during the 2008–2017 period.

- An increase in motorcyclist and pedestrian fatalities contributed to the increase in highway fatalities. Some 27 percent of motorcycle operators in fatal crashes were alcohol-impaired, the highest share among highway motor vehicle drivers.

- People outside vehicles—nonoccupants like pedestrians, bicyclists, and bystanders—comprise most fatalities in train accidents in most years and also account for a rapidly growing share of motor vehicle-related deaths—up from one-fifth in 1996 to one-third in 2017.

- Alcohol-impairment perennially ranks among the top factors contributing to motor vehicle fatalities and recreational boating fatalities. There were nearly 11,000 alcohol-related highway crashes in 2017, down from about 13,000 in 2000.

- Speeding coupled with drinking are often common factors in highway crashes. Some 37 percent of speeding drivers in fatal crashes were found to have been drinking compared to 15 percent among nonspeeding drivers in fatal crashes.

- Drivers under the age of 30 are disproportionately represented in distraction crashes, especially drivers aged 15 to 19 years.

- Nearly 20,500 lives were saved on the highways in 2017 by occupant protection devices, including seat belts, frontal air bags, child restraints, and motorcycle helmets—an increase of 3,500 from about 17,000 in 2010.

Even with growth in the U.S. population, more system users, and increased activity in all modes of transportation, there were about 5,200 fewer fatalities in all transportation modes in 2017 than in 2000—39,032 v. 44,276 (table 6-1). While total transportation fatalities have remained under 40,000 since 2008, they rose in the 2011–2017 period, chiefly due to a rise in highway fatalities [USDOT BTS NTS].

Transportation is safer today than 50, 30, or even 20 years ago by almost any measure—fatalities, injuries, or rates of fatalities and injuries. Recently, however, total transportation-related fatalities have increased compared to totals of just a few years ago. And the toll on human life and well-being remains high. Transportation accounted for about one-fourth (24.9 percent) of the total U.S. deaths from unintentional injury in 2016 [USDHHS CDC VITALITY] and millions of injuries.

This chapter discusses recent fatality and injury trends for all modes of transportation and examines potential factors contributing to crashes and accidents. It also examines the progress that has been made to improve safety.

TABLE 6-1 Transportation Fatalities by Mode: Selected Years

	2000	2010	2015	2016	2017	Change from 2016
TOTAL fatalities*	**44,276**	**35,040**	**37,372**	**39,751**	**39,032**	↓
Air	764	477	406	413	346	↓
Highway	41,945	32,999	35,484	37,806	37,133	↓
Railroad[1]	631	599	621	630	684	↑
Transit rail[2]	197	122	150	149	143	↓
Water	701	821	700	737	706	↓
Pipeline	38	22	11	16	20	↑
Other counts, redundant with above						
Railroad, trespasser deaths not at highway-rail crossing	463	441	449	465	535	↑
Railroad, killed at public crossing with motor vehicle	306	136	128	130	140	↑
Rail, passenger operations	220	215	249	253	304	↑
Rail, freight operations	717	520	500	507	520	↑
Transit, non-rail	98	100	104	108	98	↓

[1]Includes Amtrak. Fatalities include those resulting from train accidents, highway-rail crossing incidents, and other incidents.

[2]Includes transit employee, contract worker, passenger, revenue facility occupant, and other fatalities for all modes reported in the National Transit Database. Transit fatality data for 2000 is not comparable with later years due to a change in the reporting system. A change in reporting requirements led to increases after 2008.

NOTES: **Other counts, redundant with** above help eliminate double counting in the Total fatalities. See NTS table 2-1 in source below for adjustments to avoid double counting, complete source notes and an expanded time-series.

SOURCES: **2000, 2010, 2016**: Various sources as cited by U.S. Department of Transportation, Bureau of Transportation, National Transportation Statistics, table 2-1, available at www.bts.gov as of November 2018. **2017**: Preliminary or revised data from the same sources cited in NTS, table 2-1.

Fatalities by Mode

Highway Motor Vehicles

People in the United States took over 220 billion vehicle trips in 2017 (about 2.8 trips per person per day) [USDOT FHWA NHTS][1] and were involved in 7.3 million highway vehicle crashes and accidents of all levels of severity [USDOT NHTSA 2018b]. These crashes and accidents ranged from minor fender benders to fatal crashes. However, most (about 5 million) were property-only crashes involving no injury. About 2.3 million crashes resulted in one or more nonfatal injuries, while 34,439 resulted in one or more deaths. The injury crashes resulted in 3.1 million nonfatal injuries, of which 221,000 were estimated to be incapacitating. Some 37,133 people died from their injuries within 30 days of the fatal crash.[2] The overall cost of these crashes nationally has not been comprehensively examined since 2010, when the costs were estimated to be $836 billion, of which 29 percent were economic costs and 71 percent represented lost quality of life.

Highway fatalities account for nearly 95 percent of all transportation fatalities and highway injuries and over 99 percent of transportation injuries. There has been a major decrease in both the number and rate of highway fatalities over the last half century—with deaths per hundred million miles of highway vehicle travel falling from 5.50 in 1966 to a low of 1.08 in 2014, followed by increases in 2015 through 2017 to 1.16. The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) notes that the 2014 rate was the lowest since the agency began collecting fatality data through the Fatality Analysis Reporting System in 1975.

The most recent low point in the number of highway fatalities was 2011, when there were 32,479 deaths, the lowest number since 1949 [USDOT NHTSA 2018a]. Fatalities then increased by about 5,000 in the next 5 years, before falling a bit in 2017 to 37,133 [USDOT NHTSA 2018a and b].

Over time, occupant protection devices, advances in vehicle design, improved road design, graduated driver licensing for teenagers, safety campaigns, enforcement of drunk-driving laws, and many other preventative measures contributed to declines in highway vehicles deaths and injuries [KAHANE, MASTEN]. Advancements in emergency medical response capabilities and treatment also played important roles.

Overall, motor vehicle fatalities have fallen from the 7th highest cause of death in 2000 to 13th in 2016 [USDHHS CDC VITALITY]. However, motor vehicle fatalities remain the number one cause of death for people aged 8 to 24, and are the second leading cause of unintentional injury deaths for all ages [USDOT NHTSA 2018c].

Some other countries of comparable economic status to the United States have shown greater reductions in highway fatalities, both on a per

[1] The 2017 the National Highway Safety Administration (NHTSA) found that 82.6 percent of all person trips were taken in a vehicle; this amounts to 2.8 vehicle trips out of 3.4 daily trips per capita.

[2] NHTSA counts people dying at the scene, or within 30 days of a crash, as fatalities. The number of fatalities are taken directly from police accident reports. The numbers of crashes and injuries are estimated from a sample of police accident reports and are subject to more uncertainty.

capita basis and in absolute numbers. The 28 countries of the European Union reduced their road fatalities by 57 percent between 1996 and 2016, from about 60,000 to under 26,000, and by 20 percent since 2010 [EU]. The comparable U.S. data indicate that fatalities are down 11 percent since 1996, but have risen since 2010. It is not clear why there would be such differences, but societal commitment to safety, cultural norms, geography, highway infrastructure, and enforcement policies could be possible factors.

When analyzing highway safety, it is useful to identify two categories of people: vehicle occupants (including motorcycle riders) and nonoccupants— those outside the vehicle(s) when the crash occurs. Since 2000 occupant fatalities have declined by nearly 7,000, from 36,348 in 2000 to 29,564 in 2017. A conspicuous exception is motorcycle rider fatalities, which rose by 2,300 since 2000, reaching 5,172 in 2017. This was in part due to increased ridership as well as the increasing age of riders and reduced helmet usage. The number of motorcyclist fatalities per vehicle-mile of travel was 28 times greater than that for passenger car occupants in 2016 [USDOT NHTSA 2018a]. A recent travel survey estimated that the average age of motorcycle riders has increased from 46 in 2009 to 49 in 2017 [USDOT FHWA NHTS].

There also has been a recent increase in large-truck occupant fatalities, as well as other people killed in crashes involving large trucks. Large-truck occupant fatalities increased in 2015, 2016, and 2017, when there were 841 fatalities—the highest number since 1989. The number of other people killed in large truck crashes rose from 3,352 in 2014 to 3,920 in 2017—the most since 2007 [USDOT NHTSA 2018a and 2018b]. While large truck crashes comprised 3.9 percent of total highway crashes in 2016, large trucks accounted for 9 percent of highway vehicle-miles of travel (vmt) [FMCSA 2018a].

Since 2000 nonoccupant fatalities—pedestrians, bicyclists, and bystanders struck by motor vehicles—have risen sharply. Nonoccupant deaths increased by 1,500 between 2000 and 2016, when 7,193 nonoccupants died, before declining to 6,988 in 2017. More than 6,760 pedestrians and bicyclists died in highway accidents in 2017. Pedestrians and bicyclists—who often share the roads with motor vehicles—accounted for 17.2 percent of total transportation-related deaths in 2016, compared to 12.4 percent in 2000. Despite the recent rise, pedestrian deaths are below the highpoint of about 8,000 in 1980 [as cited in USDOT BTS NTS Table 2-1].

About 2,125 additional deaths were attributable to out-of-traffic motor vehicle mishaps (e.g., in driveways or parking ramps) in 2015, according to NHTSA (box 6-A). While not all states report this data, the total toll of motor vehicle related fatalities on and off traffic ways in 2015 was 37,609, compared to 35,484 on public roadways.

About 19 percent of the U.S. population lives in rural areas where about 30 percent of vehicle-miles traveled (vmt) occurs. However, a disproportionate share of fatal traffic crashes occur in these rural areas, resulting in 47.5 percent of all traffic fatalities in 2017. The rural fatality rate per 100 million vmt is 2.5

Box 6-A Motor Vehicle Mishaps Off Public Roadways

Many people die or are injured each year in motor vehicle crashes or mishaps that do not happen on public roadways. Examples include people struck in driveways, collisions with another vehicle or a structure in a parking lot, bicyclists struck on a private roadway, and people unintentionally asphyxiated by carbon monoxide gas by running a motor vehicle in their garage. These fatalities are not usually tallied in annual highway fatality/injury data issued by the National Highway Traffic Safety Administration (NHTSA). However, since 2007, NHTSA has been collecting this data, most recently published for data year 2015 [USDOT NHTSA 2018d]. However, not all states report this data to NHTSA. Based upon the reported data, the number of these deaths and injuries are sizable. In 2015, according to NHTSA:

- 2,125 people died in such incidents, of whom 827 were pedestrians and other nonoccupants, and 1,289 were vehicle occupants. Some 88 toddlers (aged 1 to 3) died, more than those killed by influenza or pneumonia (76). These incidents were also the ninth leading cause of all deaths for children and young adults between the age of 4 and 24 [NHTSA 2018c].
- 95,000 people were injured in these events, with 29,000 of the injured being nonoccupants and 66,000 occupants [USDOT NHTSA 2018d].

Far less is known about these nontraffic incidents than what is known about traffic crashes.

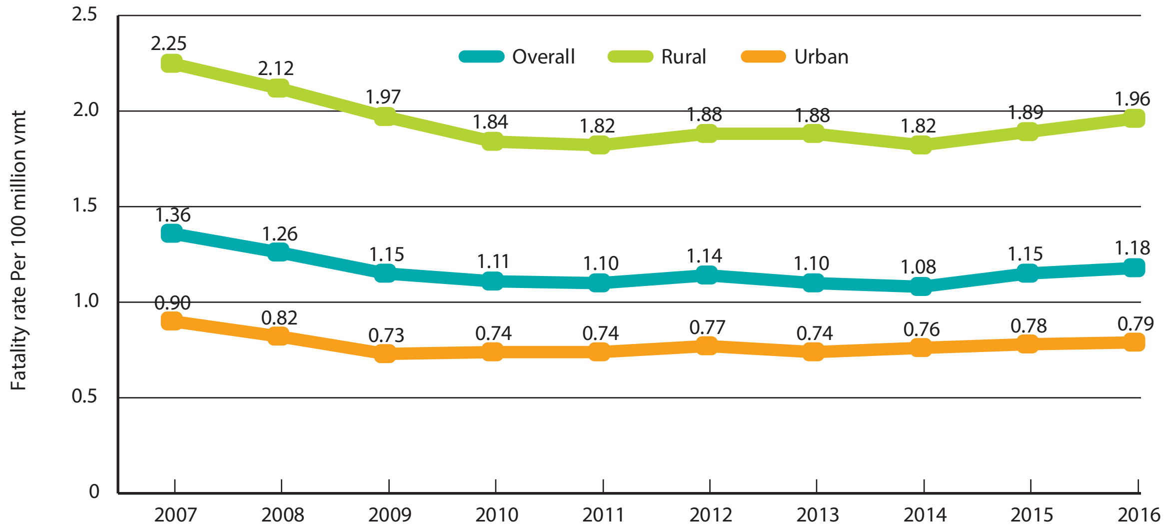
times higher than the urban area rate (1.96 v. 0.79 fatalities, respectively) (figure 6-1).

One contrast between urban and rural areas is in emergency medical response time: In fatal crashes in rural areas, 37.4 percent of crash victims do not arrive at a hospital for 1 to 2 hours from the time of the crash; in urban areas the figure is 9.7 percent [USDOT NHTSA 2018a]. Still, the number of fatalities has been increasing in urban areas while decreasing in rural areas (figure 6-2). Rural fatalities decreased by 18.0 percent between 2008 and 2017, while urban fatalities increased by 17.4 percent during this 10-year period [USDOT NHTSA 2018e].

The number of highway fatalities varies greatly by sex and age. While there are about 5 million more females than males in the United States, males accounted for over 70 percent of highway fatalities in 2016. About 2.5 males died in highway crashes to every female in 2016—26,773 males v. 10,988 females. Part of this difference arises because males, on average, drive about 27 percent more miles than females and thus have a higher exposure rate to crashes. Data from the 2017 National Household Travel Survey (NHTS) show that males drove about 22.2 miles per day, while females drove about 16.1 miles per day. Also, males comprise the overwhelming percentages of the 3 categories of road users for whom fatality numbers have risen between 2011 and 2016: 70 percent of pedestrian fatalities, 84 percent of bicycle deaths, and 91 percent of motorcycle deaths.

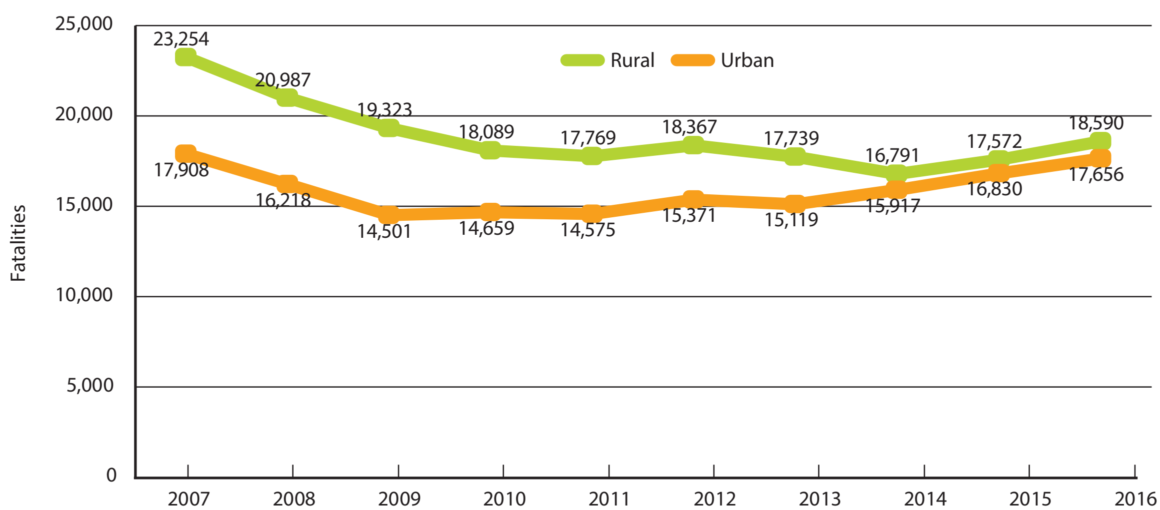
Teenagers and young adults had the highest highway fatality rates per 100,000 residents in 2017, although their deaths and death rates have declined since 2000 (figure 6-3). Since 2012

FIGURE 6-1 Fatality Rates per 100 Million Vehicle Miles Traveled (VMT), by Year and Location, 2007–2016



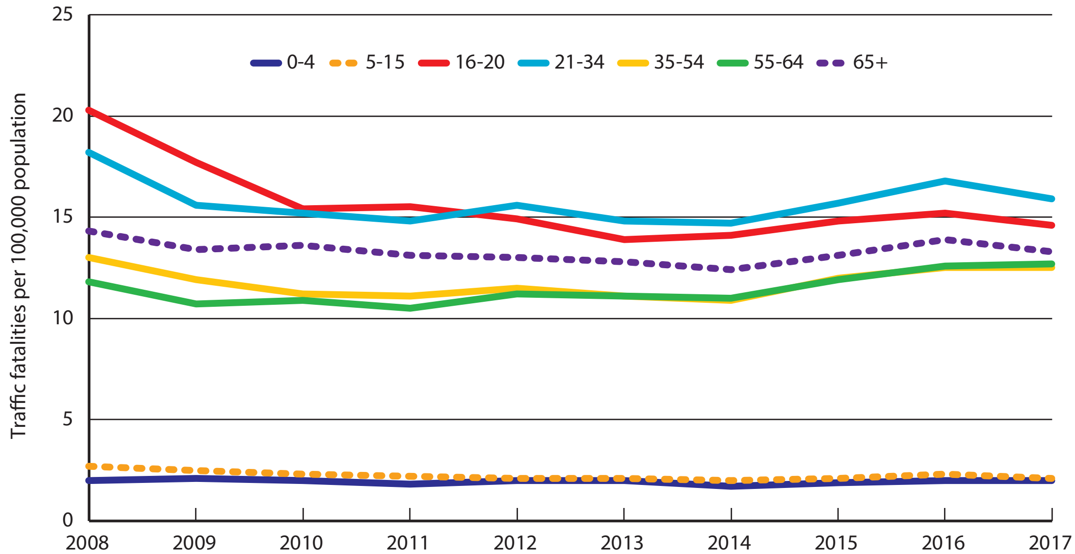
SOURCE: U.S. Department of Transportation National Highway Traffic Safety Administration Rural/Urban Comparison of Traffic Fatalities. April 2018. DOT HS 812 521. Available at http:// www.nhtsa.gov/ as of June 2018.

FIGURE 6-2 Motor Vehicle Traffic Fatalities, by Year and Location, 2007–2016



SOURCE: U.S. Department of Transportation National Highway Traffic Safety Administration Rural/Urban Comparison of Traffic Fatalities. April 2018. DOT HS 812 521. Available at http://www.nhtsa.gov/ as of June 2018.

FIGURE 6-3 Motor Vehicle Traffic Fatality Rates by Age Group–2008-2017



SOURCE: U.S. Department of Transportation. NHTSA. *Older Population*. DOT HS 812 500, May 2018

adults aged 21 to 34 have had a higher fatality rate than teenagers. A potential contributing factor for the overall decline is that younger people drove fewer miles than their counterparts in 2000, reducing their exposure to highway crashes. Average daily vehicle-miles of travel for people aged 16 to 24 in 2001 was 22.4 miles, but by 2017 it had decreased to 14.9 miles. For people aged 25 to 34, average vmt in 2001 was 32.8 miles, but by 2017 it had decreased to 26 miles [USDOT FHWA STT 2017].

Non-highway Transportation Modes

Overall, the non-highway transportation modes—aviation (including both commercial air carriers and general aviation), railroads, transit, and water (especially recreational boating)—show improved safety records over time (table 6-1). In 2017 some 1,899 people died in accidents involving these non-highway modes—compared to 2,331 in 2000, or a reduction of about 19 percent. The pace of improvement is most pronounced in air and rail, however.

Aviation

Aviation shows a greatly improved safety record over time. U.S. air carriers had zero fatalities in 2015 and 2016 for both scheduled and nonscheduled (e.g., chartered) services. In fact, in 4 of the last 10 years—2008 to 2017—there were no fatalities recorded for flights by U.S. air carriers. The last fatal crash of a major commercial airline in the United States was in 2013, when an international flight operated by a foreign carrier crashed at San Francisco International Airport, resulting in three deaths and many injuries.

General aviation (GA) has shown a notable reduction in the number of fatal accidents—from over 400 per year in the early 1990s to fewer than 250 a year between 2010 and 2017. According to preliminary estimates, the GA fatal accident rate for fiscal year 2017 (Oct. 1, 2016 through Sept. 30, 2017) was 0.84 per 100,000 flight hours—an improvement over each of the previous 5 years [USDOT FAA 2018a].

The number of fatalities has declined but less than the fatal accident rate since GA planes can have one or many occupants. In 2017, 330 people died in GA accidents, down from 386 people in 2016. GA fatalities have dropped appreciably from previous decades, and the 2017 fatality number is the lowest since at least 1970 [USDOT BTS NTS]. More than twice as many people died in GA accidents each year between 1990 and 1999—an annual average of 716 persons—as in 2017. This was followed by a drop to an annual average of 567 deaths from 2000 to 2009. The annual average for the 2010–2016 period was 417 fatalities [as cited in USDOT BTS NTS].

In addition to general aviation, fatalities also result each year from crashes involving air taxis and other commercial on-demand air services, and commuter planes with less than 10 seats. There were 16 fatalities from these services in 2017, below the annual average of 23 between 2010 and 2016. The safety trend in air taxi and similar services is improving, averaging 43 deaths per year between 2000 and 2009, compared to nearly 64 deaths annually between 1990 and 1999.

The popularity of unmanned aircraft systems (UAS) or “drones” poses several challenges for aviation safety (box 6-B). There are now more than one million UAS registrants in the United States, and there are increasing sightings of unauthorized drones from planes in the air and near airports. Information is currently too limited to determine the risks of collision with planes piloted by humans or damage on the ground to people or facilities.

Box 6-B UAS Drones and Aviation Safety

The Federal Aviation Administration announced that there were over one million registrations of small unmanned aerial systems (UAS), commonly called drones, in the United States at the beginning of 2018. The registrants include 878,000 hobbyists, allowed to fly all the drones they own under one registration number, and 122,000 individual drone registrations by commercial, public, and other parties [USDOT FAA 2018b].

According to the U.S. General Accountability Office (GAO), there were 6,117 reports of potentially unsafe operation of drones through April 2018. The reports mostly come from pilots of all aircraft types, including large, commercial passenger aircraft. However, it is not known how much risk the drones pose. Estimates of near-misses range from 4 to 36 percent in the reports of drones sighted from aircraft or other locations, with near-misses variously defined in the reports by the pilot or observer. There have been few confirmed reports of accidents—the most dramatic being a collision between a small UAS and a U.S. Army helicopter that resulted in minor damage to the helicopter and destruction of the drone [USGAO].

Better data is needed to determine how to safely integrate drone operations, which almost certainly will continue to increase rapidly into the national air space.

Railroad Operations[3]

In 2017, 824 people died in railroad-related accidents (table 6-1). The Federal Railroad Administration (FRA) attributes 304 of these deaths to passenger train operations and 520 deaths to freight train operations, which accounted for far more train-miles than passenger train-miles [USDOT FRA 2018]. Most deaths associated with train operations occur outside the train, such as people struck by trains while on track rights-of-way or people in cars struck at highway rail-grade crossings. Very few train passengers or crew members die in train accidents. In the 10 years between 2008 and 2017, 48 train passengers died in train accidents—less than 5 per year—but a total of 7,392 people died in railroad accidents or incidents, an average of 739 people per year [as cited in USDOT BTS NTS].[4]

Several hundred people die every year when struck by trains while on railroad property or rights-of-way. If they were unauthorized, they are classified trespassers. Trespassers accounted for 60.2 percent of the total railroad fatalities between 2008 and 2017, or 445 deaths per year on average. After reaching a low of 400 in 2011, trespasser deaths have since risen, reaching 513 in 2017—a few less than the average of 516 fatalities per year in the 1990s.

Highway-rail grade crossing fatalities averaged about 253 per year in the 2008–2017 period, or roughly one-third of the total railroad-related fatalities. In 2017 there were 271 deaths at grade crossings, roughly half the average of 550 deaths per year in the 1990s [USDOT BTS NTS].[5]

Suicide is the cause of many trespassing and grade crossing fatalities. According to FRA, there were 255 suicides in 2017—about 30.9 percent of all railroad fatalities. Another 40 people were injured in suicide attempts.

Transit[6]

There were 241 transit fatalities[7] in 2017, slightly below the 2010 to 2016 average of about 249 per year, according to data reported to the Federal Transit Administration (FTA) [USDOT FTA NTD].[8] Some 143 deaths involved transit rail, and 98 involved other transit vehicles, mainly bus. Like the railroad mode, most of the fatalities in transit-related accidents are not passengers or transit employees/contractors inside the transit vehicle. Onboard fatalities, 16 passengers and

[3] Data in this section are reported to the Federal Railroad Administration (FRA) as of July 3, 2018. Numbers may change as FRA receives additional or amended reports from railroads.

[4] Not counted here are passengers who died as a result of a non-train related events (e.g., health related deaths).

[5] Counts of highway-grade crossing fatalities are reported to both rail and highway agencies. In table 6-1, to avoid double-counting, these fatalities are included in the overall count for highways, but not for rail.

[6] In table 6-1 and figure 6-2, the number of transit passenger fatalities includes both passengers on the vehicle and those struck while waiting to get on or who have just gotten off the vehicle.

[7] Includes transit rail and non-rail modes (e.g., aerial tramway, motor bus, bus rapid transit, commuter bus, demand response, demand taxi, ferryboat, jitney, publico, trolleybus, and vanpool fatalities).

[8] Rail transit accounts for slightly more than half of the transit fatalities reported to the Federal Transit Administration (FTA) in table 6-1: however, commuter rail and Port Authority Trans Hudson (PATH) heavy rail safety data are counted in Federal Railroad Administration data, not FTA.

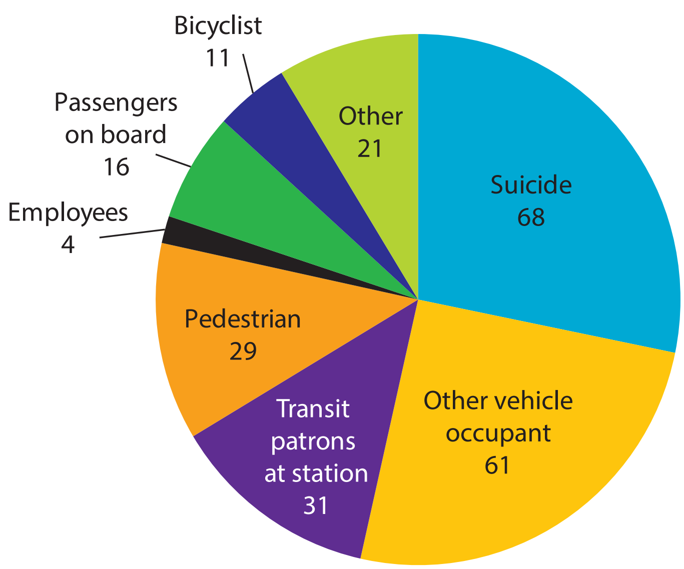
1 bus operator, together accounted for roughly 7 percent of the transit fatalities in 2017 (figure 6-4). In 2017, 68 (or 28.2 percent) of the transit fatalities were considered suicides, a slightly smaller percentage than railroads.

Water

Recreational boating accounts for most water transportation deaths, numbering 658 in 2017. This was down from 701 in 2016 but well above the historic low of 560 in 2013. One reason for the post-2013 increase may be that people have more disposable income from an improved economy to spend on leisure time activities, such as boating [NMMA]. Nearly all boating fatalities happen while the vessel was engaged in or transporting people to and from a recreational, fishing, or watersport activity [USCG 2018].

According to the U.S. Coast Guard (USCG), many boating fatalities occur on calm, protected waters; in light winds; or with good visibility. Alcohol use, operator distraction, or lack of training continues to play key roles in fatal recreational boating accidents. Where cause of death was known, about 76 percent of people who died in recreational boating incidents drowned, and 84.5 percent of these people were not wearing life jackets [USDHS USCG 2018]. While most of the deaths—454 in 2017—involved motorized boats, people in kayaks, canoes, rowboats, and other nonmotorized boats accounted for 31 percent of the fatalities.

FIGURE 6-4 Transit Fatalities by Category: 2017



NOTE: Pedestrian fatalities includes in crossings, not in crossings, and walking along track.

SOURCE: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, available at https://www.transit.dot.gov/ntd as of August 2018.

In terms of number of fatalities, recreational boating is becoming safer. In 1980 there were twice as many fatalities as in 2017—1,360 v. 658. Even with the post-2013 increase, boating fatalities are well below the 1990s average of about 800 per year [as cited in USDOT BTS NTS]. But in terms of fatality rates, it is not clear whether recreational boating is becoming safer, due in part to inadequate information. The U.S. Coast Guard uses an exposure measure based on the number of fatalities per 100,000 registered boats, but it is not known how many boats in use are unregistered. Nonmotorized boats account for over 30 percent of fatalities, but many states do not require them to be registered. The U.S. Coast Guard is seeking to develop an exposure measure based on the national number of operational boating hours, but this could take several years. It is likely that the number of nonfatal boating injuries is underestimated—in part because people may be unaware that they are supposed to report these incidents, or are unwilling to report.

As for commercial waterborne transportation, such as excursion boats, freighters, and fishing vessels, there were 53 vessel-related fatalities in 2017 inside U.S. territorial waters. Another 25 people died in incidents judged not to involve the vessel, such as slips and falls in 2017. Suicides, homicides, and some other causes of death are excluded [USDOT BTS NTS].

Oil and Gas Pipelines

There were 16 pipeline fatalities in 2016 and 20 fatalities in 2017 arising from all pipeline incidents.[9] Gas pipelines (especially gas transmission pipelines) account for most of the fatalities in most years [USDOT PHMSA].

Pipeline-related fatalities averaged about 17 deaths per year between 1998 and 2017. There were an average of 65 injuries per year during this period. Gas pipelines accounted for most of the fatalities—averaging 12 per year for gas distribution pipelines and 3 per year for gas transmission lines. Fatalities for hazardous liquid pipelines averaged 2 per year [USDOT PHMSA].

Injured People by Mode

Motor vehicle crashes account for about 99 percent of all transportation injuries. Unlike the full count of highway fatalities, NHTSA estimates injuries using a sample of police accident reports. Beginning with the data reported for 2016, NHTSA switched to a new methodology for estimating injuries. The new estimate was that 3.14 million people were injured in 2016, of whom 221,000 people (or 7 percent) were incapacitated. NHTSA cautions not to compare the new numbers with estimates made in prior years using the earlier methodology.[10] The prior method estimated that there was an appreciable drop in injuries between 2000 and 2015. It is not known to what degree, and whether, the downward trend in injuries was due to the revised method.

[9] The USDOT Pipeline and Hazardous Materials Administration (PHMSA) groups pipeline incidents under three classifications—serious, significant, and all. The fatality data above are taken from an all incidents data pull in May 2018. Data may change as PHMSA receives additional or amended reports from pipeline entities.

[10] NHTSA's new estimation procedure is called the Crash Report Sampling System; it replaces the General Estimates System, first used in 1988.

In table 6-2 the highway numbers and total numbers for 2016 are from the new method, while the numbers for 2000, 2010, and 2015 were estimated using the old method.

Not all highway vehicle categories showed a decline in injuries over the 2000–2015 period. Motorcyclist injuries rose from about 58,000 in 2000 to 92,000 in 2014, before falling to 88,000 in 2015. In 2016, the first year of data under the new method, motorcycle injuries were estimated at 110,000, of which 28,000 were incapacitating [USDOT NHTSA 2018a].

Of the roughly 36,000 people injured in the other modes, railroad and transit rail together accounted for more than 25,000. These numbers do not count people injured in highway-rail crossing incidents to avoid double counting with the highway mode estimate. The water modes had slightly over 3,000 injured people—mostly from recreational boating. Boating injuries declined from over 4,300 in 2000 to 2,620 in 2013 but edged up to over 2,900 in 2016 [USDOT BTS NTS].

Injuries account for the lion's share of the economic costs associated with transportation accidents. The economic costs of motor vehicle crashes are very large—in 2012 there were about 6,900 emergency department visits and 515 hospitalizations per day to treat crash injuries. Summed up over a year, these 188,000 hospitalizations entailed life-time medical costs of $18.4 billion [USHSS CDC 2014]. Motor vehicle injuries also result in other costs, such as lost workplace and household productivity, and indirect costs arising from traffic stoppage at the crash site. Accounting for all these costs, the total 2010 economic

TABLE 6-2 Transportation Injuries by Mode: 2000, 2010, 2015, and 2016

	2000	2010	2015	2016	Change from 2015
TOTAL	**3,218,900**	**2,259,488**	**2,462,229**	**3,162,670**	↑
Air	359	278	285	238	↓
Highway *	3,189,000	2,239,000	2,443,000	3,144,000	↑
Railroad	10,614	7,661	8,275	8,016	↓
Transit rail	13,984	8,671	7,456	7,285	↓
Water	4,355	3,770	3,165	3,044	↓
Pipeline	81	108	48	87	↑
Other counts, redundant with above					
Railroad, injured at public crossing with motor vehicle	1,029	718	870	675	↓
Transit non-rail	42,713	16,705	16,843	17,120	↑

* 2016 estimate is not comparable to earlier year estimates due to methodology change.

NOTES: **Water** for the year 2000 only includes recreational boating and does not include additional categories of water injuries that are included in the data for later years. Please see the *National Transportation Statistics* table 2-2 in source below for complete source notes and an expanded time-series.

SOURCES: Various sources as cited U.S. Department of Transportation, Bureau of Transportation, *National Transportation Statistics* (NTS), table 2-2. Available at www.bts.gov as of October 2018.

cost from motor vehicle injuries was estimated at $242 billion. An even greater toll is taken when lost quality of life from pain and injury are considered. When all these estimates were summed, the total comprehensive cost was $836 billion in 2010 [USDOT NHTSA 2015]. The costs of motorcycle crashes are especially high, with $12.9 billion in economic costs and $66 billion in comprehensive societal economic costs.[11]

Contributing Factors

Numerous human, environmental, and vehicle factors contribute to transportation crashes. The most commonly cited human factors involve driver or operator errors or risky behaviors, such as speeding, and operating vehicles or carrying out transportation operations while under the influence of alcohol or drugs, or while distracted or fatigued. Environmental factors include roadway or infrastructure design (e.g., short runway, no road shoulders), hazards (e.g., utility poles at the side of the road, hidden rocks under water), and operating conditions (e.g., fog, turbulence, choppy waters, wet roads). Vehicle factors include equipment- and maintenance-related failures (e.g., tire separations, defective brakes or landing gear, engine failure, and worn out parts) [GAO 2003]. In 2016 vehicle factors, most commonly tires, were recorded for 5.1 percent of large trucks involved in fatal crashes and 3.0 percent of passenger vehicles involved in fatal crashes [USDOT FMCSA 2018a]. Often it is hard to delineate among the various factors. For example, an impaired or fatigued driver may ignore dashboard alerts about potentially dangerous equipment problems (e.g., low tire pressure), or continue to operate the vehicle when unsafe weather conditions would make it prudent to stop.

Human factors often contribute to fatal crashes involving passenger vehicles. In 2016 one or more driver-related human factors were recorded for 64.6 percent of the drivers of highway passenger vehicles (cars, vans, pickup trucks, and sport utility vehicles) involved in single-vehicle fatal crashes and 48.3 percent of drivers of passenger vehicles involved in multivehicle fatal crashes [USDOT FMCSA 2018a]. For comparison, one or more (driver-related) human factors were recorded for 49.6 percent of the drivers of large trucks involved in single-vehicle fatal crashes and for 27.3 percent of the drivers of large trucks involved in multivehicle fatal crashes [USDOT FMCSA 2018a].

Driver-related factors in fatal crashes declined somewhat over the 2014–2016 period. For drivers of large trucks, the percentage of fatal crashes with one or more driver-related factors declined from 33.6 to 31.7 percent while for drivers of passenger cars, the decline was from 58.1 to 54.7 percent [USDOT FMCSA 2018a].

Speeding topped the law enforcement notation list for drivers of both passenger vehicles and large trucks in fatal crashes. Impairment (fatigue, alcohol, illness, etc.) closely followed speeding as the second most cited factor for passenger vehicle drivers, while distracted/inattentive driving was second on the list for large-truck drivers [USDOT FMCSA 2018a].

[11] For more detailed discussion of the cost of motor vehicle crashes, see USDOT BTS Transportation Statistics Annual Report 2017, p. 6-22 at www.bts.gov.

Speeding

Twenty-seven percent of traffic fatalities, 10,111, involved crashes in which one or more drivers were speeding. The number of speeding-related deaths in 2016 was 4 percent higher than that in 2015, while total traffic fatalities increased by 5.6 percent.

One-third of motorcyclists in fatal crashes were speeding, the highest share among vehicle driver types, as were 19 percent of passenger car drivers, 15 percent of light-truck drivers, and 7 percent of large-truck drivers in fatal crashes [USDOT NHTSA 2018f].

Younger male drivers are especially prone to speeding: 32 percent of 15- to 20-year-old males in fatal crashes, compared to 22 percent of similarly aged females. Speeding coupled with drinking are common in highway crashes [USDOT NHTSA 2018f]. Specifically, 37 percent of speeding drivers in fatal crashes were found to have been drinking compared to 15 percent among nonspeeding drivers in fatal crashes. Half of the drivers in fatal speeding-related crashes in 2016 were not wearing seat belts at the time of the crash, versus 21 percent of those who died in nonspeeding crashes [USDOT NHTSA 2018f].

Alcohol Abuse

All 50 States and the District of Columbia limit blood alcohol concentration (BAC) to 0.08 percent while operating a highway vehicle [USDHHS NIH NIAAA 2014]. In 2017 an average of one alcohol-impaired driving fatality occurred every 48 minutes in the United States [USDOT NHTSA 2018j]. Table 6-3 shows that about 10,874 people were killed in motor vehicle crashes in 2017 in which a driver or fatally struck nonoccupant or both had a BAC of 0.08 or higher; this was a slight decline from 2016, but about 600 more deaths than in 2015. Fatalities in alcohol-impaired crashes remain below the 2000 level, which was above 13,000.[12]

Figure 6-5 displays who died in fatal crashes when the driver had a BAC of 0.08 or higher. Drivers accounted for over 6,600 (61 percent) of the fatalities; about 3,000 were either passengers in the vehicle with an impaired driver or occupants of other vehicles (28 percent), and more than 1,200 were pedestrians or other nonoccupants (11 percent). Some 27 percent of motorcycle operators in fatal crashes were alcohol-impaired, the highest share among highway motor vehicle driver types.

The tangible economic costs of alcohol-related crashes in 2010 were estimated to be $44 billion, and $201.1 billion when quality of life considerations were considered [USDOT NHTSA 2018j]. This is nearly one-fourth of the $836 billion estimated total societal cost of motor vehicle accidents in 2010 [USDOT NHTSA 2018j].

As for recreational boating, alcohol use is perennially listed by the U.S. Coast Guard (USCG) as the leading contributing factor in fatal boating fatalities. The USCG found alcohol use to be the primary cause in 19 percent of fatal boating accidents in 2017,

[12] According to the USDOT National Highway Traffic Safety Administration, an alcohol-impaired crash involves at least one driver or motorcycle operator with a Blood Alcohol Concentration (BAC) of at least 0.08 gram per deciliter. Crashes where the BAC of the driver or operator measures over 0.01 are considered alcohol-related or alcohol-involved crashes.

TABLE 6-3 Fatalities by Highest Blood Alcohol Concentration (BAC) in Highway Crashes: 2000, 2010, 2015, and 2017

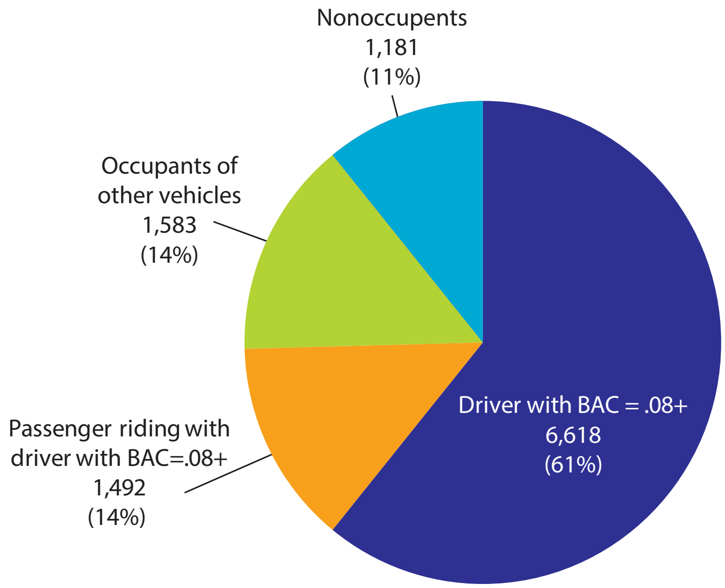
	2000	2010	2015	2017
Total fatalities	**41,945**	**32,999**	**35,484**	**37,133**
Fatalities in alcohol-related crashes (BAC = .01+)	**15,746**	**11,906**	**12,210**	**12,747**
Percent	37.5	36.1	34.4	34.3
BAC = 0.00				
Number	26,082	21,005	23,165	24,280
Percent	62.2	63.7	65.2	65.4
BAC = 0.01 - 0.07				
Number	2,422	1,771	1,930	1,873
Percent	5.8	5.4	5.4	5.0
BAC = 0.08+				
Number	13,324	10,136	10,280	10,874
Percent	31.8	30.7	29.0	29.3

KEY: BAC = blood alcohol concentration.

NOTES: *Total fatalities* include those in which there was no driver or motorcycle rider present. BAC values have been assigned by U.S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA) when alcohol test results are unknown. *Alcohol-related crashes* pertain to the BAC of the driver and nonoccupants struck by motor vehicles. For some years, numbers for Fatalities in alcohol-related crashes (BAC = .01+) may not add to totals due to rounding.

SOURCE: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, *Traffic Safety Facts: Alcohol-Impaired Driving* (Annual Issues). Special tabulation as of July 2018.

FIGURE 6-5 Fatalities, by Role, in Crashes Involving at Least One Driver with a BAC of .08 or Higher: 2017



KEY: BAC = blood alcohol concentration.

NOTE: Nonoccupants includes pedestrians, pedalcyclists, and others not listed above.

SOURCE: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, *Traffic Safety Facts: Alcohol-Impaired Driving* (Annual Issues), available at http://www-nrd.nhtsa.dot.gov/ as of August 2018.

resulting in 102 deaths [USDHS USCG 2018]. As of January 1, 2017, 47 States and the District of Columbia limit BAC to 0.08 percent for operators of recreational boats. The remaining three States—North Dakota, South Carolina, and Wyoming—have a 0.10 percent standard [USDHHS NIH NIAAA 2018].

Substance Abuse

Many states test drivers for presence of alcohol and drugs after fatal crashes. A study by the Governors Highway Safety Administration analyzed the results of these tests in 2016, finding that among drivers in fatal crashes that were tested for drugs and/or alcohol: 43.6 percent tested positive for drugs and 37.9 percent tested positive for alcohol. More than half of those testing positive for drugs were positive for two or more drugs, and over 40 percent were positive for alcohol. The tests were for any presence of alcohol or drugs in the driver's system. The study noted that presence of drugs does not imply impairment [GHSA 2018].

Since 1991[13] Federal transportation agencies have required testing on the job for safety-sensitive transportation operators and workers in many industries. Box 6-C cites the Federal regulations and minimum standards for required random testing rates under regulations issued by the USDOT operating administrations and the U.S. Coast Guard, now part of the Homeland Security Department.

Distraction and Fatigue

Distracted and fatigued vehicle operators are found in all modes of transportation, including airline pilots, bus drivers, train engineers, and tugboat operators [NTSB 2016]. The number of fatalities in distraction-affected highway crashes was 3,490 or 9.2 percent of total fatalities in 2016 (figure 6-6a). This was a decline from 3,526 fatalities in 2016. Distracted driving resulted in an estimated 479,000 injures, or 15.2 percent of all highway injuries, in 2016 [Personal communication with USDOT NHTSA], down from 16.0 percent in 2015 (figure 6-6b). Drivers under the age of 30 are disproportionately represented in distraction-affected fatal crashes, especially drivers aged 15 to 19 years [USDOT NHTSA 2018g].

Vehicle occupants comprised 84 percent of deaths in distraction-related crashes in 2016. In addition, there were 562 nonoccupants who died, mostly pedestrians, in these crashes. It is not known how many nonoccupants were also distracted when struck (e.g., walkers using a cell phone while crossing a street).

Although many other activities (e.g., eating, sipping coffee, smoking, grooming, tending to a child, adjusting a radio) are distracting to drivers, bicyclists, and pedestrians, cell phone use and texting have received the most attention as these devices have attained nearly universal usage in the last few years. Cell phones were in use in about 14 percent of fatal crashes involving a distracted driver in 2016, comprising about 1.2 percent of all fatal crashes [USDOT NHTSA 2018g]. Figures 6-7a and 6-7b show that 14 States, the District of Columbia, and Puerto Rico prohibit drivers' use of handheld cell phones; and 47 states plus the District of Columbia and Puerto Rico ban texting while driving.

[13] The testing is required by the Omnibus Transportation Employee Testing Act of 1991, Public law 102-143.

Box 6-C U.S. Department of Transportation Drug and Alcohol Testing Regulations

DOT Agency	Drug and Alcohol Testing Regulation	2018 Mninmum for Required Random Drug Testing Rate	2018 Minimum for Required Random Alcohol Testing Rate
Federal Aviation Administration (FAA)	For employers and employees in the aviation industry 14 CFR Part 120	25%	10%
Federal Motor Carrier Safety Administration (FMCSA)	For carriers and commercial driver's license holders (CDL) 49 CFR Part 382	25%	10%
Federal Railroad Administration (FRA)	For employers and employees working in the railroad industry 49 CFR Part 219	25% - Covered Service 50% - Maintenance of Way*	10% - Covered Service 25% - Maintenance of Way*
Federal Transit Administration (FTA)	For employers and employees working in the mass transit industry 49 CFR Part 655	25%	10%
Pipeline & Hazardous Materials Safety Administration (PHMSA)	For operators and employees working in the pipeline industry 49 CFR Part 199	50%	N/A
United States Coast Guard (USCG) (now with the Dept. of Homeland Security)	For employer and employees operating commercial vessels 46 CFR Part 16 46 CFR Part 4	25%	N/A

* Random testing began on 06/12/2017.

KEY: CFR = Code of Federal Regulations

NOTES: Employers (and C/TPAs) subject to more than one DOT Agency drug and alcohol testing rule may continue to combine covered employees into a single random selection pool. USCG covered employees may be combined with DOT covered employees in drug testing pools even though the USCG is now part of the Department of Homeland Security.

SOURCE: U.S. Department of Transportation, Office of Drug and Alcohol Policy and Compliance, available at https://www.transportation.gov/odapc as of November 2018.

Drowsy and fatigued driving was a factor in 795 highway fatalities (2.1 percent of all highway fatalities) in 2017 [USDOT NHTSA 2018a]. However, it is likely that the role of fatigue in crashes has been underestimated [AAA 2018]. New research, such as use of dash-cam video, may make more accurate estimation possible. In 2018 the AAA Foundation for Traffic Safety results from research examined dash-cam footage of drivers in the moments before 589 crashes, and drowsiness was found in 10.6 to 10.8 percent of crashes with an injury, air bag deployment, or significant property damage [AAA 2018].

Drowsy-driving crashes often occur in rural areas, with the vehicle going off the road at high speed without braking and with no other vehicle occupant besides the driver [USDOT

FIGURE 6-6a Distracted Driving Fatalities and Injuries: 2005–2016

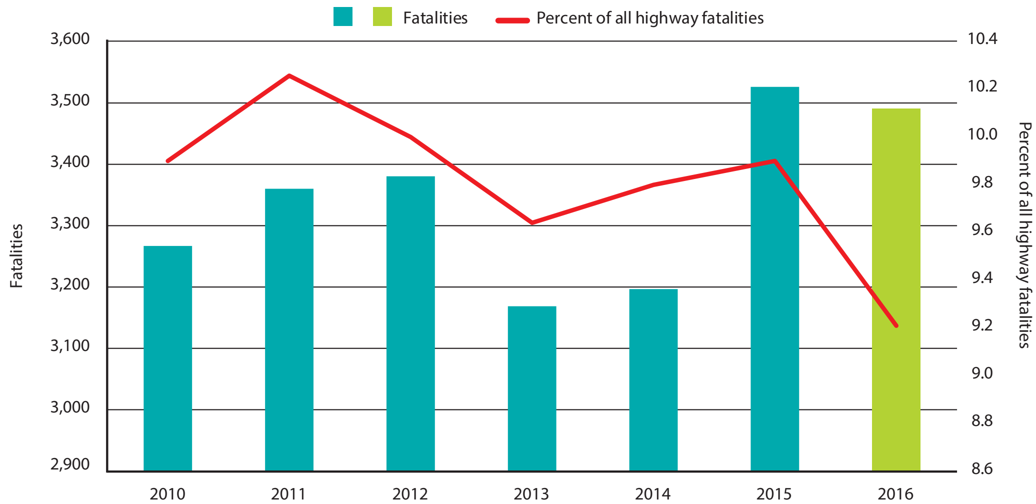
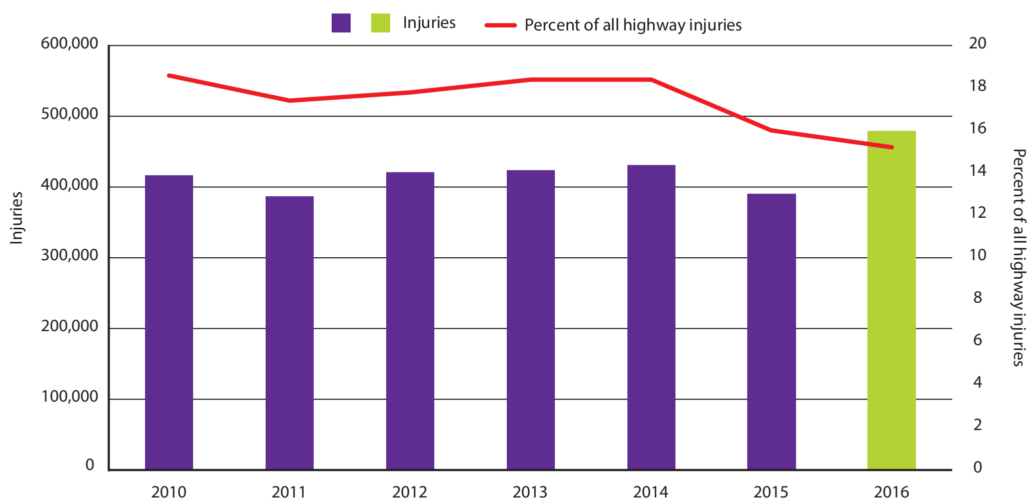


FIGURE 6-6b Distracted Driving Fatalities and Injuries: 2005–2016



NOTES: Distracted driving involves any activity that could divert a person's attention away from the primary task of driving, such as texting, using a cell phone, eating and drinking, grooming, using a navigation system, adjusting a radio, etc. 2016 Crash Reporting Sampling System (CRSS) estimates are not comparable with 2015 and earlier NASS GES estimates because of different sampling designs.

SOURCE: Fatalities: U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts, Research Note, *Distracted Driving 2016*, available at www.nhtsa.gov as of November 2018. **Injuries**: Personal communication with U.S. Department of Transportation, National Highway Traffic Safety Administration and Traffic Safety Facts, Research Note, *Distracted Driving 2015*, available at www.nhtsa.gov as of November 2018.

FIGURE 6-7a State Laws on Distracted Driving—Handheld Ban: 2018

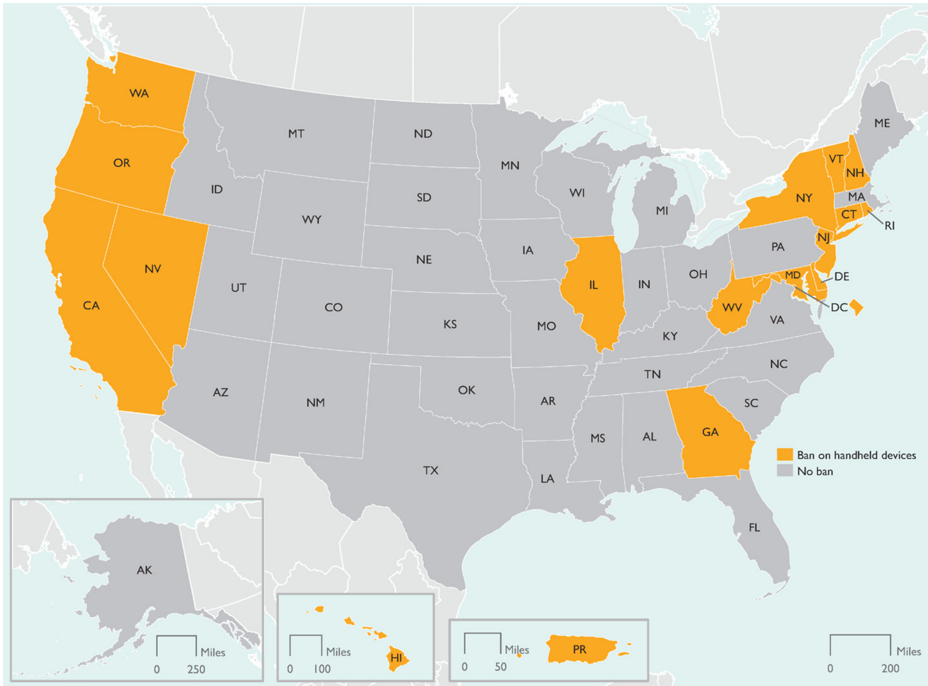
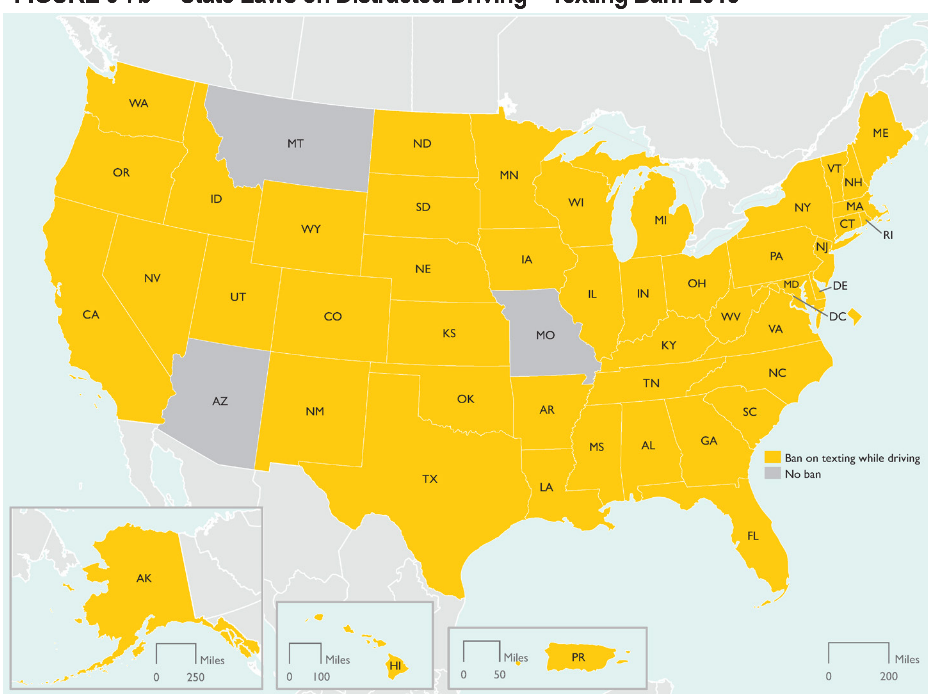


FIGURE 6-7b State Laws on Distracted Driving—Texting Ban: 2018



NOTES: *Partial ban* includes select drivers (e.g., under the age of 18, those with a learner's permit or interme-diate license).

NHTSA 2016]. About 57 percent of fatal crashes in rural areas involve a single-vehicle [IIHS].

Distracted or inattentive driving by commercial motor vehicle drivers was a contributing factor in 6.1 percent of fatal crashes involving large trucks in 2016. In addition, truck driver impairment (e.g., fatigue, drugs/alcohol, illness, etc.) was a factor in 3.8 percent of these fatal crashes [USDOT FMCSA 2018a].

In the case of recreational boating, operator inattention was cited as the top contributing factor in all boating accidents (nonfatal as well as fatal) in 2017, according to the U.S. Coast Guard—about 14 percent of boating accidents [USDHS USCG 2018].

Lives Saved by Occupant Protection Equipment

When properly used, safety devices significantly reduce the risk of death or serious injury. The NHTSA estimated that just under 20,500 lives were saved on the highways in 2017—up from about 17,000 in 2010—by occupant protection devices, including seat belts, frontal air bags, child restraints, and motorcycle helmets as well as minimum drinking age laws (table 6-5). Seat belts saved nearly 15,000 lives, frontal air bags about 2,800, child restraints about 325, and DOT-compliant motorcycle helmets nearly 1,900 lives in 2017 (table 6-4).

Seat Belt Use

About 90 percent of occupants of car, vans, and sport utility vehicles (SUVs) used safety belts in 2017, up from 71 percent in 2000 and 85.1 percent in 2010, and about the same as in 2016 [USDOT NHTSA 2018a]. Pickup truck occupants had the lowest usage at 83 percent in 2017, about the same as in 2016 (table 6-5).

Among states and territories, seat belt use ranged from a low of 67.6 percent in New Hampshire to a high of 97.1 percent in Georgia. States with primary enforcement laws, allowing police to ticket vehicle occupants solely for not wearing seat belts, have higher belt usage (91 percent in 2017) than states with weaker or no enforcement (86 percent) [USDOT NHTSA 2018h].

TABLE 6-4 Estimated Lives Saved by Selected Safety Features: 2000, 2010, 2015, and 2017

	2000	2010	2015	2017
Child restraints, age 4 and younger	479	303	273	325
Seat belts, age 5 and older	12,882	12,670	14,062	14,955
Frontal air bags, age 13 and older	1,716	2,403	2,597	2,790
Motorcycle helmets, all ages	872	1,551	1,800	1,872
Minimum drinking age law	922	560	542	538

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, National Center for Statistics and Analysis, *Traffic Safety Facts* (Washington, DC: Annual Issues). Available at http://www-nrd.nhtsa.dot.gov/ as of July 2018 as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-31. Available at http://www.bts.gov as of July 2018.

TABLE 6-5 Safety Belt and Motorcycle Helmet Use: 2000, 2010, 2016, and 2017
(Percent)

	2000	2010	2016	2017
Overall safety belt use[a]	**71**	**85**	**90**	**90**
Drivers	72	86	91	90
Right-front passengers	68	83	89	88
Passenger cars	74	86	91	91
Vans and sport utility vehicles	U	88	92	92
Pickup trucks	U	75	83	83
Motorcycle Helmet Use[ab]	**71**	**54**	**65**	**65**
Operators	72	55	68	68
Passengers	62	51	53	51

KEY: U = data are unavailable.

[a] Seat belt use is as of the Fall each year. Motorcycle helmet use is as of the Fall each year.

[b] Only those operators and riders wearing safety helmets that met U.S. Department of Transportation (DOT) standards are counted. Those safety helmets that do not meet DOT standards are treated as if the operator/rider were not wearing a helmet.

NOTE:Occupants of commercial and emergency vehicles are excluded.

SOURCES: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, Traffic Safety Facts: Research Notes, *Seat Belt Use* (Annual issues); and *Motorcycle Helmet Use—Overall Results* (Annual issues). Available at http://www-nrd.nhtsa.dot.gov as of May 2018 as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-30, available at http://www.bts.gov as of August 2018.

Seat belt use is most effective in conjunction with air bags, which deploy automatically in crashes. Many older vehicles (as many as 4 in 10) might not have passenger side air bags. Recalls to replace defective airbags and other occupant protection equipment sometimes are undertaken, most visibly in the ongoing case of airbags manufactured by Takata Corp. In January 2018, recalls of about 50 million airbags involving 19 automakers and 37 million vehicles had been announced [USDOT NHTSA].

Helmet Use

DOT-compliant motorcycle helmets reduce the risk of dying in a motorcycle crash and also reduce emergency medical care, hospitalization, intensive care, rehabilitation, and long-term care following crashes [NTSB 2010]. NHTSA estimates that DOT compliant helmets are 37 percent effective in preventing fatal injuries to motorcycle riders and 41 percent for motorcycle passengers [USDOT NHTSA 2018i]. Overall usage of DOT-compliant helmets declined from 71 percent in 2000 to a low of 48 percent in 2005, before rising to 65 percent in 2017, about the same statistically as in 2016 (table 6-5).

Only 19 states and the District of Columbia have a universal helmet law, 28 states have a partial law covering certain riders and passengers (e.g., those under the age of 18),

TABLE 6-6 Hazardous Materials Transportation Incidents: 2010 and 2014–2017

	2010	2014	2015	2016	2017
Total incidents	**14,795**	**17,407**	**16,858**	**18,283**	**17,463**
Total vehicular accident / derailment incidents	**358**	**350**	**316**	**273**	**286**
Vehicular accident-related percent of total incidents	2.4%	2.0%	1.9%	1.5%	1.6%
Air	1,295	1,327	1,130	1,203	1,161
Vehicular accident-related	2	3	3	4	15
Highway	12,648	15,316	15,124	16,524	15,725
Vehicular accident-related	320	330	280	245	247
Rail	747	717	580	545	568
Vehicular accident-related / derailment incidents	35	17	32	23	24
Water[1]	105	47	24	11	9
Vehicular accident-related	1	0	1	1	0

[1] Water include only packages (nonbulk) marine. Non-packaged (bulk) marine hazardous material incidents are reported to the U.S. Coast Guard and are not included.

NOTES: Incidents are defined in the Code of Federal Regulations (CFR): 49 CFR 171.15 and 171.16 (Form F 5800.1). *Accident-related* are the result of a vehicular crash or accident damage (e.g., a train derailment).

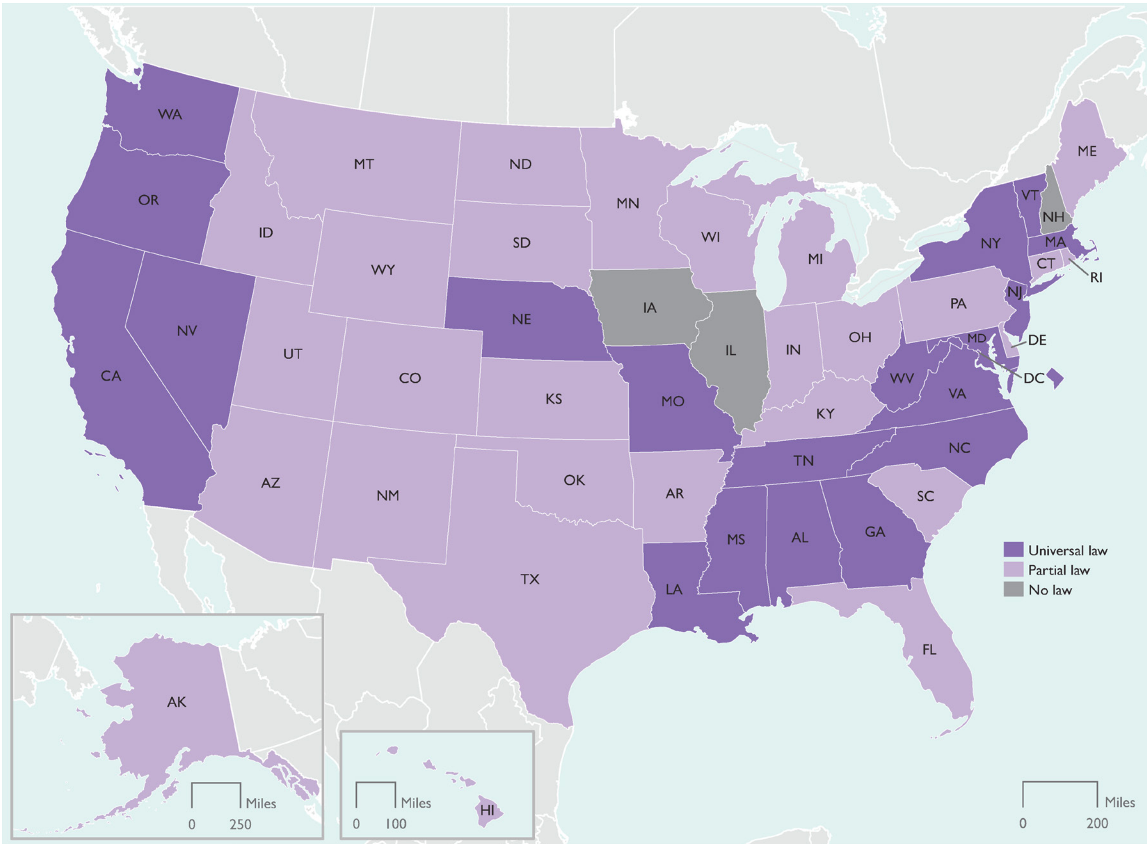
SOURCE: U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Hazardous Materials Safety, *HAZMAT Intelligence Portal*, available at https://hip.phmsa.dot.gov/ as of November 2018.

and 3 states (Illinois, Iowa, and New Hampshire) have no motorcycle helmet law (figure 6-8). Helmet use is appreciably higher in states requiring their use. The percent of riders that wore DOT-compliant helmets in states that required helmet use rose from 79.6 percent in 2016 to 87.0 percent in 2017. On the other hand, only 43.7 percent of riders wore DOT-compliant helmets in states that do not require their use—a decrease from 53.5 percent in 2016. Noncompliant helmets were worn by 9.9 percent of riders in states requiring helmet use and 4.3 percent in states not requiring helmet use [USDOT NHTSA 2018h]. In 1975, 47 states and the District of Columbia had adopted universal helmet use laws that required motorcycle helmets for all riders, but many states have subsequently made their helmet laws less restrictive [COSGROVE 2007]. By 2018 only 22 states and the District of Columbia continued to have universal helmet use laws.

Life Jackets and Boat Safety Training

About 76 percent of people who died in boating accidents in 2017 drowned, and 84.5 percent of those who drowned were not wearing a life jacket. Even if not legally required, some operators of boats insist that their passengers wear life jackets. Most states require mandatory recreational boating education and safety training courses, but eight states do not (Alaska, Arizona, California, Idaho, Maine, South Dakota, Utah, and Wyoming). Boater education helps reduce the risk of boating accidents and death [NTSB 2013], and about 42.6 percent of U.S. boat owners have taken a boating safety course. Most boating fatalities occur on vessels in which the operator had no formal instruction in boating safety. Only 14 percent of deaths in fatal boating accidents in 2017 occurred in boats operated by a person known to have received a certificate for boating safety from a nationally approved provider [USDHS USCG 2018].

FIGURE 6-8 State Laws on Motorcycle Helmet Use: 2018



SOURCE: Insurance Institute for Highway Safety, Highway Loss Data Institute, *Motorcycle Helmet Use*, available at www.iihs.org as of November 2018.

Traffic Safety Enforcement

Traffic safety enforcement promotes good driving habits (e.g., wearing a safety belt) and discourages unsafe behaviors (e.g., speeding, impaired driving). According to the Bureau of Justice Statistics, about 8.6 percent of the Nation's 223 million drivers in 2015 were stopped by police. Speeding was the leading reason, accounting for 40.9 percent of stops, followed by vehicle defects (e.g., broken tail light) at 12.2 percent. Among many other reasons given for stops were: seatbelt violations (3.2 percent); cell phone violations (1.7 percent); and sobriety checks (1.4 percent). About 14.8 percent of drivers between 18 and 24 years of age were stopped—the highest percentage among all age groups [USDOJ BJS 2018].

In 2017, according to the Federal Bureau of Investigation, law enforcement agencies across the country made just under 1 million arrests for driving under the influence (DUI). Males accounted for three out of four DUI arrests [USDOJ FBI 2018]. Studies have shown sobriety checkpoints are an effective countermeasure to reduce alcohol-impaired driving, reducing alcohol-related crashes by roughly 20 percent [USDHHS CDC NCI 2015]. Not all states authorize these checkpoints, however.

The Federal Motor Carrier Safety Administration (FMCSA) is responsible for reducing crashes, injuries, and fatalities involving the Nation's approximately 512,000 interstate freight carriers, 13,000 interstate passenger carriers, and 19,000 interstate hazardous material carriers [USDOT FMCSA 2018b]. In fiscal year 2017, about 3.5 million roadside inspections were conducted by state and federal inspectors. About 29,000 warning letters were issued to carriers whose safety data showed a lack of compliance with motor carrier safety regulations and whose safety performance had fallen to an unacceptable level [USDOT FMCSA 2018b]. Inspections may reveal violations that must be corrected before the driver or vehicle can return to service. In 2017 vehicle violations, such as defective lights, worn tires, or brake defects, put 21.3 percent of inspected trucks out-of-service until corrected. Truck driver violations put 5.1 percent out-of-service, often due to noncompliance with hours-of-service regulations. As discussed earlier, fatigue is a factor in many crashes. Comparable numbers for motor coaches were 7.5 percent for vehicle violations and 1.8 percent for driver violations. FMCSA estimated that the carrier interventions saved 168 lives and prevented of 5,811 crashes and 3,316 injuries in fiscal year 2014, the last year of published data [FMCSA 2018d].

Hazardous Materials Transportation

Transporting hazardous materials requires special precautions, handling, and packaging. There are specialized safety regulations, standards, and reporting systems in place for pipelines, rail, highway, air, and marine vehicles that transport hazardous materials. These special requirements recognize that incidents involving the transportation of hazardous materials can affect the environment in addition to potentially risking injury and death. Table 6-6 shows that, in 2017, about 17,400 hazardous materials incidents (excluding pipeline incidents) were reported to the USDOT Pipeline and Hazardous Materials Administration (PHMSA)—down from about 18,200 in 2016 [USDOT PHMSA 2017b].

About 1.6 percent of hazardous materials transportation incidents in 2017 resulted from an accident (e.g., vehicular crash or train derailment). About 90 percent of these accidents happened on highways or in truck terminals.

The above incidents do not include pipelines, which are reported separately to PHMSA. Table 6-7 shows the severity of pipeline incidents from 2010 through 2017 in terms of deaths, injuries, property damage, and liquid spilled. Figure 6-9 summarizes hazardous liquid-related and gas-related pipeline incidents reported from 2005 to 2017. Year-to-year variation in the number of hazardous liquid incidents is evident, with no consistent trend apparent. However, the number of serious incidents involving a fatality (nearly all of which involve gas pipelines) have declined.

Rail Tank Car Safety

There has been a dramatic increase in the U.S. production of petroleum crude oil, up from 23.7 million barrels in 2010 to 139.8 in 2017, but down from a peak of 382.0 in 2014 [USDOE EIA 2018]. Several derailments resulting in explosions and fireballs have occurred in this country, resulting in community evacuations. In Canada, the 2013 rail catastrophe in Lac-Mégantic, Quebec, resulted in 47 deaths and great property destruction in the town.

TABLE 6-7 All Reported Hazardous Liquid and Gas Incidents: 2010–2017

	TOTAL - All Reported					
	Number	Fatalities	Injuries	Property damage as reported	Barrels spilled (Haz Liq)	Net barrels lost (Haz Liq)
2010	586	22	108	$1,692,500,877	100,558	49,452
2011	592	14	56	$426,551,870	89,110	57,375
2012	573	12	57	$229,613,337	45,884	29,247
2013	619	9	44	$349,961,947	117,467	85,598
2014	707	19	95	$310,257,400	47,083	21,686
2015	715	12	49	$344,188,043	103,607	81,953
2016	635	17	82	$308,344,675	86,154	53,083
2017	650	20	35	$272,487,138	89,698	45,608

KEY: *Haz Liq* = Hazardous Liquid, LNG = Liquefied Natural Gas.

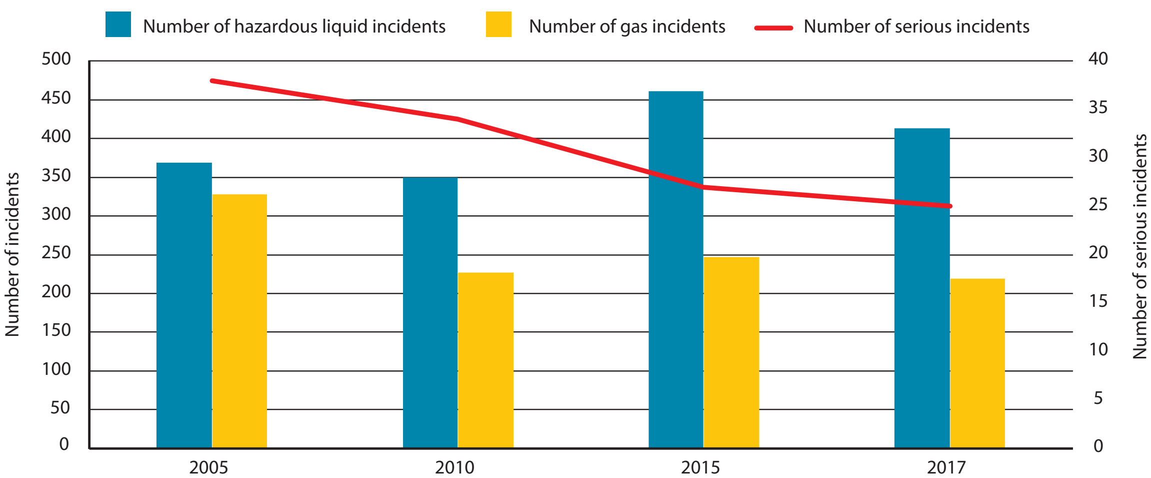
NOTES: *Hazardous Liquid* includes crude oil; refined petroleum products (e.g., gasoline, diesel, kerosene); highly volatile, flammable, and toxic liquids (e.g., propane); liquid carbon dioxide; and biodiesel. *Gross Barrels Spilled* is the amount before clean-up, whereas *Net Barrels Lost* is the amount after clean-up is attempted.

Incident means any of the following events: 1) An event that involves a release of gas from a pipeline, or of liquefied natural gas, liquefied petroleum gas, refrigerant gas, or gas from an LNG facility, and that results in one or more of the following consequences: i) A death, or personal injury necessitating in-patient hospitalization; ii) Estimated property damage of $50,000 or more. *Accident* is a failure in a pipeline system in which there is a release of the hazardous liquid or carbon dioxide transported resulting in any of the following: a) Explosion or fire not intentionally set by the operator. b) Release of 5 gallons (19 liters) or more of hazardous liquid or carbon dioxide.

Please see the Pipeline and Hazardous Materials Safety Administration's Incident Report Criteria History for a complete definition of past and present reporting requirements, which is available at https://hip.phmsa.dot.gov/Hip_Help/pdmpublic_incident_page_allrpt.pdf as of November 2018

SOURCE: U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Hazardous Materials Safety, *HAZMAT Intelligence Portal* (as of November 2018). Available at https://hip.phmsa.dot.gov/ as of November 2018.

FIGURE 6-9 Number of Hazardous Liquid and Gas Pipeline Incidents and Serious Incidents: 2005, 2010, 2015, and 2017



NOTE: Serious incidents include a fatality or injury requiring overnight, in-patient hospitalization, but does not include gas distribution incidents in which the gas release was a result of the fire, not the cause of the fire.

SOURCE: U.S. Department of Transportation, Pipeline and Hazardous Materials Administration data, as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 2-50, https://www.bts.gov/ as of September 2018.

Under a law passed at the end of 2015,[14] the Bureau of Transportation Statistics (BTS) assembles and collects data on rail tank cars transporting Class 3 flammable liquids in order to track the progress of upgrades to the rail tank car fleet to meet new safety requirements. By the end of 2029, rail tank cars carrying class 3 flammable liquids must meet the DOT-117 or DOT-117R specification or equivalent.

As the of end 2017, 20 percent of the fleet met the new safety requirements for DOT-117 and DOT-117R, a significant increase from the 2 percent in 2015. Of the tank cars meeting the new safety requirements, 61 percent (9,211 tank cars) were new and 39 percent (5,853 tank cars) had been retrofitted. The DOT-117 and DOT-117R tank cars carry a variety of flammable liquids, with 86 percent of these tank cars carrying crude oil or ethanol (26 and 60 percent, respectively).

In 2017, 77,216 rail tank cars were used to carry Class 3 flammable liquids, the fewest during the 5-year 2013–2017 period, down from a high in 2015 of 92,358 tank cars. Most of these tank cars were nonjacketed DOT-111[15] specification (47 percent of the fleet), followed by DOT-117s[16] (12 percent) and the nonjacketed CPC123217 (11 percent) [USDOT BTS 2018].

The law requires BTS to prepare an annual report detailing progress. It also requires BTS to estimate the anticipated number of DOT-117 and DOT-117R tank cars for each year through 2029 by collecting data from tank car shops that build or retrofit tank cars. Survey results indicate that 11,727 DOT-117 and DOT-117R tank cars are projected to be built or retrofitted in 2018. Of these, 3,817 will be new DOT-117 tank cars. It is expected that by the end of the transition period in 2029, all Class 3 flammable liquids will be carried in rail tank cars that meet or exceed the new standards [USDOT BTS 2018].

References

American Automobile Association Foundation for Traffic Safety (AAA): *Prevalence of Drowsy Driving Crashes: Estimates from a Large Scale Naturalistic Study* (February 2018).

[14] Section 7308 of the *Fixing America's Surface Transportation Act* (FAST Act; P. L. 114-94; December 4, 2015)

[15] DOT-111: A non-pressurized tank car with a thinner shell (7/16 of an inch) than is now required for the DOT117 tank cars. These tank cars can carry both hazardous and non-hazardous liquids. These cars are not required to have head shields to protect the tank car from an adjacent car in an incident. The top fittings and valves are not protected and are vulnerable to being sheared off in an incident leading to a release of contents. These tank cars also do not have a pressure relief device sized to protect against rupture in the event of a fire. DOT111s do have pressure relief valves that offer some protection in some fires.

[16] DOT-117 (TC-117 in Canada): A non-pressurized tank car with a shell thickness of 9/16 of an inch and insulating material providing thermal protection. The tank cars have protected top fittings, a fully protected head shield, and a bottom outlet valve with an enhanced handle designed to prevent the tank car from emptying its contents in an incident. All the enhancements are designed to protect the tank from being punctured and to prevent the valves from being disrupted. DOT-117R tank cars are cars that have been retrofitted to meet the 117 specifications.

[17] CPC-1232: Industry-sponsored specification, intended to be safer than DOT-111 tank cars for carrying petroleum crude oil and ethanol. Cars ordered after October 2011 were required to meet this specification. These tank cars include a pressure relief valve, more extensive top fittings than on the DOT-111 rail tank cars, and a full height or half-height head shield. The shell of non-jacketed tank cars must be ½ inch thick, and for jacketed tank cars must be 7/16 inch thick.

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CHAPTER 7

Transportation Energy Use and Environmental Impacts

Highlights

- Transportation used less energy in 2017 than in the 2005 peak in part because fewer person-miles and freight ton-miles were logged.
- The estimated 5.35 trillion person-miles of travel[1] and 5.26 trillion ton-miles of freight moved by the U.S. transportation system require almost one-third of total U.S. energy use.
- The energy efficiency of transportation continues to improve. Fuel economy improvements from 1975 to 2017 have saved 1.7 trillion gallons of gasoline, enough to power all such vehicles in the United States for 13 years at the 2016 rate of gasoline consumption.
- Today's commercial air carriers used about one-fourth the energy per passenger mile as in 1970 due to aircraft improvements and higher load factors.
- Transportation accounted for 70.6 percent of U.S. petroleum consumption in 2017, the highest level since 2009; transportation continues to rely on petroleum for 92.2 percent of its energy requirements.
- U.S. dependence on imported petroleum decreased to 18.8 percent in 2017, the lowest level in more than half a century due to increased domestic petroleum production, improvements in energy efficiency, and increased use of alternative fuels.
- Transportation became the largest source of carbon dioxide emissions in the United States in 2016 and continued to be the largest emitter of this greenhouse gas in 2017, exceeding emissions from electricity generation.
- Continued reductions in emissions of all major air pollutants from transportation vehicles have contributed to cleaner air in U.S. cities. Twice as many U.S. cities had fewer than 10 days of poor air quality in 2016 (58.6 percent) as in 2010 (26.4 percent).

[1] Includes person-miles of travel in commercial vehicles, such as truck drivers, but excludes air travel to and from the United States.

This chapter reviews patterns and trends in transportation energy use and impacts on the environment. Transportation accounts for almost 30 percent of U.S. energy use and, because most of that energy is derived from petroleum, it is also the leading source of emissions of carbon dioxide. Increased energy efficiency, especially of passenger cars, light trucks, commercial air, and rail transport, allows increases in transportation activity that outpace subsequent increases in energy use. Emissions from transportation vehicles also cause air pollution. However, transportation emissions have been steadily decreasing for decades, contributing to increasingly cleaner air in U.S. cities. The retirement of vehicles and replacement of infrastructure generate billions of tons of solid waste each year. However, vehicles and infrastructure are among the most recycled goods in the U.S. economy.

Energy is essential to transportation because nothing moves without energy. Transportation continues to rely on petroleum for 92.2 percent of the energy it uses to move passengers and freight [USDOE EIA 2018a]. Despite transportation's continued reliance on fuels derived from petroleum, in 2017 U.S. dependence on imported petroleum declined to its lowest level (18.8 percent) in over 50 years [USDOE EIA 2018a]. Increased domestic production of crude oil is the largest factor, but improvements in energy efficiency and increased use of alternative fuels, especially ethanol blended with gasoline, also contributed. Highway vehicles continue to account for the majority of transportation's energy use—85.0 percent in 2016 [USDOT BTS 2018a]. Although the distribution of energy use by mode has remained relatively stable, heavy-duty highway vehicles increased their share of energy use from 15.4 percent in 1990 to 22.7 percent in 2016 [USDOT BTS 2018a].

The efficiency of transportation energy use continues to increase. Today's commercial aircraft use only about one-fourth the energy per passenger-mile as in 1970. Improvements to light-duty vehicle fuel economy saved approximately 1.7 trillion gallons of gasoline from 1975 to 2017 [USDOT FHWA 2017a]. Other modes have also made major improvements. Although petroleum remains the predominant source of energy for transportation, the use of biofuels, natural gas, and electricity has increased. Blending of ethanol with gasoline expanded from 0.13 quadrillion Btu (British thermal unit) in 2000 to 1.04 in 2010 and 1.15 in 2017 [USDOE EIA 2018a]. The growth of ethanol use has slowed in recent years after the blend limit of 10 percent, the highest level that can be safely tolerated by many older vehicles, was reached. Although plug-in electric vehicle (PEV) sales grew from about 19,000 in 2011 to over 200,000 in 2017, they still comprise only 1.2 percent of total sales and less than one-fourth of one percent of vehicles on the road [Hybridcars 2017]. In 2017 they are estimated to have reduced highway motor fuel use by about 0.1 percent.

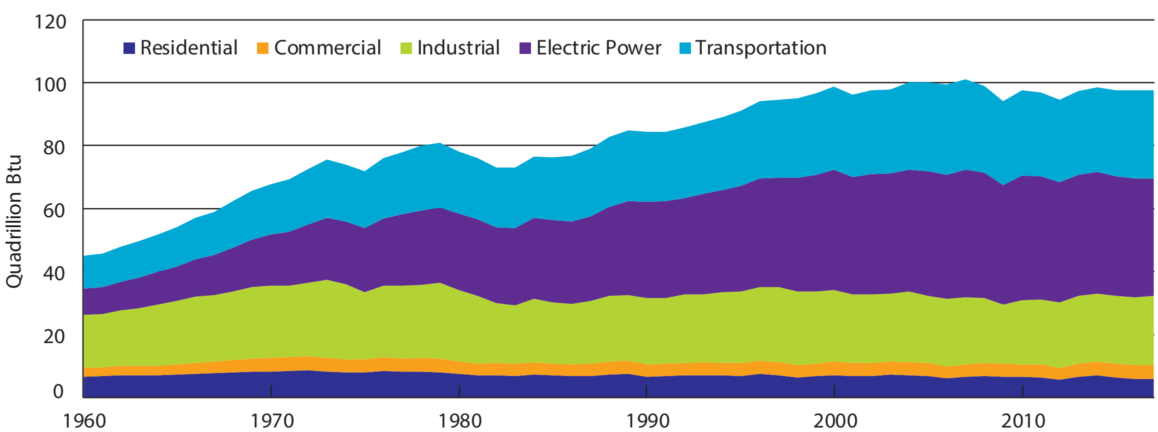
In 2016 transportation became the largest source of carbon dioxide emissions among energy using sectors of the economy and continued in that role in 2017. However, emissions of pollutants that damage urban air quality continued to decrease for all major pollutants, contributing to improving air quality in most U.S. metropolitan areas. In 2017 more than twice as many metropolitan areas experienced fewer than 10 days of poor air quality than in 2010. Petroleum spills into navigable waterways remained near historic lows in 2016, and leaks from underground fuel storage tanks continued to decrease. Salt pollution from road runoff, however, is emerging as a long-term threat to water quality in freshwater ecosystems.

Energy Use

The estimated 5.35 trillion person-miles of travel[1] and 5.26 trillion ton-miles of freight moved by the U.S. transportation system require almost one-third of total U.S. energy use, or 28.1 quadrillion [USDOT BTS 2018a and USDOE EIA 2018]. Although transportation's energy use has increased every year since 2012, because of ongoing improvements in energy efficiency, transportation energy use in 2017 was still 2.4 percent lower than in 2005 (figure 7-1). Commercial air transport and light-duty highway vehicles have made the largest improvements in energy efficiency over the past several decades, and their energy efficiency continues to improve. Light-duty vehicle fuel economy gains since 1975 have saved an estimated 1.7 trillion gallons of gasoline. From 1970 to 2016, commercial air carriers reduced energy use per passenger-mile by over 70 percent [USDOT BTS 2018a]. From 2000 to 2016, Btu per passenger-mile decreased by 15 percent for domestic flights and by 5 percent in international operations.

[1] Includes person-miles of travel in commercial vehicles such as truck drivers but excludes air travel to and from the United States.

FIGURE 7-1 U.S. Consumption of Energy from Primary Sources by Sector (Quadrillion Btu): 1960-2017



NOTES: The data for residential, commercial, and industrial sectors include only fossil fuels consumed directly. Most renewable fuels are not included. The data for the transportation sector includes only fossil and renewable fuels consumed directly. The data for electric utilities includes all fuels (fossil, nuclear, geothermal, hydro, and other renewables) used by electric utilities.

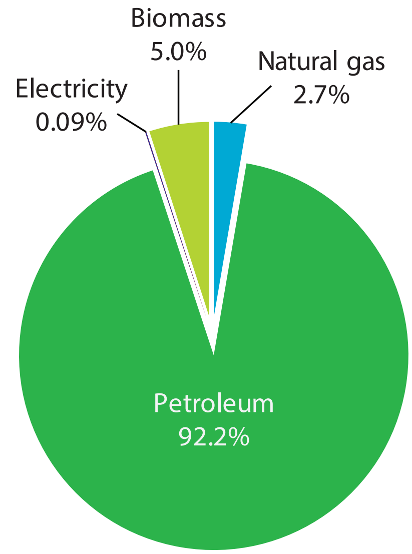
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 4-2, available at www.bts.gov as of August 2018.

Transportation remains the dominant consumer of petroleum in the U.S. economy, consuming petroleum at the rate of 6,000 gallons per second and accounting for 71.6 percent of total petroleum consumption in 2017, the highest level since 2009 [USDOE EIA 2018]. Between 2000 and 2017, transportation petroleum use increased 7.8 percent while petroleum use in other sectors decreased 12.5 percent. At the same time, U.S. dependence on petroleum imports decreased to 19 percent—the lowest level since 1967 (18 percent). Increased domestic production is the largest factor, but overall improvement in transportation energy efficiency since 2005 is also responsible.

Energy Use Patterns and Trends

Petroleum is the largest provider of energy for transportation, supplying over 90 percent of transportation's energy since 1954. Transportation continues to rely on petroleum for 92 percent of its energy requirements, despite recent gains by natural gas, biofuels, and electricity. Combustion of petroleum in internal combustion engines accounts for nearly all the pollutant emissions from the transportation sector. In 2017 the U.S. transportation sector used 25.9 quads of petroleum, 1.4 quads of fuels derived from biomass, 0.76 quads of natural gas, and 0.026 quads of electricity (figure 7-2). The great majority of biomass fuel used in transportation is in the form of ethanol blended at 10 percent or less (by volume) with almost all gasoline sold for highway use throughout the United States. Since 1975 growth in transportation energy use has been slowed by periodically higher energy prices, increasing energy efficiency across all modes and, most recently, by the Great Recession (December 2007 to June 2009) and its consequences. Since 1980 transportation and electric power generation have been the only sectors whose energy use has increased. However, transportation energy use today is slightly lower than it was a decade ago (figure 7-1).

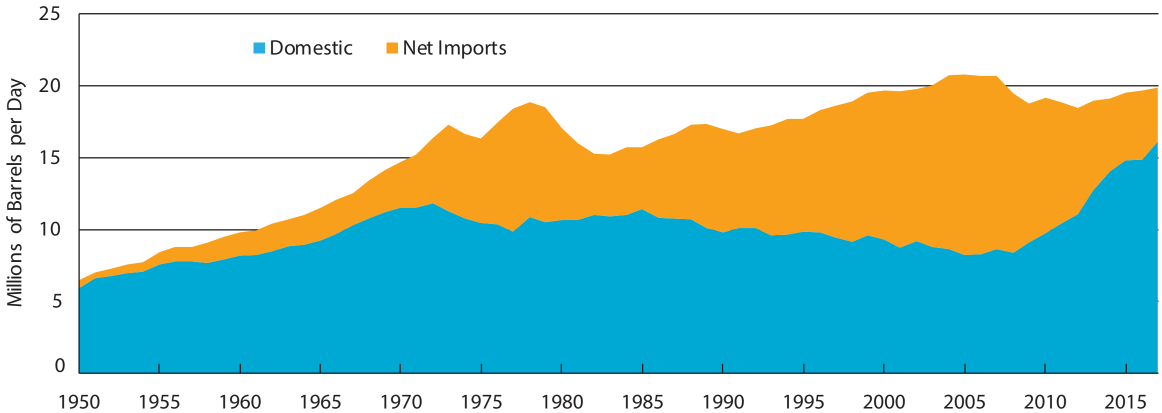
FIGURE 7-2 Transportation Energy Use by Fuel Type: 2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 4-4, available at www.bts.gov as of August 2018.

While transportation's dependence on petroleum continues to exceed 90 percent, U.S. dependence on imported petroleum has decreased dramatically since peaking at 60 percent in 2005 (figure 7-3). Increased domestic production, especially from tight oil formations, is primarily responsible for the rapid decline in U.S. imported petroleum dependence since 2005. U.S. petroleum consumption remains below its 2005 level due to the effects of the Great Recession and its aftereffects and increased energy efficiency.

FIGURE 7-3 U.S. Petroleum Net Imports and Domestic Supply: 1950–2017



SOURCE: U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, Table 3.1, Available at www.eia.gov/ as of July 2018.

Reduced dependence on imported oil has substantially improved U.S. energy security, yet concerns about the vulnerability of fuel supply chains and the ability of the energy system to withstand shocks and disruptions remain (USDOE 2017).

The growth of U.S. oil supply from 6.8 million barrels per day in 2006 to 12.8 in 2015 contributed to a major decrease in world oil prices, reducing the cost of energy to the transportation sector. The average price of a barrel of oil fell from over $100 in 2013 to $40 in 2016. But by 2017 world oil prices had increased to about $49 per barrel before rising again to $60–$70 per barrel in 2018 [USDOE EIA 2018b] despite U.S. oil supply increasing to an historic high of 13.1 million barrels per day (table 7-1). Each $20 increase per barrel of oil adds about $0.50 to each gallon of gasoline [USDOE EIA 2018e] and increases the average cost of highway vehicle travel by almost $0.03 per mile.[2]

[2] Based on an average of 17.9 miles per gallon for all highway vehicles (USDOT 2016a).

The distribution of transportation energy use by mode has changed little since 1990 (as shown in figures 7-4). The largest change was in the increased share of heavy-duty highway vehicles, from 15.4 percent of total transportation energy use in 1990 to 22.7 percent in 2016. During this period, heavy-duty vehicle-miles of travel (vmt) doubled while, in contrast, light-duty vehicle vmt increased by 44 percent. Due to steadily improving energy efficiency, the fraction of transportation energy used by air transport decreased despite substantial growth in both passengers and freight. Although railroads transport 33 percent of U.S. ton-miles of freight [USDOT BTS 2018a], rail accounts for less than 2 percent of transportation energy use.

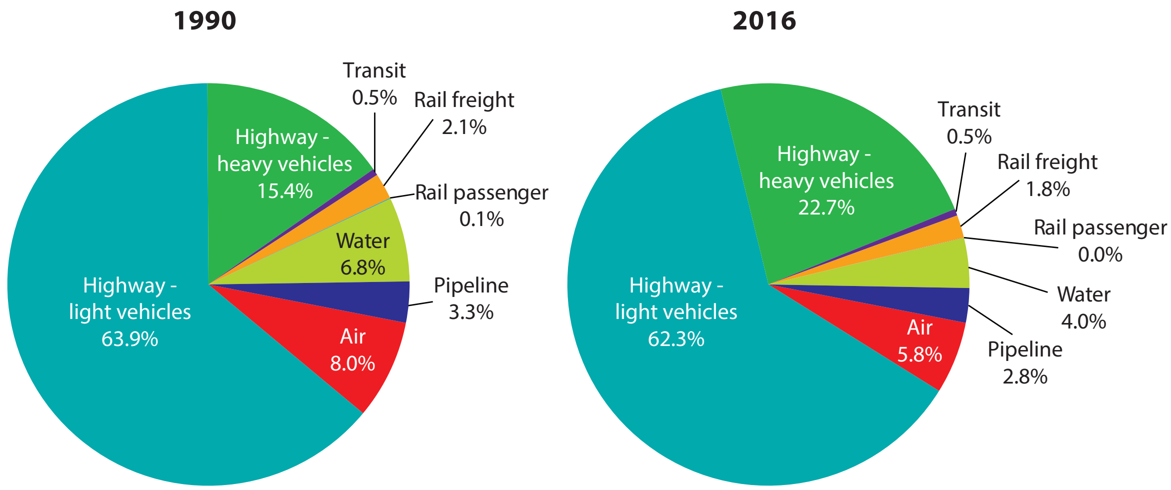
Since 2000 diesel (or distillate) fuel consumption by transportation has grown at a faster rate than gasoline consumption. Between 2000 and 2017, gasoline use increased 7.2 percent, to 137.6 billion gallons, while diesel use grew 23.4 percent, reaching 45.8 billion gallons [EIA, 2018a]. In the United States

TABLE 7-1 Transportation Energy Use, Reliance on Petroleum and World Oil Prices (2017 inflation-adjusted dollars): 2000, 2010, 2017

	2000	2010	2017
World Oil Price ($2017/bbl)	**$38**	**$85**	**$49**
U.S. Oil Supply (mmbd)	**19.7**	**19.2**	**19.9**
Domestic	9.3	9.7	16.1
Imported	10.4	9.4	3.7
Imported (percent)	52.9%	49.2%	18.8%
Transportation Energy (quads)	**26.6**	**27.1**	**28.2**
Petroleum	25.7	25.2	25.9
Biomass	0.1	1.1	1.4
Natural Gas	0.7	0.7	0.8
Electricity	0.1	0.1	0.1
Petroleum (percent)	97.0%	93.3%	92.2%

SOURCES: U.S. Department of Energy, Energy Information Administration, 2018a *Monthly Energy Review*, Table 3.1 and 2018c *Annual Average Imported Crude Oil Price*, Available at www.eia.gov/ as of July 2018.

FIGURE 7-4 Transportation Energy Use by Mode: 1990 and 2016



NOTES: The following conversion rates were used: Jet fuel = 135,000 Btu/gallon. Aviation gasoline = 120,200 Btu/gallon. Automotive gasoline = 125,000 Btu/gallon. Diesel motor fuel = 138,700 Btu/gallon. Compressed natural gas = 138,700 Btu/gallon. Distillate fuel = 138,700 Btu/gallon. Residual fuel = 149,700 Btu/gallon. Natural gas = 1,031 Btu/ft3. Electricity 1kWh = 3,412 Btu, negating electrical system losses. To include approximate electrical system losses, multiply this conversion factor by 3.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-6, available at www.bts.gov as of August 2018.

diesel is the predominant fuel of choice for medium- and heavy-duty trucks and buses, accounting for 89.4 percent of fuel use by those vehicles in 2015. Diesel comprised a relatively small fraction of energy use by passenger cars (0.6 percent) and light trucks (4.5 percent) in 2015, shares that had changed little since 2000 (0.6 and 3.8 percent, respectively) [Davis et al., 2018; 2002]. Likewise, diesel engines make up 0.6 percent of passenger car and light truck sales, mostly in the larger and heavier light truck market segments [hybridcars.com, 2018]. The U.S. picture is quite different from that in the European Union (EU) where nearly half of passenger car sales have been diesels. Diesel light-duty vehicles have been hindered in the U.S. light-duty market by lower gasoline prices and tight emissions standards [NRC 2015]. The discovery of deceptive emissions testing practices for some diesel vehicles in 2015 was followed by declines in diesel light-duty vehicle sales in the United States of 29.9 percent from 2015 to 2016 and of 18.7 percent from 2016 to 2017 [hybridcars.com 2018]. The market share of diesel passenger cars in the EU fell from 49.9 percent in 2016 to 44.8 percent in 2017 [ACEA 2018].

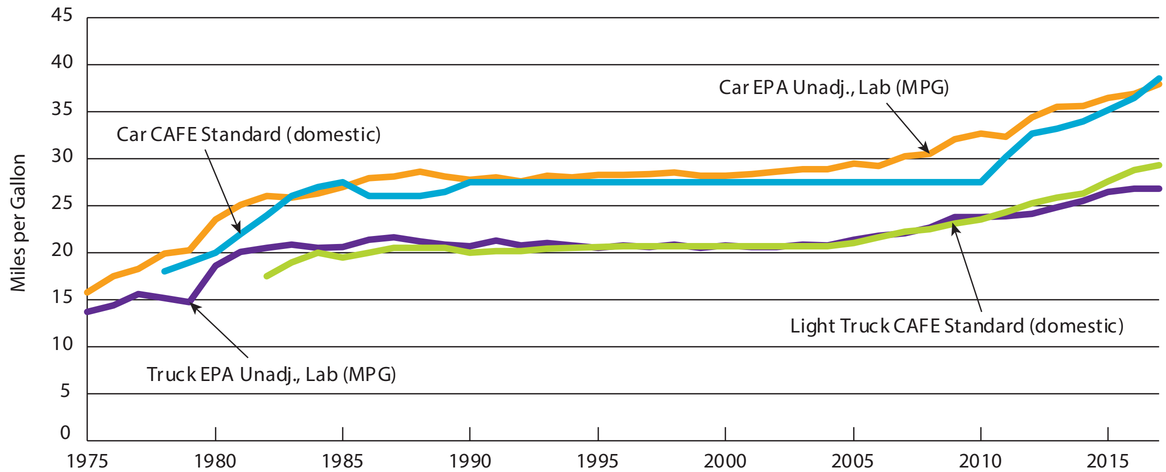
Energy Efficiency

Transportation energy efficiency continues to improve, enabling greater mobility at lower cost and with reduced environmental impact. Energy efficiency is the ratio of the amount of transportation activity to the amount of energy required to accomplish it. Commonly used measures include vehicle-, passenger- or ton-miles per gallon or per Btu. Improvements in energy efficiency can be made via operational measures, such as increased vehicle occupancy, improved traffic flow, and reduced idling or by advances in vehicle technology.

The fuel economy (miles per gallon) of new passenger cars and light trucks has increased episodically, closely following fuel economy and greenhouse gas emissions standards (as shown in figure 7-5). The values shown in figure 7-5 are laboratory test cycle values on which compliance with the standards is based. The fuel economy achieved in actual use by motorists differs due to traffic conditions, driving style, trip lengths, ambient temperatures, and other factors [Greene et al. 2017]. For this reason, the fuel economy estimates on vehicle window stickers, websites like www.fueleconomy.gov, and those used in advertising are adjusted downward to better represent the miles per gallon the average U.S. motorist would experience on the road. Starting in 1984, test cycle mpg estimates were reduced by approximately 15 percent, depending on the vehicle's city and highway test cycle results [Greene et al. 2017]. In 2008 the estimated on-road shortfall was increased to about 20 to 25 percent. Despite the importance of verifying that mpg improvements on test cycles translate into meaningful on-road fuel savings, there is currently no comprehensive and rigorous source of data on the real-world fuel economy of motor vehicles.

Fuel economy standards established in 1975 required automobile manufacturers to increase the sales-weighted average fuel economy of their new passenger cars to 27.5 miles per gallon (mpg) by 1985. The passenger car standard was briefly lowered to 26.0 mpg in 1986 after the

FIGURE 7-5 Car and Light Truck Corporate Average Fuel Economy (CAFE) and Miles per Gallon (MPG): Model Years 1975-2017



KEY: MPG = Miles per Gallon; EPA = U.S. Environmental Protection Agency.

NOTE: Corporate Average Fuel Economy (CAFE) standards, which must be met at the manufacturer level were established by the U.S. Energy Policy and Conservation Act of 1975 (PL 94-163).

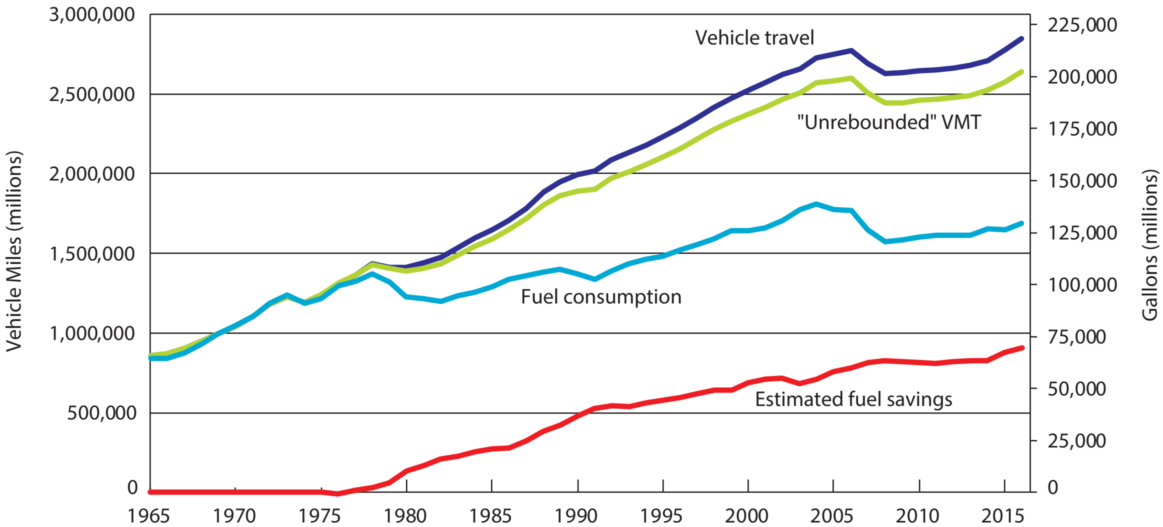
SOURCE: As cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-23, available at www.bts.gov as of August 2018.

collapse of world petroleum prices but restored to 27.5 in 1990. New light trucks were required to achieve 20.5 mpg by 1987. With minor adjustments in the light truck standard, the fuel economy requirements remained essentially unchanged through 2004 for light trucks and 2010 for passenger cars. By rulemaking, the Department of Transportation increased the light truck standard to 21.0 mpg in 2005 and gradually raised it to 29.3 mpg in 2017. The form of the standards was also changed to index each manufacturer's mpg requirement to the size of the vehicles it sold. The size was measured by a vehicle's "footprint," the product of its wheelbase and track width. The footprint metric was later incorporated into the passenger car standards by the Energy Independence and Security Act of 2007. In 2010 the USDOT and U.S. Environmental Protection Agency (USEPA) jointly issued fuel economy and greenhouse gas emissions standards requiring increases in fuel economy and reductions in greenhouse gas emissions through 2016; in 2012 the Agencies required continued improvements to 2025 [USEPA and USDOT NHTSA 2017]. In 2018 the Agencies issued a notice of proposed rulemaking that would freeze the standards at 2020 levels [USEPA and USDOT NHTSA 2018].

Fuel economy improvements from 1975 to 2016 have substantially reduced fuel use by light-duty vehicles, saving 1.5 trillion gallons of gasoline [Greene 2017]. Federal Highway Administration [USDOT FHWA 2017] estimates show that prior to 1975, vehicle-miles traveled (vmt) and fuel use by passenger cars and light trucks progressed at the same rate (figure 7-6). After 1975 vehicle travel and fuel use diverged as fuel economy increased. The divergence primarily reflects fuel savings as increases in mpg outpaced vehicle-miles traveled even as vehicle-miles increased, induced by the reduced cost of fuel, a phenomenon known as the "rebound effect." Published studies provide a range of estimates of the size of the rebound effect with a consensus that a 10 percent increase in fuel economy would result in an increase of vmt by 0.5 to 2.5 percent (5 to 25 percent of the increase in mpg) [Gillingham et al. 2016]. The fuel savings shown in figure 7-6 assume a rebound effect of 15 percent as the midpoint of the range. Estimating fuel use with the "unrebounded" vmt trajectory,[3] cumulative savings from light-duty vehicle fuel economy improvements from 1975 to 2017 amount to 1.7 trillion gallons. Savings in 2016 alone were almost 70 billion gallons. Rebound effects of 25 and 5 percent produce savings estimates of 1.4 to 1.9 trillion gallons, respectively. At the 2016 rate of gasoline consumption, 1.7 trillion

[3] Because increased fuel economy reduces the cost of vehicle travel, vehicle-miles of travel increase. Estimates vary, but a 10 percent reduction in fuel costs per mile will result in an increase in vehicle travel in the range of 0.5 to 2.5 percent. If fuel economy had not improved from 1975 to 2016, there would have been less vehicle travel. Reducing the actual vehicle travel to remove the rebound effect is the "unrebounded" vmt. Estimated fuel savings are the difference between the gallons that would have been consumed at the unrebounded level of vmt and the actual fuel consumption (red line).

FIGURE 7-6 Vehicle Miles of Travel and Fuel Use by Light-duty Vehicles: 1965–2016



NOTES: Includes passenger cars, light trucks and motorcycles for year 1965. The definition of light-duty vehicle was changed after 2006, affecting the vehicle types included in the personal vehicle category. *Unrebounded vehicle travel* incorporates a reduction in the actual vehicle travel to remove the "rebound effect," the increase vehicle-miles of travel due to the reduction in fuel cost per mile as a result of increased fuel economy. *Estimated fuel savings* are the difference between the gallons that would have been consumed at the unrebounded level of VMT and the actual fuel consumption.

SOURCE: Data - U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (multiple years), Table VM-1, available at www.fhwa.dot.gov/ as of August 2018. **Methodology** - Greene, D.L., *A Trillion Gallons of Gasoline*, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee, available at http://bakercenter.utk.edu/ as of August 2017.

gallons of gasoline is enough to power all the passenger cars and light trucks in the United States for 13 years. In terms of avoided CO2 emissions, 1.7 trillion gallons equals 15 billion metric tons. [4]

In 2011 the USDOT National Highway Traffic Safety Administration (NHTSA) and U.S. Environmental Protection Administration (EPA) established fuel economy and greenhouse gas (GHG) standards for new medium- and heavy-duty vehicles with gross vehicle weights above 8,500 lbs. for model years 2014 to 2018 [USEPA and USDOT NHTSA 2011]. Three main categories of vehicles were covered by the rulemaking, including combination tractors, heavy-duty pickup trucks and vans, and vocational vehicles,[5] a highly varied category including both trucks and buses. The standards varied by size and function of vehicle, requiring GHG reductions of 9 to 23 percent for combination tractors, 12 to 17 percent for heavy-duty pickups and vans, and 6 to 95 percent for vocational vehicles [USEPA and USDOT NHTSA 2011].

As of 2016 the impacts of the medium- and heavy-duty vehicle standards on truck and bus fuel consumption were not evident in the Federal Highway Administration's (FHWA's) vehicle travel and fuel use data [USDOT FHWA 2017]. This lack of impact is partly because the standards had only been in effect for 3 years and partly because of the moderate size of the initial fuel economy improvements. The FHWA data show only a 1 percent increase in average medium and heavy-duty fuel economy from 2010 to 2016, from 6.40 to 6.46 miles per gallon [USDOT FHWA 2017]. It is possible that the data and methods used to estimate medium- and heavy-duty vehicle travel and fuel use are not sufficiently precise to detect small changes in fuel economy. As is the case for light-duty vehicles, there is no comprehensive and rigorous source of data on the actual fuel economy of medium- and heavy-duty vehicles.

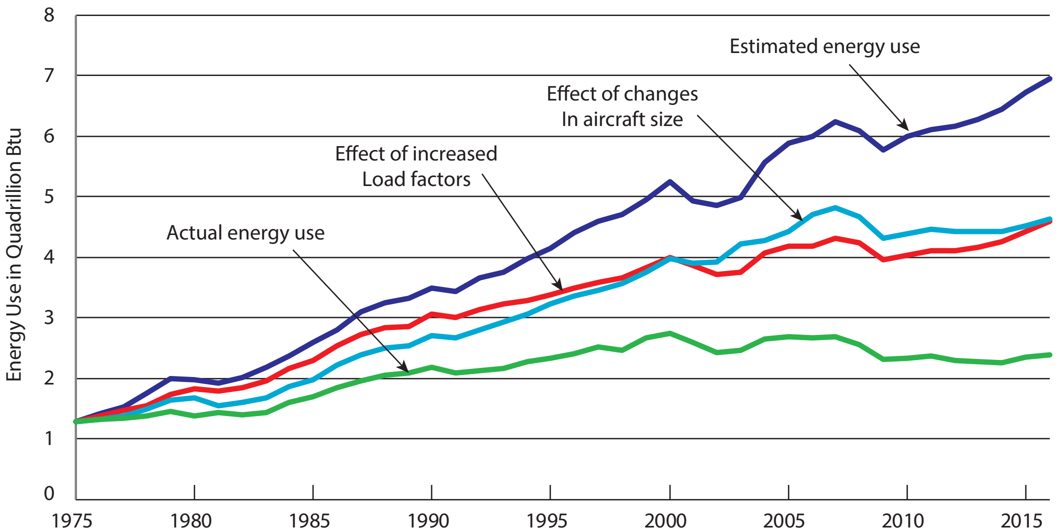
Passenger-miles and ton-miles per Btu are arguably better measures of the overall efficiency of passenger and freight transportation than vehicle-miles per gallon because they more fully represent system efficiency by including vehicle occupancy rates and load factors. However, vehicle occupancy rates are not available on an annual basis, and reliable annual data on freight truck load factors are also lacking.

In the absence of energy efficiency regulations, air transport has achieved even greater improvements in energy efficiency than highway vehicles through a combination of operational and aircraft efficiency improvements. Between 1975 and 2016, commercial air carriers reduced energy use per passenger-mile by 73.2 percent in domestic operations and 58.2 percent in international operations [USDOT BTS 2018a]. An analysis of the contributions of load factors (passenger-miles/seat-mile), aircraft size (seat-miles/aircraft-miles), and aircraft efficiency is shown in figure 7-7. The uppermost black

[4] Assumes 8,887 x 10^{-3} metric tons of CO_2 per gallon of gasoline [USEPA 2018].

[5] Vehicles with a gross vehicle weight rating (GVWR) above 8,500 pounds excluding heavy-duty pickup trucks and vans, medium duty passenger vehicles; and truck tractors, except vocational tractors, with a GVWR above 26,000

FIGURE 7-7 Effects of the Relative Change of Operational and Aircraft Efficiencies on Air Carrier Energy Use: 1975–2016



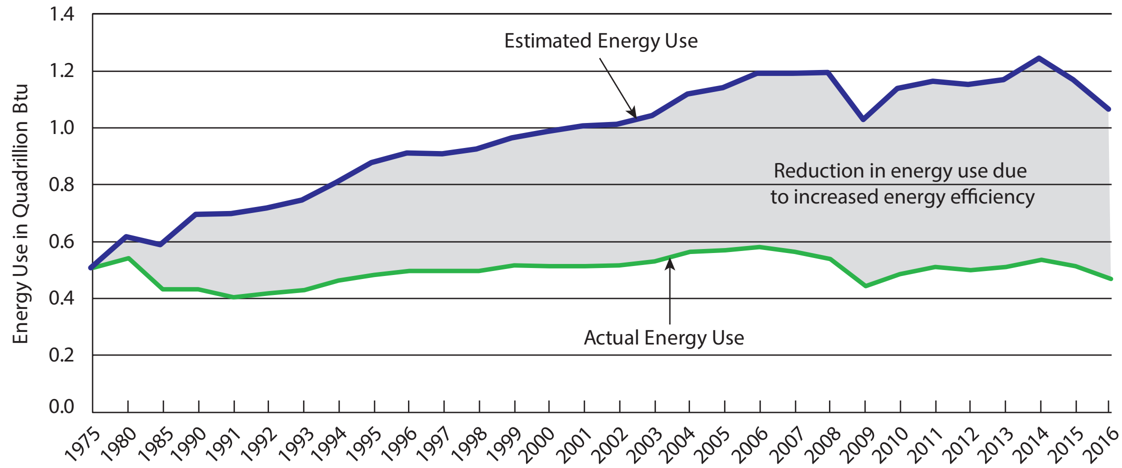
NOTES: **Estimated Energy Use** - Assumes Actual Passenger Miles But No Efficiency Improvements. **Effect of Increased Load Factors** – Assumes at 1975 Aircraft Size & Efficiency. **Effect of Changes in Aircraft Size** - Assumes Actual Load Factors.

SOURCE: Calculations based on data from - Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 36*, Table 9.2, available at https://cta.ornl.gov/ as of August 2018.

line shows what aircraft energy use would have been without any reduction in energy use per passenger-mile. For example, in 1975 173.3 billion revenue passenger-miles (p-m) were traveled at an average energy intensity of 7,404.6 Btu/p-m and a total energy use of 1.28 quadrillion Btu (quads), the starting point of all lines in figure 7-7. If the 939.2 billion passenger-miles traveled in 2016 had required the same 7,404.6 Btu/p-m as in 1975, air carrier energy use would have been 6.95 quads, the end point of the upper black line in figure 7-7. The red line shows what air carrier energy use would have been if only load factors had increased. The blue line adds the effects of changes in aircraft size. Initially, the trends show larger aircrafts and decreased energy use. Greater use of smaller regional jets eventually led to increased energy use, but by 2016 this trend had been reversed again with the net effect of aircraft size almost zero by 2016. The green line adds the effect of increased aircraft energy efficiency.

Although ton-miles carried by Class I railroads more than doubled from 1975 to 2007, rail freight energy use decreased by 7.8 percent [USDOT BTS 2018a]. In 1975 class I freight railroads transported 754 billion ton-miles (t-m) of freight at an average energy intensity of 672.49 Btu/t-m, using a total of 0.51 quads (figure 7-8). If the 1,585 billion ton-miles transported in 2016 had required the same amount of energy per ton-mile, Class I railroads would have used 1.07 quads instead of the 0.47 quads they actually used. Energy efficiency measured in terms of revenue ton-miles per Btu increased by 127.1 percent.

FIGURE 7-8 Effects of Car Loading and Efficiency on Rail Freight Energy Use: 1975–2016



NOTE: **Estimated Energy Use** - Assumes Actual Ton-Miles But No Reduction in Energy Use per Ton-Mile

SOURCE: Calculations based on data from - U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-25, available at www.bts.gov as of August 2018.

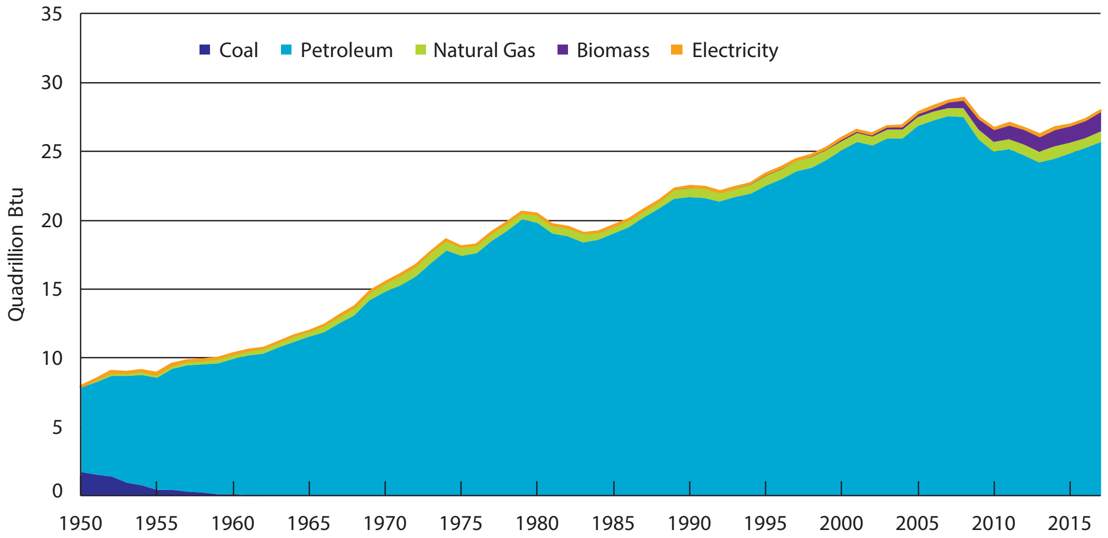
Higher load factors (tons carried per freight car) were a major contributor to the improved energy efficiency (as shown in figure 7-8). Technical improvements to locomotives and rail cars were also important factors. Rail freight revenue ton-miles decreased sharply in 2009 due to the economic recession and remained below the 2008 level in 2016.

Rail freight energy efficiency remained relatively constant from 2009 to 2016. Amtrak decreased the energy intensity of its rail passenger service by 42 percent from 2000 to 2016, including a 7 percent reduction from 2010 to 2016 [USDOT BTS 2018a]. Unfortunately, data are not adequate to evaluate the trends in energy intensity for the remaining water and pipeline transportation modes.

Alternative Fuels and Vehicles

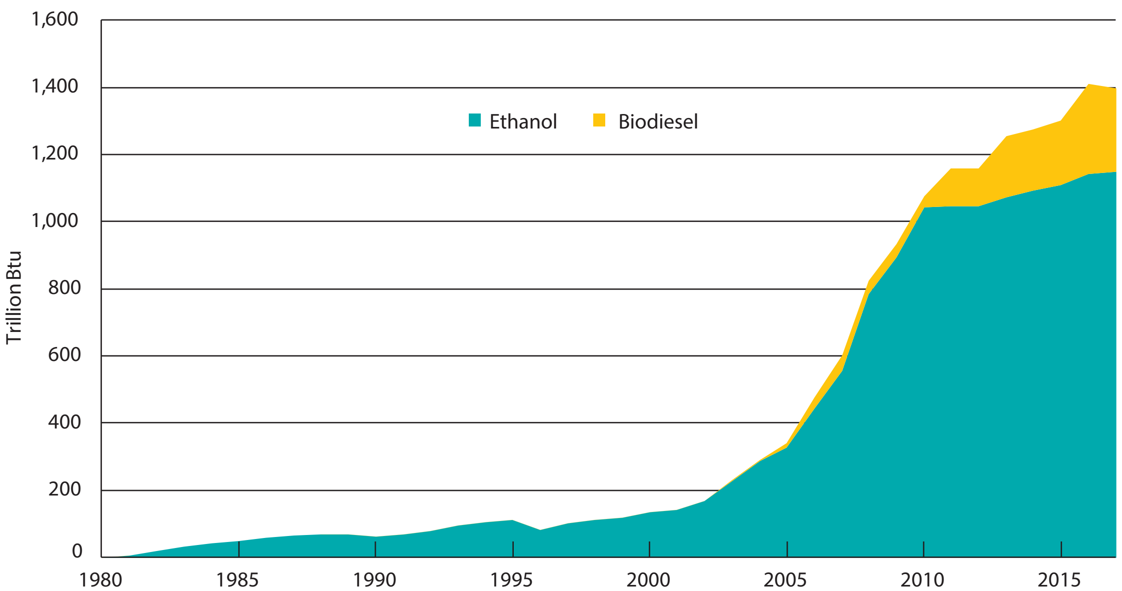
Although transportation continues to rely on petroleum for over 90 percent of its energy needs, alternative forms of energy, especially biofuels, natural gas, and electricity, are making a growing contribution (as shown in figure 7-9). After the virtual elimination of coal use in steam engines by 1960, petroleum supplied over 95 percent of transportation's energy until 2008. Driven by renewable fuels requirements, biofuel in the form of ethanol blended up to 10 percent by volume with nearly all gasoline sold in the United States increased from 0.13 quads in 2000 to 1.04 quads in 2010 and 1.15 quads in 2017 (as shown in figure 7-10). Many gasoline-powered vehicles, in particular model years older than 2011, were not designed to tolerate ethanol blends higher than 10 percent by volume. A 1978 Clean Air Act waiver by the Environmental Protection Agency allowed use of ethanol in gasoline up to blends of 10 percent. In 2011 the EPA approved blends of up to 15 percent ethanol but only for model year 2001 or newer passenger cars, light

FIGURE 7-9 Transportation Energy Use by Fuel Type: 1950–2017



SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, Table 2.5, available at www.eia.gov/ as of July 2018.

FIGURE 7-10 Transportation Use of Biofuels: 1980–2017

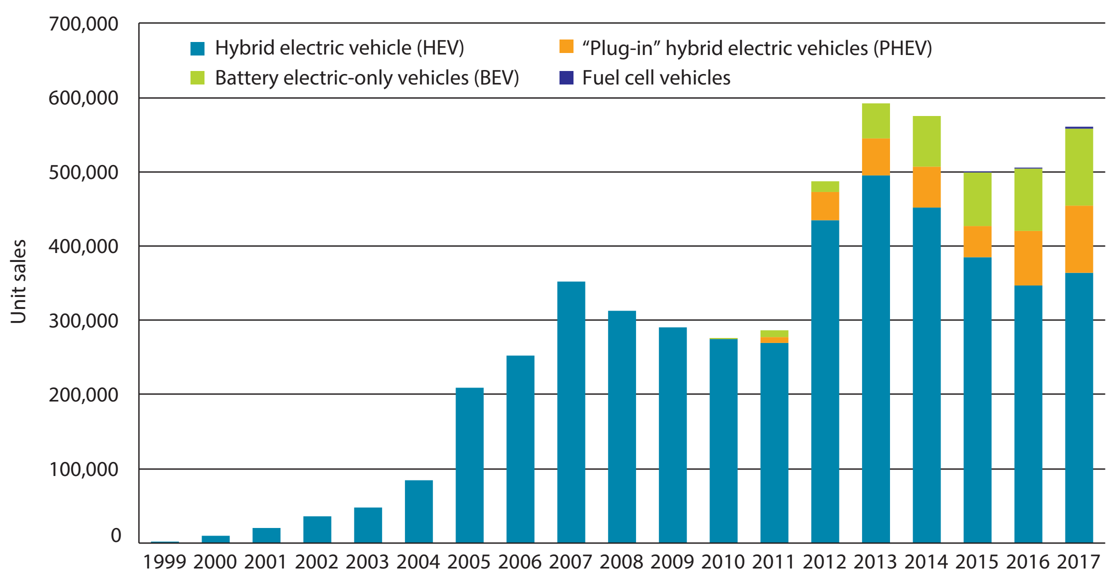


SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, Table 10.2b, available at www.eia.gov/ as of July 2018 trucks, and medium-duty vehicles (USEPA 2018d). Once nearly all U.S. gasoline was blended with 10 percent ethanol by volume, the growth of ethanol use slowed markedly. From negligible quantities prior to 2000, biodiesel blended at 5 to 20 percent with petroleum diesel increased from 0.001 quad in 2001 to 0.25 quad in 2017. Use of higher biodiesel blends in most diesel vehicles requires engine modifications.

Encouraged by low natural gas prices, abundant domestic supply, and efforts to improve urban air quality, natural gas use by buses and trucks increased from 2000 to 2013. Specifically, natural gas used in transportation increased from 0.67 quad in 2000 to a peak of 0.89 quad in 2013 [USDOE EIA 2018a]. Since then natural gas has lost ground partly because of lower oil prices, with only 0.76 quad used in 2017.

Electricity has supplied less than 1 percent of the energy for transportation since 1950. This may be about to change with the introduction of mass-market plug-in electric vehicles (PEV) by major automobile manufacturers, encouraged by government incentives, zero-emission vehicle requirements, and technological advances. The first mass-market battery-electric vehicles (BEVs) were introduced in 2011, 12 years after the first hybrid electric vehicle. Since then the number of PEV models has increased to 14 battery-electric and 27 plug-in hybrid electric product lines (figure 7-11) [USDOE USEPA 2018]. From initial sales of 10,000 battery-electric vehicles and 8,000 plug-in hybrid electric vehicles (PHEVs) in 2011, U.S. PEV sales increased tenfold to 200,000 in 2017, more than half of which were BEVs [USDOT 2018 and EVvolumes.com 2018]. Still, plug-in vehicles amounted to only 1.2 percent

FIGURE 7-11 Sales of Hybrid, Plug-in Hybrid and Battery Electric Vehicles: 1999–2017



NOTE: 2018 data are through the end of June.

SOURCE: HybridCars, December Dashboards, Annual Issues, available at https://www.hybridcars.com/ as of August 2018.

of U.S. vehicle sales and an even smaller fraction of the on-road vehicle population. An estimated 740,000 PEVs were on U.S. roads by the end of 2017, a little more than one-quarter of 1 percent of the approximately 270 million vehicles on U.S. highways [USDOT BTS 2018 and EVvolumes.com 2018]. The impacts of electric vehicles on U.S. gasoline consumption and gasoline tax revenues have been correspondingly small. Electric vehicles are estimated to have reduced U.S. motor fuel consumption by 215 million gallons in 2017, 0.1 percent of total U.S. motor fuel use in that year [Gohlke and Zhou 2018; USDOT FHWA 2017].

Advances in battery technology and manufacturing are changing the design and cost of PEVs. For example, when first introduced in 2011, the Nissan Leaf had an EPA-rated range of 73 miles. Enabled by advances in the energy density of electric vehicle batteries and reductions in manufacturing costs, the 2018 Leaf's range has more than doubled to 151 miles [USDOE and USEPA 2018]. The average range of BEVs sold in the United States increased to over 160 miles in 2017 [Gohlke and Zhou 2018]. At 335 miles per charge, the Tesla Model S has the longest range of commercially available EVs. The average electric range of PHEVS on the other hand, has remained within a band of 20 to 35 miles in the electric-only mode.

In addition to limited range and long recharging times, the greatest barrier to EV sales is the cost of batteries [NRC 2015]. But battery costs have declined rapidly over the past decade. From 2007 to 2014, the cost per kWh of battery capacity is estimated to have decreased from over $1,000 to $400 [Nykvist and Nilsson 2015] and to have fallen to $210-$240 per kWh in 2017 [Kapoor and MacDuffie 2017; Chediak 2017]. Cost reductions achieved to date reflect technological progress, as well as learning-by-doing and scale economies driven largely by the growth of the global market for PEVs. Worldwide sales of PEVs were 1.28 million in 2017, about 1.3 percent of global vehicle sales, with the largest markets in China and Europe [EVvolumes.com 2018]. Globally, more than 60 percent of PEVs sold are BEVs. The global PEV population was estimated to be 3.3 million vehicles at the end of 2017.

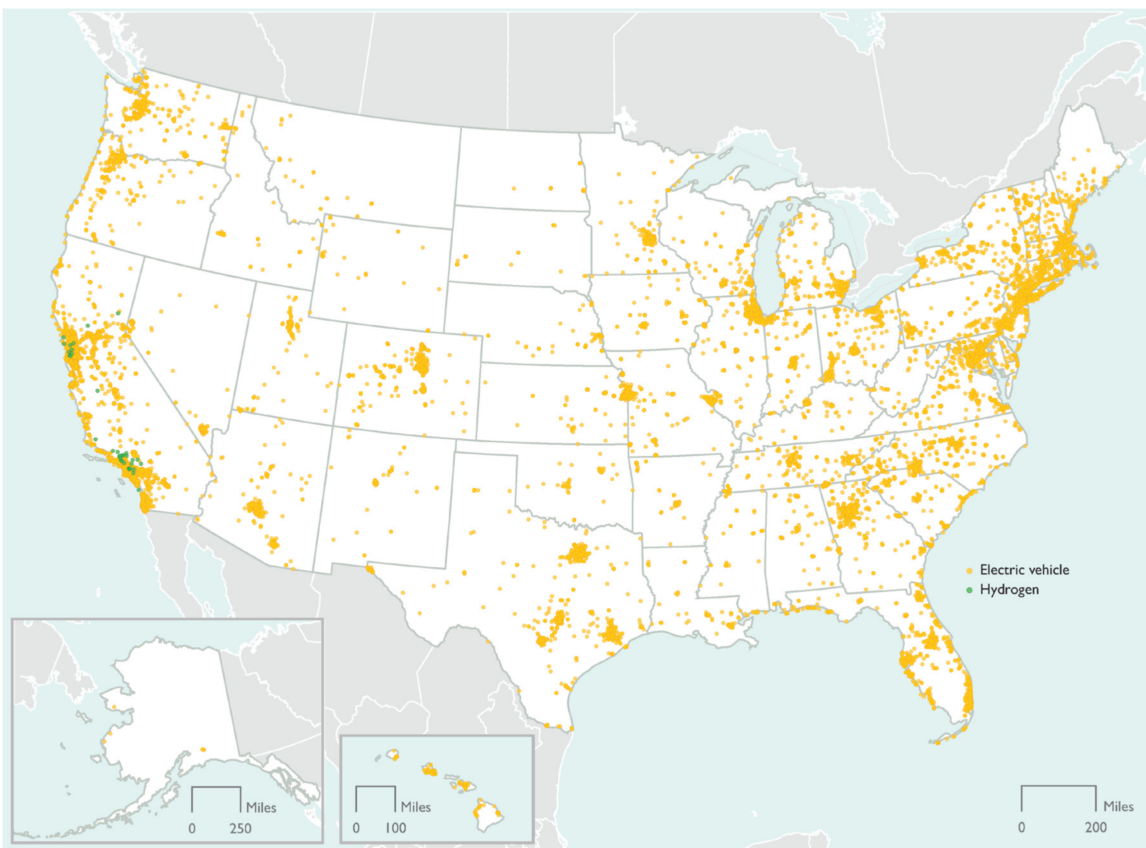
The lack of availability of public charging stations is another barrier to PEV sales [NRC 2015]. When the first two mass-market plug-in models were introduced in 2011, there were 687 electric vehicle (EV) charging stations in the United States, 433 of which were in California [USDOE 2013]. Today there are over 18,000 public EV charging stations in the United States (figure 7-12) [USDOE 2018a]. Of these, 2,320 are direct current fast chargers, capable of charging most BEVs to 80 percent of their battery capacity in less than 30 minutes. The remaining chargers would require 3 to 4 hours to deliver the same amount of electricity. PEV owners do 80 to 90 percent of their charging at home (INL, 2015). According to the California Vehicle Survey [CEC 2017], 56.6 percent of BEV owners and 39.7 percent of PHEV owners have installed home charging equipment.

Fuel cell electric vehicles (FCEV) powered by hydrogen are at a relatively early stage of market development. In contrast to BEVs, FCEVs have ranges of more than 350 miles and can be refueled in less than 10 minutes [USDOE AFDC 2018b]. Commercial sales of FCEVs to the public began in 2015 when 115 FCEVs were sold, essentially all in California. FCEV sales increased to 1,074 in 2016 and 2,313 in 2017. As of August 2018, a total of 4,925 FCEVs had been sold in the United States. Sales continue to be concentrated in California where manufacturers can obtain Zero Emission Vehicle credits and where nearly all the hydrogen refueling stations in the United States are located (as shown in figure 7-12). Thirty-five retail hydrogen refueling stations are now operating in California, with another 29 in development [CAFCP, 2018]. The state plans to have 200 hydrogen refueling stations in operation by 2025. Twenty-one fuel cell buses also operate in regular route service in California.

Greenhouse Gas Emissions

Transportation became the largest emitter of carbon dioxide (CO_2) emissions among all energy using sectors of the U.S. economy in 2016, overtaking electricity generation for the first time. Transportation's 28.2 quads of energy use and continued reliance on fossil

FIGURE 7-12 Electric Vehicle Charging Stations and Hydrogen Refueling Stations: 2018



SOURCE: U.S. Department of Energy, Alternative Fuels Data Center, *Alternative Fueling Station Counts*, available at http://www.afdc.energy.gov/ as of August 2018.

fuels made it the largest emitter of CO_2 again in 2017 (figure 7-13). Transportation's CO_2 emissions grew at 1.3 percent per year from 2012 to 2017, but emissions from electricity generation have been decreasing rapidly for more than a decade, largely due to the substitution of plentiful and low-cost domestic natural gas for coal. On an annual basis, emissions from electricity generation were 672 million metric tons lower in 2017 than in 2005. CO_2 emissions from every economic sector except transportation were significantly lower in 2017 than in 2005.

Transportation's greenhouse gas emissions are comprised almost entirely of carbon dioxide from the combustion of petroleum fuels. The shares of the four principle gases in CO_2 equivalent quantities are shown in figure 7-14, including indirect emissions of carbon dioxide from the generation of electricity used by transportation (eCO_2).

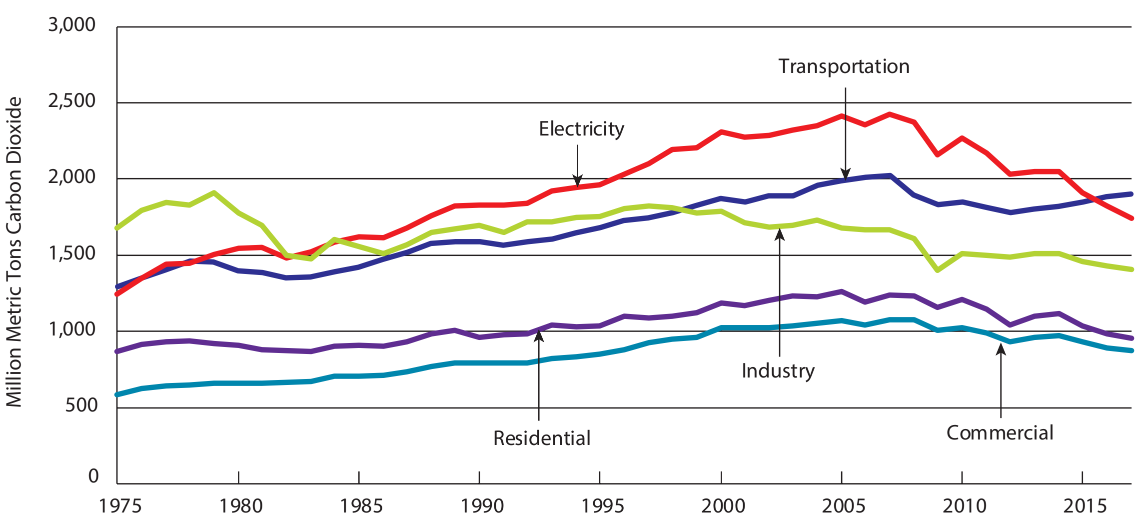
The second largest source of greenhouse gases are hydrofluorocarbons (HFCs) and other gases used as refrigerants in the air conditioners of transportation vehicles. Transportation emissions of HFCs are subject to environmental regulation and have been steadily decreasing since 2008 [USEPA 2018a].

Environmental Impacts

Air and Water Quality, Solid Waste, Habitat, and Noise Impacts

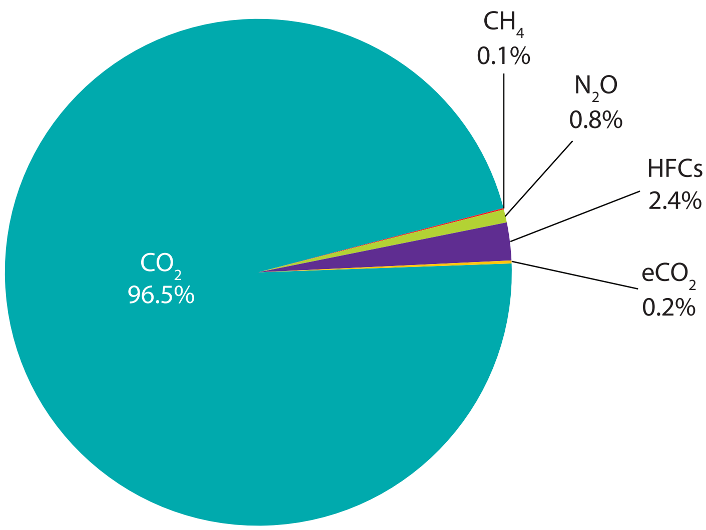
The transportation system's environmental impacts include pollutant emissions that affect local air quality, greenhouse gases, runoff that pollutes surface and ground water, solid waste from scrapped vehicles and demolished infrastructure, effects of infrastructure and vehicles on wildlife and their habitats, and noise.

FIGURE 7-13 U.S. Carbon Dioxide Emissions from Energy Consumption: 1975–2017



SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, Table 12.2-12.6, available at www.eia.gov/ as of June 2018.

FIGURE 7-14 Transportation's Greenhouse Gas Emissions by Gas: 2016



NOTES: The data for the transportation sector includes only fossil and renewable fuels consumed directly. The data for non-transportation includes the residential, commercial, and industrial sectors, which include only fossil fuels consumed directly, and electric utilities, which includes all fuels (fossil, nuclear, geothermal, hydro, and other renewables) used by electric utilities. Most renewable fuels are not included. Totals may not add to 100 percent due to rounding.

SOURCE: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017*, table 2-12 and table ES-6, available at www.epa.gov/ghgemissions/ as of March 2018.

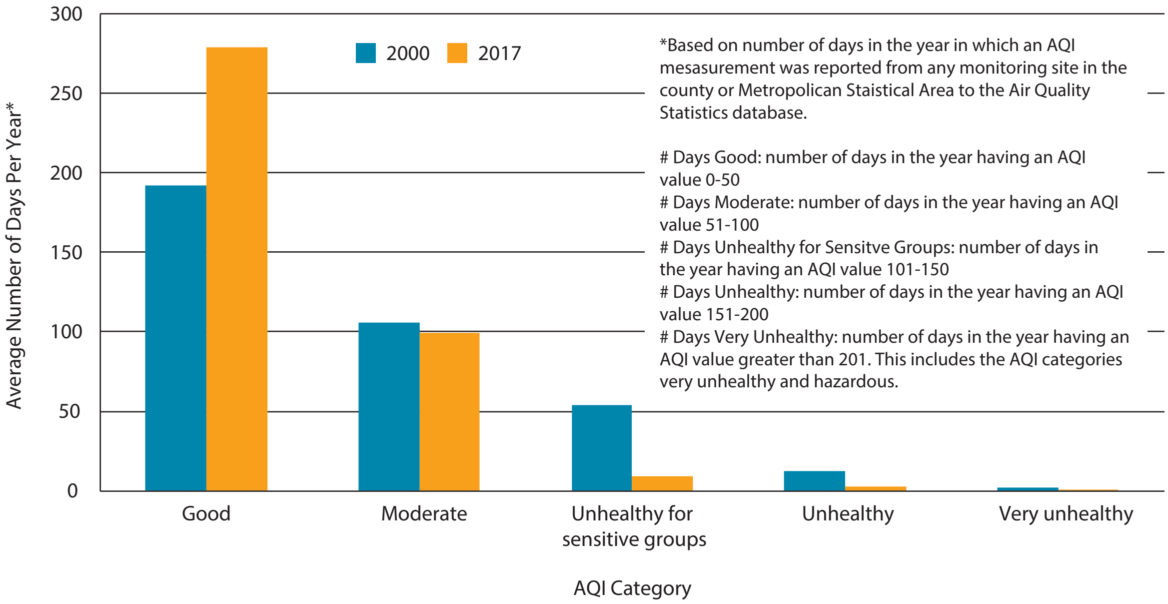
Transportation emissions of carbon monoxide (CO), oxides of nitrogen (NO_x), volatile organic compounds (VOC), particulate matter of 10 or 2.5 microns or less (PM10, PM2.5) and sulfur dioxide (SO_2) were all lower in 2017 than in 2010, despite a tripling of highway vehicle-miles of travel since 1970. This accomplishment has contributed to improved air quality in U.S. metropolitan statistical areas (MSAs).

In continuously monitored MSAs, 26 percent of cities experienced fewer than 10 days with an Air Quality Index (AQI) > 100 in 2010, but in 2016, 59 percent of the MSAs experienced fewer than 10 days of poor air quality. An AQI greater than 100 indicates that at least one of six major pollutants exceeded ambient air quality standards on the day in question. Across all cities for which AQI data are available, the number of days with good air quality has increased since 2000, while the number of days with unhealthy air has decreased substantially (figure 7-15).

Air quality measures vary from one year to the next due to weather and other factors, but the data shown in figure 7-15 are representative of overall annual trends toward improved air quality and the larger shift in favor of cleaner air (fewer days that violate air quality standards) in U.S. cities, especially between 2010 and 2016 [USDOT BTS 2018a].

The U.S. EPA estimates that 39 million people live near ports, many of which are in areas in non-attainment of air quality standards [USEPA 2016]. Pollutants from diesel engines

FIGURE 7-15 Air Quality Index (AQI) Across U.S. Cities: 2000 and 2017



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-51, available at www.bts.gov as of August 2018.

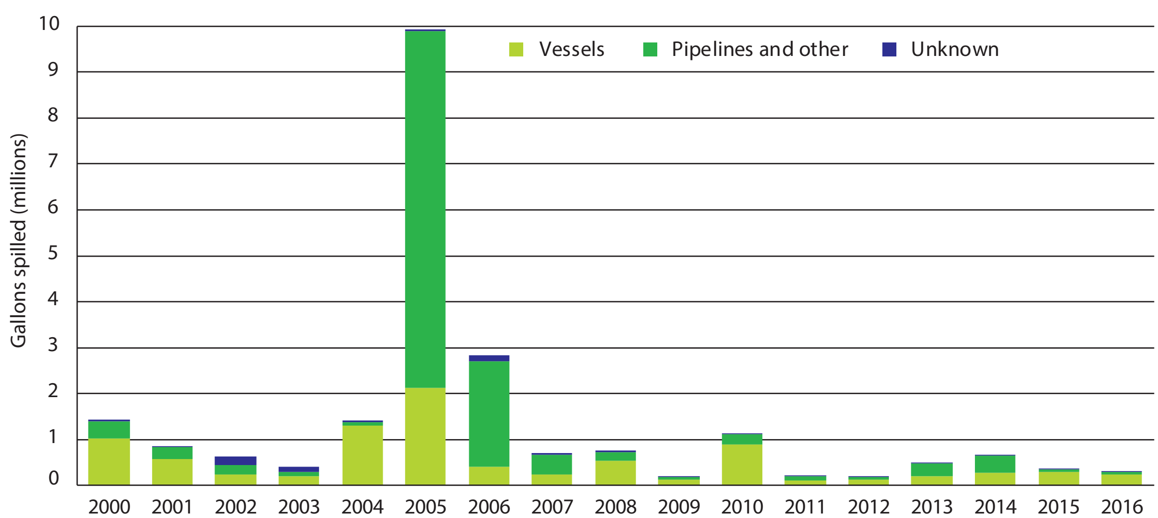
in ocean-going vessels, harbor craft, drayage vehicles, cargo handling equipment, and railroads include particulate matter, NO_x, ozone, air toxics, CO_2 and black carbon particulates. Key control strategies include replacement of older diesel engines with newer, cleaner diesels; installing exhaust gas cleaning systems; reducing the sulfur content of diesel fuels; substituting liquefied natural gas for diesel fuel; reducing idling by ships, trucks, and other equipment; and increasing the use of port electric power by ocean-going vessels [USEPA 2016b]. At the Port of Los Angeles, these actions and others, such as the electrification of vehicles and equipment, reduced NO_x emissions by 57 percent, PM emissions by 87 percent, and sulfur dioxide emissions by 98 percent between 2005 and 2016 [Port of Los Angeles 2017]. Over the same period, container throughput at the port increased by 18 percent. The EPA projects that these and other strategies will reduce PM and NO_x emissions at U.S. ports by about 40 percent by 2020 [USEPA 2016a].

In the decades before the year 2000, highway vehicles were the predominant source of carbon monoxide emissions and smog-forming volatile organic compounds and nitrogen oxides. But dramatic reductions in vehicle emissions, driven by repeatedly tightened emissions regulations, have steadily decreased emissions of these pollutants by motor vehicles despite a near tripling of highway vehicle travel since 1970 (as shown in table 7-2). By 2017 highway vehicles were a minor source of all three types of pollutant. Emissions of carbon monoxide and volatile organic compounds from highway vehicles, largely a result of incompletely combusted fuel in vehicle exhaust, were reduced to 11 percent of their 1970 levels in 2017. Emissions of NO_x were reduced by almost 70 percent over the same period. Emissions from off-highway vehicles, including other modes as well as agricultural, construction, and recreational vehicles, were also reduced but by smaller amounts.

Sources of surface and ground water pollution from transportation include spills of crude oil and petroleum products from pipelines, ships and barges, railroad cars and tank trucks, and run-off from roads and other transportation infrastructure. Figure 7-16 shows that the quantities of petroleum spilled into navigable waterways are highly variable from year to year because they are strongly affected by a few extreme events. In general, quantities spilled have been decreasing over time with the important exceptions of the spills associated with Hurricane Katrina in 2005, when over 200 million gallons are estimated to have been released. Spills in 2016 decreased to 302,000 gallons from 361,000 gallons in 2015, as the number of incidents decreased from 2,873 to 2,663 [USDOT BTS 2018a].

Underground fuel storage tanks may leak, contaminating soil and groundwater. In 1985 the EPA began regulating underground storage tanks and requiring improved designs and cleanup of identified leaks. Between 1990 and 1991, 39,288 new leaks were identified. By 2001 the annual number of new leaks had

FIGURE 7-16 Petroleum Spills Impacting Navigable Waterways: 2000–2016



NOTES: The spike in gallons spilled for 2005 can be attributed to the passage of Hurricane Katrina in Louisiana and Mississippi on Aug. 29, 2005, which caused numerous spills approximating 8 million gallons of oil in U.S. waters. The largest spill in U. S. waters began on Apr. 20, 2010, with an explosion and fire on the mobile offshore drilling unit (MODU) DEEPWATER HORIZON. Subsequently, the MODU sank, leaving an open exploratory well to discharge crude oil into the Gulf of Mexico for several weeks. The most commonly accepted spill amount from the well is approximately 206.6 million gallons, plus approximately 400,000 gallons of oil products from the MODU. The totals in this table may be different from those that appear in the source, due to rounding by the source.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-54, available at www.bts.gov as of August 2018.

dropped to 6,526. Between 2016 and 2017, 5,773 new leaks from underground storage tanks were found—a decrease of 12 percent [USDOT BTS 2018a]. By the end of 2017, 87 percent of all leaks from underground storage tanks had been cleaned up.

Runoff from roads, parking lots, bridges, ports, and other transportation infrastructure is a source of both surface water and groundwater pollution. Sediment in runoff from road construction can affect stream habitats and obstruct waterways. The EPA lists heavy metals, oils, other toxics, and road salt as pollutants in runoff from transportation facilities. Salt applied to roadways as a de-icing agent has been identified as a major source of chloride in groundwater, streams, and lakes in North America [Dugan et al. 2017]. Each year about 20 million tons of salt, amounting to 40 to 50 percent of total U.S. salt use, are spread on U.S. roads as a deicing or anti-icing agent [USDOT FHWA 2017b]. A recent study of 371 freshwater lakes in North America found that most urban lakes and rural lakes surrounded by more than 1 percent impervious land cover showed increasing chloride concentrations and were likely to exceed the EPA's threshold for chloride exposure within the next 50 years if current trends continue [Dugan et al. 2017]. Most alternatives to sodium chloride also include soluble chlorine and are more expensive than conventional road salt. Because of the importance of road salt for safety in snowy and icy conditions, mitigation measures focus on reducing the amount of salt used. Measures include using weather information systems to avoid unnecessary application, calibration of quantities and application equipment for more precise application, pre-salting with brine, and targeted substitution of more expensive de-icing compounds [USDOT FHWA 2017b].

Transportation vehicles and infrastructure are major sources of solid waste that can be recycled, combusted, or placed in landfills. The Asphalt Industry Association estimates that 182 million tons of used asphalt were removed from U.S. roads in 2017, of which 80 million tons were recycled as paving material, while 102 million tons were stockpiled for future recycling [Williams et al. 2018]. Recycled asphalt pavement as a percent of asphalt used to pave U.S. roads increased from 15 percent in 2009 to 20 percent in 2017. In addition, 1.4 million tons of asphalt shingle waste were recycled in hot and warm-mix asphalt mixtures.

Over 17 million new vehicles were sold in 2017, and an approximately equal number of the 270 million vehicles in operation were scrapped. More than 95 percent of scrapped vehicles are recycled in some way [SPI 2016]. Approximately 84 percent of the material content of scrapped vehicles is either reconditioned as replacement parts, recycled as steel (about 60 percent of a motor vehicle is steel or iron), recycled as other materials, or used to produce energy [SPI 2016 ARA 2018]. Parts that wear out before the end of a vehicle's life are also intensively recycled by reconditioning for resale. The EPA estimates that 99 percent of lead acid batteries and 40 percent of motor vehicle tires were recycled in 2015 (the most recent year for which data are available). About half of all scrapped tires are burned and the energy recovered for other purposes. Automotive materials not reused, remanufactured, or recycled are converted to automotive shredder residue (ASR). Approximately 5 million tons of ASR are placed in landfills each year. Recycling ASR has proven challenging because of the heterogeneity and complexity of its composition, and because it also contains small amounts of heavy metals.

Roads and other transportation infrastructures affect wildlife via roadkill and damage to habitats. Linear structures, like highways and rail lines, can fragment habitats by impeding the movement and migration of wildlife. Projects undertaken to mitigate such impacts include salamander and badger tunnels under roads, mountain goat underpasses, and fish passes through culverts. An estimated 323,000 motor vehicle crashes involved collisions with animals in 2004 [Najm et al. 2007]. Crashes with animals are reported to have caused 189 human fatalities in 2016, the same as in 2015 and typical of the past 15 years [IIHS 2018].

Noise from transportation vehicles is produced by internal combustion engines, exhaust, tires, and aerodynamic drag. Unwanted noise can not only be annoying but can disrupt sleep, interfere with communication, and have adverse impacts on academic performance and health. At highway speeds tires are the major source of motor vehicle noise, while exhaust noise from jet engines and aerodynamics predominate for aircraft. Since 1963, 7.4 billion dollars have been spent on 3,284 miles of noise barriers to shield communities from highway noise [USDOT BTS 2018a]. At a cost of $273 million, 120 miles of noise barriers were constructed in 2016, an increase of 42 miles over 2015.

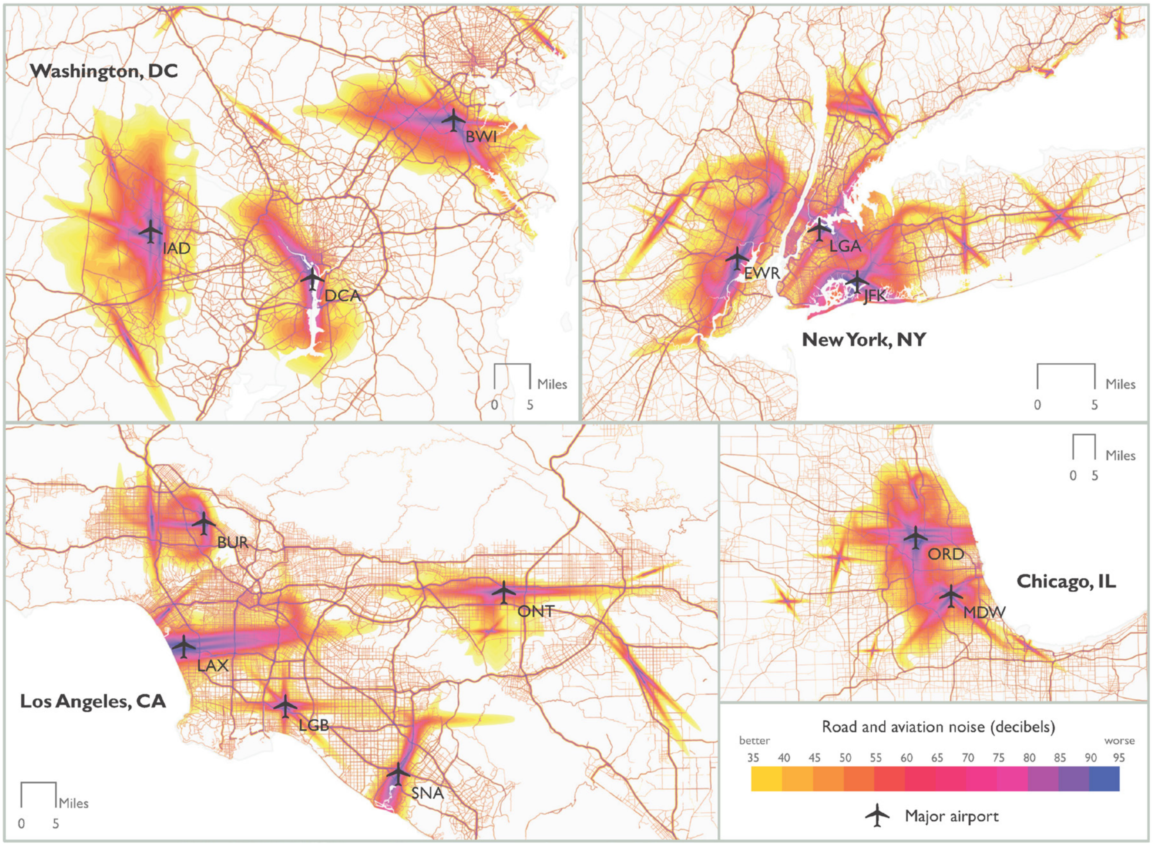
Although highways are the most pervasive source of transportation noise, exposure to transportation noise is systematically measured over time only for aircraft. According to the Federal Aviation Administration (FAA), the number of people living in areas with significant levels of aircraft noise (greater than 65 decibels, louder than conversational speech) decreased from 7 million in 1975 to 874,000 in 2000. The reductions were achieved by a combination of improvements to aircraft engines, airframes, and operating strategies during take-off and landing. However, exposure to aircraft noise has been gradually increasing since 2010. In 2017 an estimated 408,000 people lived in areas with high levels of aircraft noise (greater than 65 decibels), an increase from 343,000 in 2016.

A national picture of the exposure to transportation noise for both highways and airports is provided in the BTS National Transportation Noise Map (as shown below in figure 7-17 for select cities). BTS estimates are based on a separate methodology that include both aviation and highway noise on a comprehensive national scale and use a different exposure threshold (e.g., A-weighted 24-hour LAeq decibels). According to BTS, the percentage of the total U.S. resident population that had the potential to be exposed to transportation noise greater than 60 dBA (louder than conversational speech) was 0.22 percent for aviation and 0.75 percent for road noise.

Transportation Energy Outlook

The Energy Information Administration's *Annual Energy Outlook 2018* (AEO) projects declining transportation energy use through

FIGURE 7-17 Road and Aviation Noise for Selected Cities: 2017



NOTES: Data from the National Transportation Noise Map supplementary information. LAEQ – a 24-hour equivalent sound level is the average of sound energy over a 24-hour period. A-weighting is a correction applied to sound levels to better reflect the way the human ear hears sound. A-weighted sound levels are described by the unit dBA (a-weighted decibel).

SOURCES: Map - U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Noise Map*, available at https://maps.bts.dot.gov/ as of September 2018. **Table** - U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Noise Map press release*, available at https://www.bts.gov/ as of March 2017.

TABLE 7-2 Estimated Percent of the U.S. Population with the Potential Exposure to Transportation Noise: 2014

A-weighted 24-hour LAEQ (dBA)	Common comparable sounds	Aviation	Road (interstate)
Less than 50	Refrigerator humming (~40 dBA)	97.12	98
50 to 59	Quiet office (~50 dBA)	2.65	1.3
60 to 69	Conversational speech (~60 dBA)	0.21	0.44
70 to 79	Vacuum cleaner (~70 dBA)	0.01	0.25
80 or more	Garbage disposal (~80 dBA)	< 0.01	0.06

2035, followed by a gradual increase through 2050 (figure 7-18). Total energy use is projected to be four quads lower in 2035 than it was in 2015. Energy use by highway vehicles is expected to be the most important factor in the decline. Their energy use is expected to decrease by more than five quads, with the largest reductions coming from light-duty vehicles (4.9 quads) and freight trucks (0.2 quads). The largest increase in energy use, 0.9 quads, is likely to be in air transport.

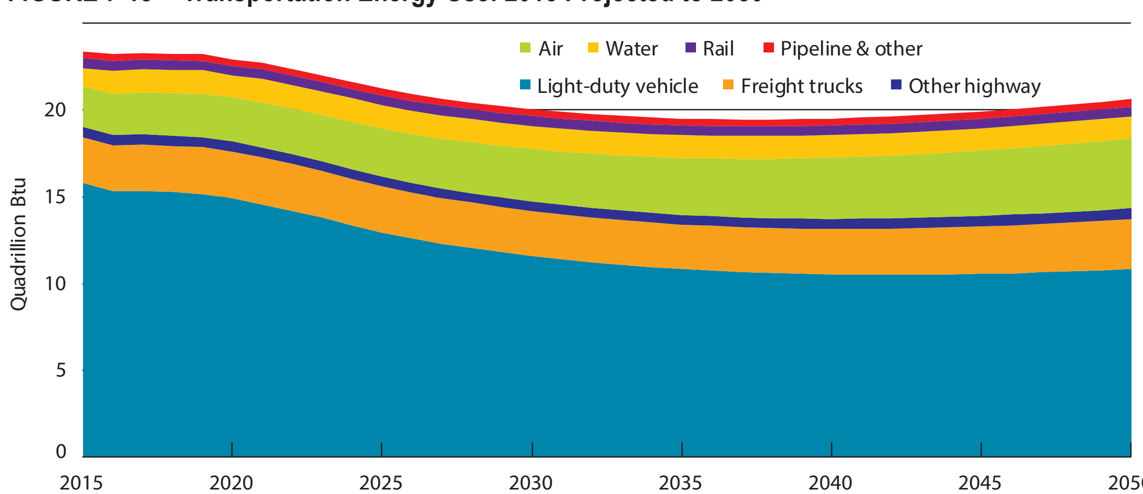
Light- medium- and heavy-duty vehicles are all subject to fuel economy and/or greenhouse gas emission regulations, which are projected to lead to energy efficiency improvements at the rate of 1.6 percent per year for light-duty vehicles and 1.2 percent per year for freight trucks through 2050. Over the same period, light-duty vehicle-miles are expected to grow the least at 0.5 percent per year while freight truck-miles are projected to increase by 1.2 percent per year. The AEO projections include only policies in effect at the time the projections were created (released February 6, 2018). Possible new policies or changes to existing policies are not considered.

New vehicle fuel economies are projected to change little after 2025 because the AEO includes only policies in effect at the time the projections are made. Taking into consideration the time required for newer vehicles to replace the existing stock and adjusting test values for on-road performance, the fuel economy of all light-duty vehicles in use was projected to increase from 22.4 in 2016 to 27.8 in 2025 and eventually to 38 mpg by 2050.[6]

Fuel economy improvements to passenger cars and light trucks under existing regulations are projected to create fuel savings, reaching 65 billion gallons per year by 2050. While light-

[6] New regulations under consideration by the USDOT and USEPA would freeze the fuel economy standards at the 2020 levels of 42.9 for new cars and 31.2 for light trucks, resulting in a smaller increase in on-road fuel economy and smaller future reductions in energy use and greenhouse gas emissions.

FIGURE 7-18 Transportation Energy Use: 2015 Projected to 2050

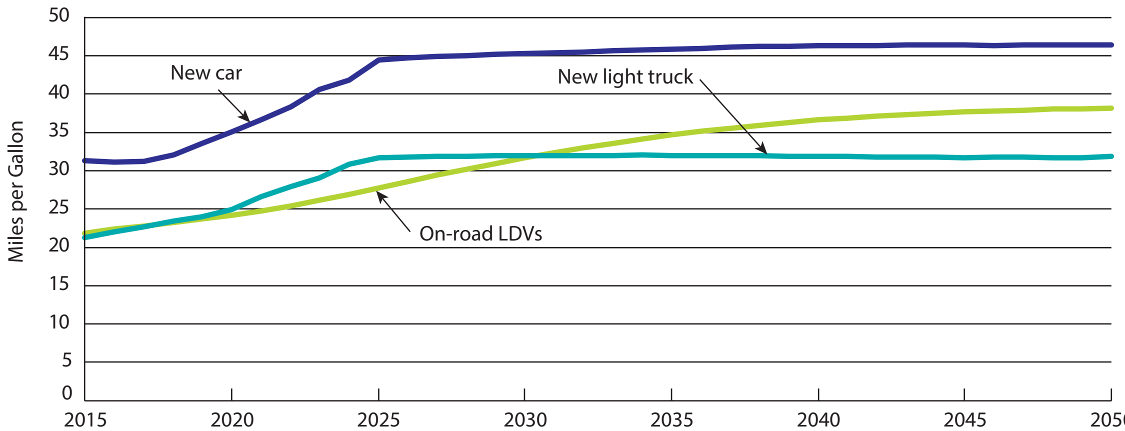


SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2018*, Table 7, available at www.eia.gov/ as of June 2018.

duty vehicle travel is projected to increase from 2.7 trillion miles in 2016 to 3.0 trillion in 2035 and 3.3 trillion by 2050, fuel use is projected to decrease from 127 billion gallons per year in 2016 to 91 billion gallons in 2035 and then level off, finishing at 90 billion gallons in 2050 (figure 7-20).

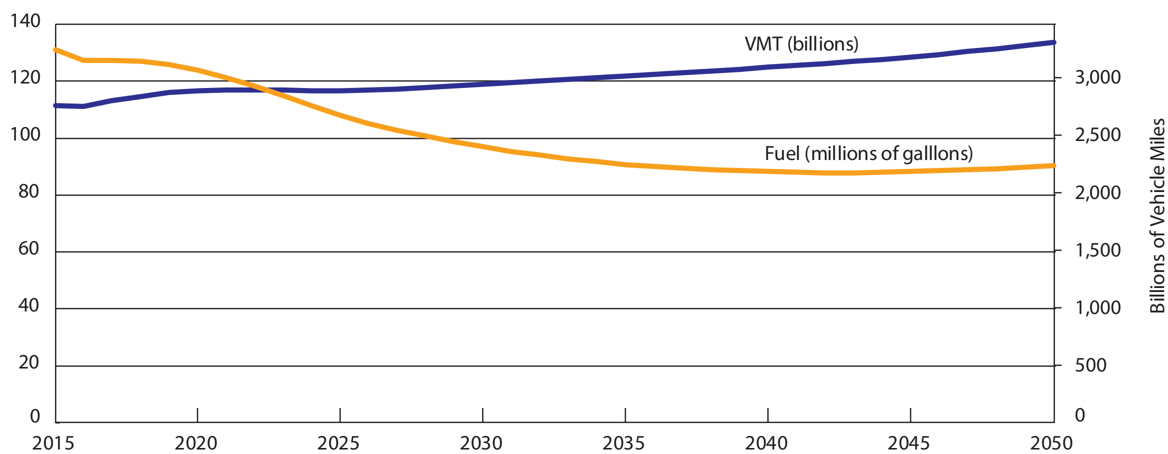
Air passenger travel is projected to increase at an average annual rate of 2.2 percent per year. Available seat-miles are projected to more than double between 2015 and 2050 (figure 7-21), when available seat-miles could reach about 2,300 billion. Future improvements in the energy efficiency of air travel are projected

FIGURE 7-19 Light-duty Vehicle Fuel Economies: 2015 Projected to 2050



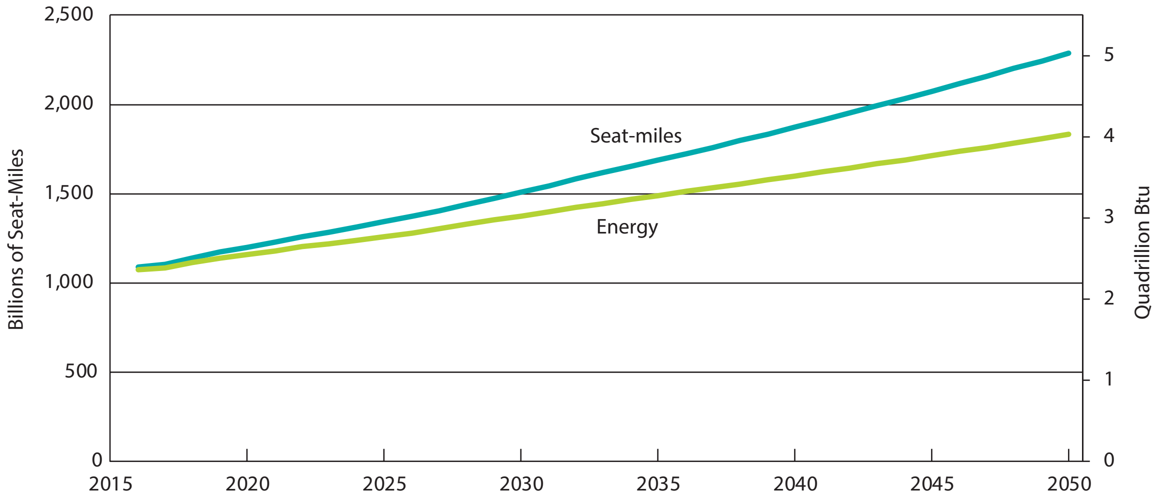
SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2018*, Table 7, available at www.eia.gov/ as of June 2018.

FIGURE 7-20 Light-Duty Vehicle Travel and Fuel Use: 2015 Projected to 2050



SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2018*, Table 7, available at www.eia.gov/ as of June 2018.

FIGURE 7-21 Air Transport Seat-Miles and Energy Use: 2015 Projected to 2050



SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2018*, Table 7, available at www.eia.gov/ as of June 2018.

to be much smaller than past achievements. In part, this is because the AEO 2018 projects no further increase in load factors from the already high current average of 85 percent. Passenger-miles and seat-miles are projected to grow at the same rate.

The EIA projects that transportation will be overtaken by electricity generation shortly after 2025 as the largest source of energy-related carbon dioxide emissions in the U.S. economy [USDOE EIA 2018b]. Electricity generation is expected to remain the largest emitter of CO_2 through 2050. As with energy use, the greatest reductions in transportation's CO_2 emissions come from light-duty vehicles. In 2050, CO_2 emissions from light-duty vehicles are projected to be 719 million metric tons (mmtCO_2), 312 mmtCO_2 below the 2016 level of 1,031 mmtCO_2. The major sources of increased emissions are expected to be air transport (+118 mmtCO_2) and freight trucks (+24mmtCO_2).

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CHAPTER 8

The State of Transportation Statistics

Highlights

- Progress is being made on the availability of expanded transportation statistics, such as the establishment of an annual Port Performance Freight Statistics Program and implementation of the Repository and Open Science Access Portal, but long-standing information shortcomings remain.
- Extensive data are available on local passenger travel, most long-distance freight movement, and the cost of local and long-distance passenger travel, but data shortcomings persist for most long-distance surface passenger travel, domestic movement of international trade, local freight movement, and the costs of local and long-distance freight movement.
- Information on public revenues and spending for transportation across all levels of government is not timely, and information on availability of private capital to finance transportation investment and on innovative finance in transportation such as Public-Private Partnerships, is piecemeal.
- Substantial data are available on crashes related to transportation, but the availability of data on causation of safety problems varies by mode of transportation, and the integration of data on motor vehicle crashes, the conditions surrounding each crash, and consequences of the crash remains elusive.
- Understanding the effects of transformational technologies and services, such as automated vehicles, new forms of ride-hailing, and e-commerce; on vehicle-miles of travel; congestion; personal vehicle ownership versus shared use vehicles; cost of mobility to households and cost of logistics to businesses; mobility of disadvantaged groups; and transportation employment is based on speculation rather than quantitative evidence.
- Through activities, such as the Safety Data Initiative and the Safety Data Visualization Challenge, the United States Department of Transportation (USDOT) is employing new data sources and analytical methods for updating, validating, and improving the detail of traditional statistics, and using new methods for visualizing and analyzing statistics to provide decision makers with effective and accessible insights.
- Research is needed to determine the reliability and validity of statistics derived from new and blended data sources, to establish institutional arrangements for access to proprietary databases, and to integrate data from new sources with traditional forms of data and analysis for effective information that supports decision makers.
- The Bureau of Transportation Statistics (BTS) has achieved significant progress in improving the state of transportation statistics and will continue to create increasingly robust, timely, credible statistics that support evidence-based decision making and that are useful and used throughout the Nation.

Transportation is important for how it serves and affects individuals, businesses, the economy, the environment, and the Nation. Statistics, maps, and their interpretation inform public and private decisions about transportation. To assure that statistics provide effective support for decision making, Congress requires that the *Transportation Statistics Annual Report* assess the quality of transportation statistics and identify efforts to improve statistical information.[1] This chapter reviews the current strengths and weaknesses of transportation statistics, identifies major shortcomings in those statistics, explores new data sources and methods that could improve statistical information, and highlights efforts to provide effective statistics for decision making in transportation.

Strengths and Weaknesses of Current Statistics on the Extent, Use, Condition, and Performance of the Transportation System

Table 8-1 summarizes existing statistics on the extent, use, condition, and performance of the transportation system as well as shortcomings in those statistics. Statistics are generally available to the public for aviation, highways, transit systems, and waterways because the Federal Government operates the aviation and inland waterway systems and provides financial assistance for highways and transit systems. Publicly available statistics on railroads, pipelines, and ports are limited because those entities are either privately owned or privately operated on leased public facilities.

[1] 49 U.S.C. § 6312

Data on the connectivity and condition of transportation infrastructure are maintained by USDOT's modal administrations.

- The Federal Highway Administration (FHWA) obtains network data from state departments of transportation.
- The Federal Railroad Administration (FRA) obtains its data from instrumented FRA railcars operating over the railroad network.
- The Federal Transit Administration (FTA) gets summary information rather than segment-specific data from transit properties.
- The Corps of Engineers (COE) collects waterway data from the facilities it operates.
- The Federal Aviation Administration (FAA) has extensive data on the aviation networks and airports that fall under its National Airspace Plan. BTS obtains performance data from commercial airlines.

BTS compiles and publishes data on the extent and characteristics of the Nation's transportation network in the National Transportation Atlas Database (NTAD). BTS updates the NTAD continuously and adds new layers of information as new geo-spatial data files are made available.

While extensive statistics exist on the extent, use, condition, and performance of components of the transportation system, some of the underlying data are collected for different reasons and are not comparable across other parts of the system. In response to the

TABLE 8-1 Statistics on the Extent, Use, Condition, and Performance of the Transportation System

Topic	Coverage of existing statistics	Major shortcomings in existing statistics	Why the shortcomings matter
Extent of and geographic access to the transportation system	• Multiple versions of the highway and rail networks • Detailed representation of the waterway network • Intermodal passenger connectivity database • National Transportation Atlas Database, including the National Transit Map	• Public data on road networks lacks adequate detail to support vehicle automation technology • Infrastructure needs of Alternative Fuel and Electric Vehicles • Little public data on availability of taxi and taxi-like services or transportation provided by social service agencies and non-profit organizations • Piecemeal representation of intercity bus networks • Partial information on intermodal connections among networks and connections of major freight and passenger travel generators to the networks	• The private sector is developing expensive, duplicative, incompatible network databases to support vehicle automation technology • Deployment of Alternative Fuel and Electric Vehicles to reduce emissions requires supporting infrastructure • Opportunities to enhance the effectiveness and efficiency of multimodal transportation services are missed • The need for new services in localities that appear isolated from economic opportunities, social services, and upward mobility may be misrepresented
Vehicle, aircraft, train, and vessel volumes	• Number of vehicles on highway segments • Number of aircraft by airport; number of car-loadings by rail segment; number of vessels by port and waterway	• Inconsistent differentiation among types of highway vehicles (car, bus, truck) • Inadequate data on market penetration of motor vehicle automation equipment	• Different vehicle types have very different consequences for traffic flow and congestion, pavement and bridge wear, exposure to safety risks, and air quality • Motor vehicle automation has major implications for safety and for the mobility of disabled populations
Condition and performance	• Condition and reliability of highways by segment, transit by property, and inland waterways by facility • Reliability of commercial aviation by flight and airport and by causes of delay	• Condition and reliability of freight railroads • Non-comparable capacity data across ports • Condition of urban bus and rail transit maintenance facilities, rural transit systems, and rail transit infrastructure • Comprehensive metrics for identifying bottlenecks and network resiliency	• Opportunities to identify and reduce bottlenecks, deteriorating condition, vulnerabilities to disruption, and other potential losses of efficiency in moving freight and passengers may be missed • Data are needed to guide management of transit programs • No informed basis for preparing responses to disruptions and emergencies

lack of comparable data on ports, Congress directed BTS, in the *Fixing America's Surface Transportation (FAST) Act of 2015*, to establish a port performance freight statistics program to annually publish nationally consistent measures of port capacity and throughput.[2] As required by the FAST Act, BTS convened a working group to recommend performance measures and methods for obtaining those measures, and BTS published the recommendations and initial statistics in the first annual report [USDOT BTS 2017a]. Subsequent annual reports are adding new statistics on capacity and throughput as new data sources are developed.

Data on the extent and condition of transportation services that support passenger mobility remain elusive. Public transit systems report system-wide information on condition and performance for each transit property to the FTA, and many transit properties report route information to BTS as a byproduct of their publication of data through the General Transit Feed Specification (GTFS) to provide scheduling and arrival information to customers. Since intercity bus carriers also use GTFS, BTS is beginning to expand its National Transit Map to include intercity services.

National data on transportation services provided by school districts for students, social service agencies for their clients, charter bus operators for groups of travelers, or taxis and other ride-hailing services are lacking, even though these services may be a substantial portion of the mobility resources in many areas. The long-standing lack of information on bicycles as part of the transportation system is being exacerbated by the apparent upsurge of electric scooters for rent in many cities. Information on the availability of these services is key to understanding how well communities are being served and why public transit usage is changing.

Most current and planned statistics on performance are from the perspective of those who build and operate the transportation system. This perspective is important but incomplete unless it is complemented by performance measures from the user's perspective. For example, a transportation system that spreads delay evenly over all travelers may be better tolerated than a system that concentrates the same total delay on only a portion of the travelers. Delay also matters more for some purposes than others. Delay is critical for responses to medical emergencies but may only be a minor irritant for leisurely sightseeing. In freight transportation, delay is generally a greater problem for perishable or high-valued goods than for bulk commodities. Statistics on delay rarely identify which users or what kind of travel are being affected or how frequently individuals and groups are being delayed.

Strengths and Weaknesses of Current Statistics on Passenger Travel

Statistics on travelers who use the transportation system and on the purposes of travel are key to determining whether problems with transportation system performance warrant public action. Table 8-2 summarizes existing statistics on passenger travel and shortcomings in those statistics. Existing statistics include total travel on sections of the

[2] Section 6018 of Public Law 114-94, Dec. 4, 2015

TABLE 8-2 Transportation Statistics on Passenger Travel

Topic	Coverage of existing statistics	Major shortcomings in existing statistics	Why the shortcomings matter
Intercity and international travel	• Volumes and origin-destination patterns of commercial aviation passengers • Amtrak ridership • Volumes of people and number of motor vehicles at border crossings	• Origins, destinations, and volumes of travelers by personal vehicles, buses, and general aviation • Amount of travel by demographic characteristics of travelers • Domestic travel of international visitors by traveler and trip characteristics	• For guiding investments in airports, intercity rail passenger service, and interregional highways • For guiding decisions that maximize the economic benefits of travel and tourism • For evaluating the impact of regulations on the contribution of local and long-distance travel to safety risks and environmental problems
Local travel	• Sporadic national surveys of volumes and demographic patterns of travelers by type of place • Transit ridership by property • Detailed origin-destination patterns of journeys-to-work and demographic characteristics of commuters • Geographic and demographic patterns of all resident travelers in metro areas that have conducted local surveys	• Pedestrian and bicycle travel • Local travel other than commuting in metro areas that have not conducted local surveys • Ridership and social and economic benefits of transportation services provided by social service and non-profit organizations • Growth of ride-hailing services and their relationship to transit ridership	• For guiding investments in streets and public transportation • For managing exposure to safety risks • For providing physical connections between mobility-challenged citizens and services and employment opportunities

transportation system and characteristics of the travelers and trips.

National statistics on total travel by portion of the transportation system are drawn from sources such as the border crossing data from Customs and Border Protection [USDHS CBP OFO], the Federal Transit Administration's National Transit Database [USDOT FTA NTD], the BTS monthly passenger enplanement data [USDOT BTS 2018a], and the National Census of Ferry Operators [USDOT BTS 2017c].

Statistics on the characteristics of travelers and trips come from the National Household Travel Survey (NHTS), sponsored by FHWA and several states and metropolitan planning organizations [USDOE ORNL 2018]. The NHTS collects information on individual trips and the demographic and other characteristics of the traveler that influence his or her decision on when, how, and how far to travel. Although the NHTS collects all personal travel taken by all modes of transportation, it mainly captures local travel. The high cost of conducting this type of nationwide survey has limited the frequency of this survey to once every 5 to 8 years. Despite these limitations, NHTS remains the only national source that provides the comprehensive data needed to understand travel decisions and predict travel demand.

The Census Bureau's American Community Survey (ACS) is another commonly used source of passenger travel information. The ACS collects commute-to-work data from an annual survey of the population. This survey provides small-area information every year, unlike the once-per-decade information formerly provided by the decennial census. The ACS also provides statistics for small units of geography aggregated over several years, while metropolitan statistical areas are the most detailed level of geography covered by the NHTS [USDOC ACS 2017].

Data from the NHTS, the ACS, and other sources are central to understanding the transportation consequences of population shifts across demographic groups and across geography. Declining rural areas, possible differences in travel behavior of millennials versus older generations, and other shifts in geography and demographics may place different demands on the future transportation system that may or may not be served by planned investments by the public and private sectors.

Strengths and Weaknesses of Current Statistics on Freight Movement

In addition to travelers, the transportation system serves the movement of freight. Statistics on shippers and carriers who use the transportation system and on the goods being moved are key to determining whether problems with transportation system performance warrant public action. Table 8-3 summarizes existing statistics on freight movement and shortcomings in those statistics.

Due to the magnitude and complexity of freight transportation, no single data collection provides a comprehensive picture of annual freight movement from origin to destination by all modes of transportation and by all commodity types. Among the various data sources, the Commodity Flow Survey (CFS), cosponsored by BTS and the Census Bureau, provides the most comprehensive coverage of U.S. freight flows [USDOT BTS 2018b]. The CFS is the only source of nationwide data on domestic freight shipments by manufacturing, mining, wholesale, and selected retail industries covering all modes of transportation. It also provides comprehensive data on domestic hazardous material shipments. The CFS is conducted every 5 years as part of the Economic Census.

The Freight Analysis Framework (FAF) builds on the CFS to provide national estimates of total freight movement by mode of transportation and type of commodity for over 130 regions based on states and metropolitan areas [USDOT BTS 2018c]. The CFS covers roughly two-thirds of the tonnage and value measured in the FAF. The remaining freight is measured from multiple, publicly available data sources, such as BTS data on freight flows across U.S. borders [USDOT BTS 2018d]. The FAF combines these sources into a time series of 5-year benchmarks based on the CFS, annual estimates, and 30-year forecasts.

The FAF is based on observed data wherever possible, but must turn to models and assumptions to fill the remaining data shortcomings in the 5-year benchmarks and to make annual updates and forecasts. Among the data shortcomings in the 5-year benchmarks

TABLE 8-3 Transportation Statistics on Freight Movement

Topic	Coverage of existing statistics	Major shortcomings in existing statistics	Why the shortcomings matter
International freight movement	• Volumes and value of freight at international gateways • Value of trade by country	• Domestic transportation of international trade, including domestic leg of imports, exports, and movements between foreign origins and destinations that pass through the United States	• For supporting connections between local and global economies • For assessing the role international flows play in domestic travel • For assessing the role of transportation in U.S. international economic competitiveness
Intercity freight movement	• Tonnage and value of region-to-region flows by commodity and mode	• County to county flows of freight by truck • Relationships between industry supply chains and region-to-region commodity flows • Highway routes used between specific origins and destinations by vehicle type • Pipeline volumes by segment	• For guiding investments in transportation facilities • For assuring access of local economies to suppliers and markets • For managing exposure to safety risks • For understanding the consequences of safety and other regulations • For expanding access to international opportunities of poorly served areas • For diagnosing and mitigating freight bottlenecks that are barriers to economic development and competitiveness • For understanding how pipeline volumes affect markets of competing modes and exposure to safety risks
Local freight movement	• Freight movement only where state and metro area surveys are conducted	• County-to-county and intracounty flows of freight • Freight passing through the local area to and from distant locations • Use of new distribution strategies and new technologies for local delivery	• For guiding investments in last-mile transportation facilities • For supporting local supply chains • For assessing the impacts on local congestion of freight movements • For managing exposure to safety risks

requiring significant modeling are shipments from farms, the movement of municipal solid waste, and the domestic transportation of foreign trade. While movements of goods between U.S. international gateways and foreign countries are tracked continuously, movements of international trade between gateways and domestic origins for exports and domestic destinations for imports have not been observed directly since the 1970s.

The freight system is undergoing significant changes as on-line shopping becomes more prevalent and new distribution strategies and new delivery technologies are deployed. New forms of data collection may be required to capture potential changes in freight flows caused by e-commerce, the use of retail outlets as mini-distribution centers, other shifts in supply chains, the use of robotic systems on the ground and in the air for local delivery, and shifts in economic activity among regions and among sectors of the economy.

Strengths and Weaknesses of Current Statistics on Transportation's Role in the Economy

Table 8-4 summarizes existing statistics on transportation's role in the economy and shortcomings in those statistics. Statistics cover how much the Nation spends on transportation, how transportation costs have changed, how many people are employed in transportation companies and occupations, and how transportation contributes to economic output.

Transportation's role in the economy is derived from statistics on expenditures by households and businesses for transportation services, employment in transportation industries and occupations, and the value of transportation to the economy. These statistics come from the Census Bureau, the Bureau of Economic Analysis (BEA), and the Bureau of Labor Statistics, each of which treats transportation as a significant sector of the economy.

For-hire transportation is one of the many sectors covered in the Economic Census, conducted every 5 years. This sector is also covered in the Census Bureau's Services Annual Survey, which collects operating revenue and other industry-specific data. BEA uses these data to estimate the flow of expenditures among sectors of the economy in order to understand how changes in the costs in a specific sector affect the rest of the economy. BTS expands on this accounting in its Transportation Satellite Account to include the sizable contribution to the economy made by in-house transportation services within non-transportation industries, such as truck fleets operated by large retail companies. BTS also estimates the economic contribution of personal transportation that falls outside the standard accounting of gross domestic product.

Transportation is not often highlighted in monthly national economic statistics. To provide a perspective on transportation's role in a dynamic economy, BTS developed the monthly Transportation Services Index (TSI) [USDOT BTS 2018e]. This index is based on activity in all modes of for-hire passenger and freight transportation services, and affords a better understanding of the relationship between transportation and the current and future course of the economy.

TABLE 8-4 Statistics on Transportation's Role in the Economy

Topic	Coverage of existing statistics	Major shortcomings in existing statistics	Why the shortcomings matter
Transportation capital stocks	• National estimates of the value of transportation capital stocks • State inventories of public capital stocks for asset management systems	• National economic return on future capital stock investment by mode • Economic return to states on facility specific investments	• Efficient public investment is hampered by inability to match transportation investments to economic returns.
Transportation expenditures and investments	• Total transportation expenditures and investments by households, businesses, and government	• Amount of borrowing by public and private entities to support transportation investment	• Informed decision-making requires understanding of capacity of the financial system to support public and private investments in transportation
Transportation costs and prices	• Gasoline and diesel prices • Costs of automobile ownership • Air carrier costs for selected categories • For-hire carrier price indices • Cost to maintain highway, transit and waterway condition	• Trucking costs by type of cost • Rail costs based on actual operating expenses rather than regulatory formula • Comprehensive costs for bus, general aviation, pipeline • Cargo damage and loss • Comprehensive estimates of cost savings from congestion reduction	• Cost data are used by businesses and consumers to make transportation choices and by government to identify the economic consequences of transportation investments and regulations
Transportation's contribution to the economy	• Transportation as a share of Gross Domestic Product by sector of the economy • Transportation embedded in other industries (the Transportation Satellite Account) • Transportation employment	• Economic and social activity enabled by transportation • Value of travel time by households using the transportation system • Employment related to new forms of transportation service and disruptive transportation technologies	• Input to establishing the appropriate size of investment programs and levels of revenue collection

Strengths and Weaknesses of Current Statistics on the Unintended Consequences of Transportation

In addition to the intended economic activity that transportation creates, transportation has unintended impacts on safety, energy consumption, the environment, and communities. Table 8-5 summarizes existing statistics and shortcomings in those statistics.

Of the unintended consequences, safety is the main focus for several of the largest statistical programs in the U.S. Department of Transportation (USDOT). The National Highway Traffic Safety Administration (NHTSA) and the Federal Motor Carrier Safety Administration (FMCSA) account for almost 40 percent of the expenditures on major statistical programs in the Department [EOP

TABLE 8-5 Statistics on the Unintended Consequences of Transportation

Topic	Coverage of existing statistics	Major shortcomings in existing statistics	Why the shortcomings matter
Safety	• Transportation fatalities and injuries for all modes • Safety incidents involving hazardous materials • Precursor events (close calls) for aviation, selected transit, and off-shore oil extraction and transport	• Risk factors • Exposure by type of safety risk • Precursor events (close calls) for most forms of surface transportation • Disabilities and medical costs related to transportation injuries	• Effective reduction of transportation-related casualties and property loss depends on detailed understanding of safety risks and causes of safety incidents • Measures of safety program effectiveness guide public investments and regulations
Energy consumption and air quality	• Energy efficiency estimates for highway and rail movements • Air quality by type of pollutant and airshed • Relationship of vehicle emissions to type of vehicle and vehicle speed	• In-use fuel economy and emissions • Energy intensity of waterborne freight and pipeline transport • Vehicle occupancy • Amount of vehicle travel by type of vehicle and vehicle speed in each airshed	• Vehicle occupancy is a key aspect of energy efficiency • Estimates of air quality issues are based primarily on laboratory conditions and assumed operating patterns and should be tested against actual operating conditions
Noise, recycling, water quality, habitat dislocation	• Noise footprints around airports • National Transportation Noise Map • Environmental disruptions related to individual transportation projects	• Impacts of new street lighting technology • Vehicle and tire disposal • Natural habitat disruption • Number of animals killed on highways	• Deployment of LED street lights raises community concerns with environmental quality and health issues • Motor vehicle and tire disposal is a major economic cost and environmental disruption in many locations • Geographic distributions of habitat disruption identify mitigation investment needs and target mitigation measures • Animal collisions are a major safety problem for motorists in many areas; disposal of remains is a maintenance cost and potential public health issue
Community disruption	• Social and economic characteristics of populations adjacent to transportation facilities	• Social and economic connections among urban neighborhoods and among rural locations	• Better data will support planning to avoid or mitigate community disruption from transportation facilities and to provide physical connections between mobility-challenged citizens and services and employment opportunities

OMB 2017]. The Pipeline and Hazardous Materials Safety Administration (PHMSA) and FHWA also have large-scale safety programs in place. Altogether, the Department's annual expenditures on safety data exceed $50 million spread across its operating administrations.

In addition to its long-standing safety data programs, USDOT is exploring new sources of information and new analytical strategies to better understand safety risks. The Safety Data Initiative includes pilot efforts to integrate and analyze large databases, including real-time data sets in the private sector, such as Waze, that have not been previously tapped for risk analysis. The initiative focuses primarily on highway safety, which accounts for the preponderance of transportation fatalities.

In comparison to highway fatalities, the relatively low fatality rates of commercial aviation, railroads, transit, and pipelines do not reduce the need for data to understand risks and maintain or improve the safety of these modes. The focus of data programs for these modes goes beyond determining causes of infrequent crashes to understanding circumstances surrounding near misses or other mishaps that could have resulted in a serious incident. To identify safety problems and develop information for mitigating those problems, BTS provides a close calls reporting system that allows individuals and companies to report problems without fear of retaliation. Anonymity of respondents is assured under the *Confidential Information Protection and Statistical Efficiency Act*.[3] The Metrorail and bus operations of the Washington Metropolitan Area Transit Authority and the Bureau of Safety and Environmental Enforcement of the U.S. Department of the Interior currently use this BTS authority and service.

The areas of energy consumption and related environmental emissions are another focus of statistics on unintended consequences of transportation. The transportation sector accounts for more than two-thirds of the petroleum consumed in the country and produces between one-quarter and one-third of all of the carbon dioxide (CO2) emitted by the Nation's energy consumption. The U.S. Department of Energy has a major data program that tracks energy consumption by transportation sector [USDOE EIA 2018], and transportation's contributions to greenhouse gases and other emissions are tracked by the Environmental Protection Agency [USEPA OTAQ 2018].

Energy efficiency in transportation is typically measured as vehicle-miles per gallon, but would better be measured as passenger-miles and ton-miles per Btu which would more fully represent system efficiency by including vehicle occupancy rates and load factors. Unfortunately, vehicle occupancy rates are not available on an annual basis, and reliable annual data on freight truck load factors are also lacking. Information about vehicle occupancy rates is available from infrequent surveys such as the NHTS. Data on actual occupancy rates based on field observation are rare and not comprehensive. Give the importance of vehicle occupancy to the energy and environmental impacts of connected and automated vehicles, more frequent and comprehensive data collection and analysis may be appropriate.

[3] Title V of Public Law 107-347, Dec. 17, 2002

While individual agencies compile information to meet specific needs, integrating these data and developing analytical techniques from many disciplines are the keys to effectively using these data sources to reduce transportation-related energy consumption and emissions. For example, the relationships between vehicle usage patterns and energy usage intensity are crucial to measuring and assessing the effectiveness of different energy and emission reduction opportunities and policies. Unfortunately, with the discontinuation of the Vehicle Inventory and Use Survey (VIUS) in 2002, much of the data necessary to help make these assessments are now over 15 years out of date [USDOC CB VIUS 2002]. A plan by BTS and its partners to revive the VIUS is currently under consideration. An influx of new VIUS data might prove invaluable for tracking the deployment of driver assistance technology for collision avoidance, lane tracking, and other steps toward full vehicle automation. The VIUS is also essential for measuring the economic activities performed by motor vehicles.

Energy and safety concerns converge in the transportation of crude petroleum, ethanol, and other hazardous cargos by railroad. In response to the FAST Act,[4] BTS worked with the Association of American Railroads to measure the use of tank cars for carrying these cargos—distinguishing tank cars that meet new standards from those that have not yet been brought up to standard. BTS published summary statistics in its first annual report [USDOT BTS 2017b], and added statistics on planned construction and retrofits of tank cars to new standards in its second annual report [USDOT BTS 2018f].

[4] Section 7308 of Public Law 114-94, Dec. 4, 2015

The Major Statistical Information Shortcomings

Considering the wide range of transportation data sources and information needs for public decisions, key shortcomings in statistical information are apparent:

- Understanding the effects of transformational technologies and services such as automated vehicles, new forms of ride-hailing, and e-commerce on vehicle miles of travel, congestion, personal vehicle ownership versus shared use vehicles, cost of mobility to households and cost of logistics to businesses, mobility of disadvantaged groups, and transportation employment is based on speculation rather than quantitative evidence.
- Long-distance, intercity travel remains poorly measured for surface modes of transportation.
- Understanding the domestic movement of international trade is based on models and assumptions more than on data from observations.
- Basic performance measures for public use are much improved for some modes, such as trucking and commercial aviation, but are lacking for other modes, such as freight railroads.
- Cost data are available for most forms of passenger travel but are limited for freight movement.

- Information on public revenues and spending for transportation across all levels of government is not timely, and information on availability of private capital to finance transportation investment and on innovative finance in transportation such as Public-Private Partnerships is piecemeal.
- The value of transportation to the economy and society is poorly articulated.
- Availability of data on causation of safety problems varies by mode of transportation.
- Integration of data on motor vehicle crashes, the conditions surrounding each crash, and consequences of the crash remains elusive.
- Data on highway vehicle use by vehicle characteristics, type of user, energy consumed, and economic activity have not been collected since 2002.

Of the major statistical information shortcomings, intercity passenger travel is particularly significant. While data are available on the number of trips on commercial aircraft and intercity rail, long-distance travel in personal vehicles, intercity bus, and general aviation are poorly understood. The demographic characteristics of the long-distance traveler by any mode have not been measured for almost two decades. The last national survey of intercity travel was conducted in 1995. As a consequence, current discussions about trends in passenger travel and the consequences of travel are dominated by measures of local travel. This limitation may result in misguided conclusions because long-distance travel involves different trip purposes and conditions than local travel, and one long-distance trip can generate as many miles of travel as dozens or even hundreds of local trips. Without information on long-distance travel, decision makers do not know how local congestion affects long-distance travel, how long-distance travel contributes to local congestion and the local economy, and how the total of local and long-distance travel contributes to safety risks and environmental problems.

New Data Sources, Methods, and Challenges

Statistical information shortcomings are surprising to many observers who perceive a world being flooded with data from satellites, cell phones, networked traffic control devices, vessel tracking systems, and the "smart devices" in homes and workplaces. While data are being generated by many new sources, methods for accessing and using the flood of data intelligently—especially for public decisions—are far less developed than the traditional world of surveys.

New sources of data include:

- Administrative records, such as vehicle registration files and police reports from highway crashes.
- Sensors, such as the rubber hoses stretched across highways to count traffic, engine monitors to estimate fuel economy, and the positions reported by cell phones to track travel and by transponders to track ships and aircraft.
- Imagery, such as traffic monitoring cameras and satellite photos.

- Crowd sourcing, such as Open Street Map for tracking changes in the highway network and Waze for tracking highway disruptions.
- Web scraping, such as the Billion Prices Project, to track the prices of consumer goods.

While these data sources show great promise, the availability of data alone does not assure that robust statistics exist to help answer the questions of decision makers. Significant quality issues, inadequate methods for analyzing data to create effective information, and confidentiality concerns can undermine the effectiveness of these data for credible, public statistics.

Data quality is a critical aspect because all sources of data have errors. Sensors break or are poorly calibrated. Administrative records suffer from misspellings, duplicate names for different individuals, and incompatible categories of information collected about those individuals. All data sources have coverage limitations that could bias resulting statistics.

Statistical agencies have extensive, well-established methods identifying and controlling for error in data from sample surveys, but methods are less developed for dealing with error in data from sources other than surveys. Some sources of error in alternative data sources are analogous to those found in surveys; for example, sensor failure can be treated like survey non-response. Other sources of error may require very different approaches to identification and correction. The challenge is compounded when data are blended from many sources for an estimate: do the individual sources of error cancel each other out or compound one another?

The concern of federal statistical agencies about data quality is not a mindless quest for statistical purity. New data sources, analytical methods, and data visualizations are potential sources for new insight and understanding for decision makers, but they can just as easily misguide decision makers with splashy graphics and spurious correlations. To serve this brave new world, the federal statistical system needs to develop methods for understanding and communicating potential error in new data sources and in estimates based on non-statistical and integrated data similar to the rich history of methods for dealing with error in data collections designed for statistical purposes. Specifically, federal statistical agencies need to provide the best statistics within available time and resources and communicate the risk and range of potential error related to those statistics in a meaningful and effective way to decision makers so that the statistics are used wisely. Statistical agency must also understand the many dimensions of data quality, including the risk of errors, to make optimum tradeoffs among the dimensions of quality and maximize improvements within available resources. This understanding is based on consideration of eight basic questions:

1. Are we measuring something that the public and decision-makers care about?
2. Are we measuring what we think we are measuring?
3. Are we measuring with minimal error?
4. Are we measuring with adequate timeliness

and granularity to meet the needs of the public and decision-makers?

5. Are we measuring with minimal costs and burden to respondents and to the public?
6. Are we protecting confidentiality and proprietary interests related to our measures?
7. Are we making the measures available and understandable?
8. What are cost and benefit trade-offs for improvement?

In addition to developing new data sources, BTS and its partners are also exploring new analytical methods for creating useful information from the new data sources. Frequently labeled "big data analytics," these methods were originally developed to make short-term forecasts from very large datasets. These methods are being adapted by private shippers to monitor and manage supply chains, and are now being explored by public agencies as early indicators of changing social and economic conditions and of emerging safety problems. The potential for adapting these methods to long-range forecasting and to understanding of complex, uncontrolled transportation phenomena remains unproven. In any case, traditional statistical methods are still needed to avoid confusing correlation with causation and misleading public decisions.

Forecasting is important for planning infrastructure investments and for identifying safety risks, and good forecasts can be made without a complete understanding of causation; however, causation is essential to understanding the effectiveness of public programs and learning from experience. Data and analysis methods to determine causation are central to the recommendations of the Commission on Evidence-Based Policymaking for supporting public and private decisions through a "learning agenda" (CEP 2017).

To encourage an increased collective focus on the quality of data and analysis methods, BTS plans to create a Statistical Quality Council with members drawn from the major statistical programs throughout USDOT. The Council would collaboratively identify any accuracy, validity, and other quality issues with the statistical products and programs of BTS and of USDOT's operating administrations; collaboratively develop strategies for resolving statistical quality issues; facilitate implementation of the strategies; foster research to improve surveys and data collection methods to improve accuracy; and develop quality standards for data integrated from alternative, multiple sources, such as administrative records, satellite imagines, and sensors. The Statistical Quality Council would serve as an internal replacement for some of the functions of the Advisory Council on Transportation Statistics, which is currently inactive as part of a government wide review of federal advisory committees.

Since all data sources and estimation methods have quality issues, understanding whether the data quality problems are large or small is key to assuring appropriate use of the data and to credibility of the resulting statistics. Credibility also depends on the perception that the information is free of political influence. To assure objectivity, the Office of Management and Budget exempts the products of BTS and all other principle federal statistical agencies from political review through Statistical Policy Directive No. 1 [EOP OMB 2014]. BTS objectivity is protected further by the FAST Act, which requires that "the [BTS] Director shall not be required to obtain the approval of any other officer or employee of the Department [of Transportation] with respect to the collection or analysis of any information; or prior to publication, to obtain the approval of any other officer or employee of the United States Government with respect to the substance of any statistical technical reports or press releases lawfully prepared by the Director."[5]

Improving Transportation Statistics

The tables in this chapter include many areas of improved statistical information in recent years. Much of the improved information involves data integrated from multiple sources. The Freight Analysis Framework, built primarily on data collected by BTS, provides a comprehensive picture of goods movement throughout the United States. The Transportation Satellite Account provides a more complete accounting of transportation's role in supporting other sectors of the national economy. The safety tables in the BTS on-line compendium, *National Transportation Statistics* enumerate fatalities and injuries across all modes of transportation with double counting removed.

BTS contributions in 2018 leading to improved statistical information include:

- Publication of over 100 products, including 82 data releases, 1 report to the President and Congress, 3 reports to Congress, 3 reports in the Facts and Figures series, 3 annual reports for clients of the confidential close calls program, quarterly updates to National Transportation Statistics, continuous updates and expansions to the National Transportation Atlas Database, an annual update to the Freight Analysis Framework, a mobile app, and several web apps.
- Successful launch of the Repository and Open Science Access Portal (ROSA_P), the on-line repository of documents and data of interest to the transportation community, including all research documents funded by USDOT.
- Development of a popular application on the BTS website for tracking the transportation impacts of hurricanes.
- Assistance to USDOT operating administrations in meeting statistical quality standards to obtain OMB approval for over 100 information collection requests.
- Innovative use of maritime GPS data to estimate ship dwell times as part of Port Performance Freight Statistics Program.
- Completion of data collection for the 2017 Commodity Flow Survey (CFS) and release of preliminary data.
- Initiation of two cooperative agreements to look beyond 2017 CFS and explore alternatives methods to collecting freight flow data.

[5] 49 U.S.C. § 6302(d)(1)

- Establishment of the first data collection of tank car facilities for the second report to Congress on industry progress in modifying rail tank cars carrying flammable liquids to safer specifications.
- Completion of data collection for the 2018 National Census of Ferry Operators.
- Publication of the "Travel Patterns of American Adults with Disabilities" report in advance of the Automated Vehicle 3.0 release.
- Initial completion of a major redesign of the BTS website launched to make BTS products easy to find and use, to serve the novice and power users, to encourage serendipity, and to reduce time and resources needed to keep the website up to date.
- Update of the BTS strategic plan to incorporate priorities in the Secretary's strategic plan for USDOT.

Other efforts to improve statistical information and data management are underway throughout USDOT. The biggest effort across USDOT is the Safety Data Initiative to integrate data sources with each other and with new "big data" sources that are becoming available to enhance understanding of crash risk and our ability to mitigate it. The initiative has three core components:

- Data Visualization: Make data analysis and insights accessible to policy-makers through clear, compelling data visualizations;
- Data Integration: Integrate existing DOT databases and new private sector data sources to answer safety questions; and
- Predictive Insights: Use advanced analytic techniques to identify risk patterns and develop insights that anticipate and mitigate safety risk to reduce injuries and fatalities.

BTS supports the Safety Data Initiative by leading the Safety Data Visualization Challenge and managing the first phase of an innovative analysis of Waze data as an indicator of locations with safety problems.

Looking Ahead

The transportation community must juggle the demands of evidence-based decision making and the development and interpretation of new data sources with the maintenance and improvement of traditional statistics on which decision makers and planers are dependent. BTS has direct control over a small portion of the data sources highlighted in this chapter, but it has a leadership role in many external data sources as the principal Federal statistical agency for transportation.

While other prominent data programs exist in USDOT:

- BTS is the Department's only source of statistics that covers all modes of transportation.
- BTS is the Federal Government's primary source of original information on commercial aviation.
- BTS is the only part of USDOT that is designated by the Office of Management and Budget (OMB) as a Principal Federal

Statistical Agency and covered by all Statistical Policy Directives.

BTS recognizes that it must evolve its statistical products, data collection methods, and expertise to provide effective services to the transportation community in a rapidly changing world. As a forward looking, effective statistical agency, BTS must:

- Provide fresh, recent information to a wide range of users in the formats that best meet their needs.
- Be flexible and nimble to address emerging issues.
- Focus on new technology for collection and delivery of information.
- Adhere to Statistical Policy Directives of the Office of Management and Budget and provisions of the FAST Act to assure that statistics are objective, accurate, timely, and credible.

Toward these ends, BTS will expand its statistical products, publish to the web immediately rather than wait for printed reports, continue to streamline its data processing procedures, and implement new ways for the transportation community to find and use information on the BTS website. BTS will also continue to operate and improve the National Transportation Library, which is making transportation information, statistics, databases, and research findings from throughout USDOT transparent and accessible to the public under the government-wide Open Data Policy [EOP OMB 2013]. All BTS products and the collections of the National Transportation Library are available on the Internet at www.bts.gov.

As resources permit, BTS is undertaking research to explore alternative data sources and new methods of estimating statistics on the extent and use of the transportation system and on the consequences of transportation. New data sources are critical for replacing surveys that suffer from declining response rates and increasing costs. BTS is looking at new approaches to measure phenomena such as passenger travel and freight movement, for which traditional surveys are decreasingly effective. BTS is working with the other principal Federal statistical agencies to explore the use of administrative records, data from sensors, and advanced data mining analytics. BTS has initiated a major research program to develop methods for supplementing and enhancing portions of the FAF and reducing respondent burden for the CFS in 2022. In addition to research, BTS is continuing to work with its partners in USDOT and the principal Federal statistical agencies to identify and resolve significant problems with comparability and quality of transportation statistics.

BTS recognizes the need to take a more active role with its partners to assist with performance measurement and evidence-based decision making. BTS provides statistical expertise to advise the design of performance measures and program evaluations, portals to data that can be used in performance measurement and program evaluations, and public access to statistics created by performance measurement and program evaluations.

BTS has achieved significant progress in improving the state of transportation statistics over the last quarter century [USDOT BTS 2015]. The Bureau will continue to strive in the years ahead to create increasingly robust, timely, credible products in each of the topic areas identified in legislative mandates and departmental goals. BTS will continue to enhance timeliness, improve the quality of its products, and produce statistics that are useful, relevant, and used throughout the Nation.

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APPENDIX A Legislative Responsibilities

BTS compiles these and other statistics as required by 49 U.S. Code § 6302 - Bureau of Transportation Statistics, which requires information on:

- transportation safety across all modes and intermodally;
- the state of good repair of United States transportation infrastructure;
- the extent, connectivity, and condition of the transportation system,
- building on the national transportation atlas database developed;
- economic efficiency across the entire transportation sector;
- the effects of the transportation system on global and domestic economic competitiveness;
- demographic, economic, and other variables influencing travel behavior, including choice of transportation mode and goods movement;
- transportation-related variables that influence the domestic economy and global competitiveness;
- economic costs and impacts for passenger travel and freight movement;
- intermodal and multimodal passenger movement;
- intermodal and multimodal freight movement; and
- consequences of transportation for the human and natural environment

FIGURE/TABLE No. and Title	*Transportation Safety* **i**	*State of Good Repair* **ii**	*Extent, Connectivity, and Condition* **iii**	*Economic Efficiency* **iv**	*Global and Domestic Economic Competitiveness* **v**	*Demographic, Economic, and Other Variables Influencing Travel Behavior* **vi**	*Transportation-Related Variables that Influence Economy* **vii**	*Economic Costs and Impacts for Tracel and Freight Movement* **viii**	*Intermodal and Multimodal Passenger Movement* **ix**	*Intermodal and Multimodal Freight Movement* **x**	*Consequences of Transportation for the Human and Natural Environment* **xi**
Introduction											
Chapter 1–*Extent and Use*											
FIGURE 1-1 Net Value of Transportation Capital Stock			X								
FIGURE 1-2 National Highway System, Intermodal Connectors, and Principal Arterials			X						X		
FIGURE 1-3 Licensed Drivers, Vehicle Registrations, Vehicle-Miles Traveled, and Resident Population			X			X			X		
FIGURE 1-4 Levels of Automation			X								
FIGURE 1-5 Automated Vehicle Legislation by State			X								
FIGURE 1-6 Top 50 Transit Systems by Total Ridership			X						X		
FIGURE 1-7 U.S. Cities with More than 10 Bike-Share Stations			X						X		
FIGURE 1-8 Enplanements at the Top 50 U.S. Airports			X						X		
FIGURE 1-9 Class I. Railroad System Mileage and Ton-Miles of Freight			X							X	
FIGURE 1-10 Top 25 Busiest Amtrak Stations			X						X		
FIGURE 1-11 Vessel Size and Corresponding Port Infrastructure			X							X	
FIGURE 1-12 Container Cranes versus Annual TEU at Top 25 Container Ports			X							X	
FIGURE 1-13 Ferry Passenger and Vehicle Boardings by State			X						X		
FIGURE 1-14 U.S. Petroleum and Natural Gas Pipelines			X							X	
FIGURE 1-15 Intermodal Passenger Facilities by Mode			X						X		
TABLE 1-1 Public Roads, Streets, and Bridges			X								
TABLE 1-2 Transit Vehicles and Ridership			X								
TABLE 1-3 U.S. Air Transportation System			X						X		
TABLE 1-4 Rail Transportation System			X							X	
TABLE 1-5 Passenger Rail Transportation System			X						X		
TABLE 1-6 Water Transportation System			X							X	
Chapter 2- Condition and Performance											
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FIGURE 2-2 Percent of Deficient Bridges and Average Daily Traffic on Deficient Bridges by Urban and Rural Road Function		X									
FIGURE 2-3 Average Age of U.S. Transit Vehicle Fleets, Select Modes		X									
FIGURE 2-4 Bus Miles Failures and Number of Major Failures		X									
FIGURE 2-5 Percent On-Time Departures and Arrivals		X				X			X		
FIGURE 2-6 Domestic Flight Delays by Cause, Percent of Total Delays in Minutes		X				X			X		
FIGURE 2-7 Percent of On-time Arrivals and Departures by Time of Day (Top 30 U.S. Airports)		X							X		
FIGURE 2-8 Percent of Flights by Length of Time Delayed and Passenger impacted by > 120 minute delay		X							X		
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FIGURE 2-10 Rail Capital and Maintenance Investment on Infrastructure and Track-Caused Accidents per Million Train-miles		X								X	

FIGURE/TABLE No. and Title	*Transportation Safety* **i**	*State of Good Repair* **ii**	*Extent, Connectivity, and Condition* **iii**	*Economic Efficiency* **iv**	*Global and Domestic Economic Competitiveness* **v**	*Demographic, Economic, and Other Variables Influencing Travel Behavior* **vi**	*Transportation-Related Variables that Influence Economy* **vii**	*Economic Costs and Impacts for Tracel and Freight Movement* **viii**	*Intermodal and Multimodal Passenger Movement* **ix**	*Intermodal and Multimodal Freight Movement* **x**	*Consequences of Transportation for the Human and Natural Environment* **xi**
FIGURE 2-11 Transportation Resiliency Cycle		X								X	
FIGURE 2-12 Impact of Select Hurricanes on U.S. Ports		X								X	
FIGURE 2-13 Impact of Hurricane Florence on Transportation Infrastructure		X								X	
FIGURE 2-14 Impact of Hurricane Michael on Transportation Infrastructure		X								X	
FIGURE 2-15 Use of Vessel Heat Signals to Observe Hurricane-Related Operational Impacts, Port of Houston, Hurricane Harvey		X								X	
FIGURE 2-16 Port of Houston Daily Average Cargo and Tanker Net Vessel Counts During Hurricane Harvey		X								X	
TABLE 2-1 Trends in Rural v. Urban Pavement Conditions (as measured in trend of "poor" rating)		X									
TABLE 2-2 Congested Hours (metropolitan statistical areas with a population > 1 million)		X									
TABLE 2-3 Total Lockages, Percent Commercial, Average Delay, and Percent of Vessels Delayed on U.S. Waterways with U.S. Army Corps of Engineers' Locks		X								X	
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FIGURE 3-1 Everyday Travel by Mode. Daily Travel-Miles per Capita						X			X		
FIGURE 3-2 Everyday Travel by Purpose. Number of Trips per Capital per Day						X			X		
FIGURE 3-3 Distribution of Vehicle Trips by Trip Purpose and Start Time						X			X		
FIGURE 3-4 Urban Transit Users by Age Group Who Also Used Ride-Hail Services in the Prior 30 Days						X			X		
FIGURE 3-5 Everyday Walking by Purpose						X			X		
FIGURE 3-6 Trends in the Total Time Spent Traveling on Weekdays and Weekends						X			X		
FIGURE 3-7 Percent Change in Population by Country						X					
FIGURE 3-8 Number of People (millions) Living in Urban and Rural Areas						X			X		
FIGURE 3-9 Vehicle-Miles of Travel in Urban and Rural Areas by Age						X			X		
FIGURE 3-10 On-line Purchases and Deliveries by Age Groups					X	X		X	X	X	
FIGURE 3-11 Distribution of Workers by their Usual Means of Travel to Work						X			X		
FIGURE 3-12 Workers Net Change by Mode of Transportation						X			X		
FIGURE 3-13 Number of Workers (millions) by Age Group						X			X		
FIGURE 3-14 Percent of Workers by Age Group Who Work from Home						X			X		
FIGURE 3-15 Percent of Commuters Who Travel Directly to Work or Make a Stop on the Way						X			X		
FIGURE 3-16 Purposes of Stopping While Commuting						X			X		
FIGURE 3-17 Number of Drivers (millions) Aged 65 and Older						X			X		
FIGURE 3-18 Number and Percent of People Reporting a Mobility Impairment						X			X		
FIGURE 3-19 People Living in Zero-Vehicle Households by Disability and Worker Status (age 18-64)						X			X		
FIGURE 3-20 Strategies for Dealing with a Travel Disability						X			X		
FIGURE 3-21 Distribution of Households by Number of Household Vehicle						X			X		

FIGURE/TABLE No. and Title	*Transportation Safety* i	*State of Good Repair* ii	*Extent, Connectivity, and Condition* iii	*Economic Efficiency* iv	*Global and Domestic Economic Competitiveness* v	*Demographic, Economic, and Other Variables Influencing Travel Behavior* vi	*Transportation-Related Variables that Influence Economy* vii	*Economic Costs and Impacts for Tracel and Freight Movement* viii	*Intermodal and Multimodal Passenger Movement* ix	*Intermodal and Multimodal Freight Movement* x	*Consequences of Transportation for the Human and Natural Environment* xi
FIGURE 3-22 Average Individual Household Transportation Expenditures						X		X	X		
FIGURE 3-23 People Entering into the United States at Land Border Crossings and U.S. Airports with Scheduled International Service					X	X			X		
FIGURE 3-24 Number of Foreign Visitors (millions) by Main Market					X	X			X		
FIGURE 3-25 Percent Change from Previous Year in Total Foreign Visits					X	X			X		
TABLE 3-1 Person-Miles of Travel by Mode						X			X		
TABLE 3-2 Characteristics or Urban and Rural Residents						X					
TABLE 3-3 Ranking Alternative Transportation Choices						X			X		
TABLE 3-4 Commute Characteristics						X			X		
TABLE 3-5 Enplanements at the Top 10 U.S. Airports					X	X			X		
TABLE 3-6 Countries Sending the Most Travelers to the United States					X	X			X		
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FIGURE 4-1 Value, Tonnage, and Ton-Miles by Distance Traveled					X		X			X	
FIGURE 4-2 Freight Flows by Highway, Railway, and Waterway					X		X			X	
FIGURE 4-3 Ratio of Outbound to Inbound Domestic Shipments by Value					X		X			X	
FIGURE 4-4 Ratio of Outbound to Inbound Domestic Shipments by Weight					X		X			X	
FIGURE 4-5 Weight and Value of Top Ten Commodities by Tansporation Mode					X		X			X	
FIGURE 4-6 Top 25 U.S.-International Freight Gateways by Value of Shipments					X		X			X	
FIGURE 4-7 Value and Weight of U.S.-International Freight Flows by Transportation Mode					X		X			X	
FIGURE 4-8 Top 25 Water Ports by TEU					X		X			X	
FIGURE 4-9 Top 25 Water Ports by Tonnage					X		X			X	
FIGURE 4-10 Waterborne Import and Export of LNG					X		X			X	
TABLE 4-1 Weight and Value of Shipments by Transportation Mode					X		X			X	
TABLE 4-2 Value of U.S.-International Freight Flows by Geography and Transportation Mode					X		X			X	
TABLE 4-3 Value and Weight of U.S. Freight Flows with Canada and Mexico by Transportation Mode					X		X			X	
Chapter 5 - Transportation Economics											
FIGURE 5-1 Components of the Demand for Transportation				X	X	X	X	X			
FIGURE 5-2 Gross Domestic Product (GDP) Attributed to Transportation by Mode				X	X	X	X	X			
FIGURE 5-3 Use of Transportation by Sector				X	X	X	X	X			
FIGURE 5-4 Transportation Required Per Dollar of Output by Sector				X	X	X	X	X			
FIGURE 5-5 Freight Transportation Services Index and the Economic Growth Cycle				X	X	X	X	X			
FIGURE 5-6 Freight Transportation Services Index Modal Data				X	X	X	X	X		X	

FIGURE/TABLE No. and Title	*Transportation Safety* i	*State of Good Repair* ii	*Extent, Connectivity, and Condition* iii	*Economic Efficiency* iv	*Global and Domestic Economic Competitiveness* v	*Demographic, Economic, and Other Variables Influencing Travel Behavior* vi	*Transportation-Related Variables that Influence Economy* vii	*Economic Costs and Impacts for Tracel and Freight Movement* viii	*Intermodal and Multimodal Passenger Movement* ix	*Intermodal and Multimodal Freight Movement* x	*Consequences of Transportation for the Human and Natural Environment* xi
FIGURE 5-7 Transportation-Related Labor Force Employment in the United States				X	X	X	X	X			
FIGURE 5-8 Employment in Selected Transportation-Related Industries				X	X	X	X	X			
FIGURE 5-9 Employment and Wages in Select Transportation and Transportation-Related Occupations				X	X	X	X	X			
FIGURE 5-10 Labor Productivity Indexes of Transportation Sectors				X	X	X	X	X			
FIGURE 5-11 Multifactor Productivity Indexes for Transportation Sectors				X	X	X	X	X			
FIGURE 5-12 Average Revenue per Passenger-Mile Indexes				X	X	X	X	X	X		
FIGURE 5-13 Average Freight Revenue per Ton-Mile Indices				X	X	X	X	X		X	
FIGURE 5-14 Total National Household Expenditures (Major Expenditure Categories)				X	X	X	X	X			
FIGURE 5-15 Federal, State, and Local Government Expenditures				X	X	X	X	X			
FIGURE 5-16 Federal Transportation Expenditures by Mode				X	X	X	X	X			
FIGURE 5-17 State and Local Expenditures by Mode				X	X	X	X	X			
FIGURE 5-18 Value of Transportation Construction Put in Place				X	X	X	X	X			
FIGURE 5-19 Federal Own-Source Revenue by Mode				X	X	X	X	X			
FIGURE 5-20 State and Local Own Source Revenue by Mode				X	X	X	X	X			
FIGURE 5-21 Government Transportation Revenue and Expenditures				X	X	X	X	X			
FIGURE 5-22 Public and Private Fixed Investment				X	X	X	X	X			
FIGURE 5-23 Average Change in Amount Received for Producing Transportation Equipment				X	X	X	X	X			
FIGURE 5-24 Sales Price of Transportation Fuel to End-Users (Dollars / gallon)				X	X	X	X	X	X		
FIGURE 5-25 Year-Over-Year Percent Change in Total Employee Compensation (All Civilian Workers)				X	X	X	X	X			
FIGURE 5-26 Average Change in Amount to Produce Transportation Services				X	X	X	X	X			
FIGURE 5-27 Average Changes to Transportation Prices Paid by Urban Consumers				X	X	X	X	X	X		
FIGURE 5-28 U.S. Trade of Transportation-related Goods				X	X	X	X	X			
FIGURE 5-29 U.S. Trade of Transportation Services				X	X	X	X	X			
TABLE 5-1 Sources of Economic Growth				X	X	X	X	X			
Chapter 6 - Safety											
FIGURE 6-1 Fatality Rates per 100 Million Vehicle Miles Traveled (VMT), by Year and Location	X										
FIGURE 6-2 Motor Vehicle Traffic Fatalities, by Year and Location	X										
FIGURE 6-3 Motor Vehicle Traffic Fatality Rates by Age Group	X										
FIGURE 6-4 Transit Fatalities by Category	X										
FIGURE 6-5 Fatalities, by Role, in Crashes Involving at Least One Driver with a BAC of .08 or Higher	X										
FIGURE 6-6 Distracted Driving Fatalities and Injuries	X										
FIGURE 6-7 State Laws on Distracted Driving—Handheld and Texting Bans	X										
FIGURE 6-8 State Laws on Motorcycle Helmet Use	X										
FIGURE 6-9 Number of Hazardous Liquid and Gas Pipeline Incidents and Serious Incidents	X										

FIGURE/TABLE No. and Title	*Transportation Safety* i	*State of Good Repair* ii	*Extent, Connectivity, and Condition* iii	*Economic Efficiency* iv	*Global and Domestic Economic Competitiveness* v	*Demographic, Economic, and Other Variables Influencing Travel Behavior* vi	*Transportation-Related Variables that Influence Economy* vii	*Economic Costs and Impacts for Tracel and Freight Movement* viii	*Intermodal and Multimodal Passenger Movement* ix	*Intermodal and Multimodal Freight Movement* x	*Consequences of Transportation for the Human and Natural Environment* xi
TABLE 6-1 Transportation Fatalities by Mode	X										
TABLE 6-2 Transportation Injuries by Mode	X										
TABLE 6-3 Fatalities by Highest Blood Alcohol Concentration (BAC) in Highway Crashes	X										
TABLE 6-4 Estimated Lives Saved by Selected Safety Features	X										
TABLE 6-5 Safety Belt and Motorcycle Helmet Use	X										
TABLE 6-6 Hazardous Materials Transportation Incidents	X										
TABLE 6-7 All Reported Hazardous Liquid and Gas Incidents	X										
Chapter 7- Transportation Energy Use and Environmental Impacts											
FIGURE 7-1 U.S. Consumption of Energy from Primary Sources by Sector (Quadrillion Btu)											X
FIGURE 7-2 Transportation Energy Use by Fuel Type											X
FIGURE 7-3 U.S. Petroleum Net Imports and Domestic Supply											X
FIGURE 7-4 Transportation Energy Use by Mode											X
FIGURE 7-5 Car and Light Truck Corporate Average Fuel Economy (CAFE) and Miles per Gallon (MPG)											X
FIGURE 7-6 Vehicle Miles of Travel and Fuel Use by Light-duty Vehicles											X
FIGURE 7-7 Effects of the Relative Change of Operational and Aircraft Efficiencies on Air Carrier Energy Use											X
FIGURE 7-8 Effects of Car Loading and Efficiency on Rail Freight Energy Use											X
FIGURE 7-9 Transportation Energy Use by Fuel Type											X
FIGURE 7-10 Transportation Use of Biofuels											X
FIGURE 7-11 Sales of Hybrid, Plug-in Hybrid and Battery Electric Vehicles											X
FIGURE 7-12 Electric Vehicle Charging Stations and Hydrogen Refueling Stations											X
FIGURE 7-13 U.S. Carbon Dioxide Emissions from Energy Consumption											X
FIGURE 7-14 Transportation's Greenhouse Gas Emissions by Gas											X
FIGURE 7-15 Air Quality Index (AQI) Across U.S. Cities											X
FIGURE 7-16 Petroleum Spills Impacting Navigable Waterways											X
FIGURE 7-17 Road and Aviation Noise for Selected Cities											X
FIGURE 7-18 Transportation Energy Use											X
FIGURE 7-19 Light-duty Vehicle Fuel Economies											X
FIGURE 7-20 Light-Duty Vehicle Travel and Fuel Use											X
FIGURE 7-21 Air Transport Seat-Miles and Energy Use											X
TABLE 7-1 Transportation Energy Use, Reliance on Petroleum and World Oil Prices											X
TABLE 7-2 Estimated Percent of the U.S. Population with the Potential Exposure to Transportation Noise											X

APPENDIX B Glossary

Air carrier: Certificated provider of scheduled and nonscheduled services.

Alternative fuel (vehicle): Nonconventional or advanced fuels or any materials or substances, such as biodiesel, electric charging, ethanol, natural gas, and hydrogen, that can be used in place of conventional fuels, such as gasoline and diesel.

Arterial: A class of roads serving major traffic movements (high-speed, high volume) for travel between major points.

Block hours: The time elapsed from the moment an aircraft pushes back from the departure gate until the moment of engine shutoff at the arrival gate following its landing.

Bus: Large motor vehicle used to carry more than 10 passengers, including school buses, intercity buses, and transit buses.

Capital stock (transportation): Includes structures owned by either the public or private sectors, such as bridges, stations, highways, streets, and ports; and equipment, such as automobiles, aircraft, and ships.

Chained dollars: A method of inflation adjustment that allows for comparing in dollar values changes between years.

Class I railroad: Railroads earning adjusted annual operating revenues for three consecutive years of $250,000,000 or more, based on 1991 dollars with an adjustment factor applied to subsequent years.

Commercial air carrier: An air carrier certificated in accordance with Federal Aviation Regulations Part 121 or Part 127 to conduct scheduled services on specified routes.

Commuter rail: Urban/suburban passenger train service for short-distance travel between a central city and adjacent suburbs run on tracks of a traditional railroad system. Does not include heavy or light rail transit service.

Consumer Price Index (CPI): Measures changes in the prices paid by urban consumers for a representative basket of goods and services.

Current dollars: Represents the dollar value of a good or service in terms of prices current at the time the good or service is sold.

Deadweight tons: The number of tons of 2,240 pounds that a vessel can transport of cargo, stores, and bunker fuel. It is the difference between the number of tons of water a vessel displaces "light" and the number of tons it displaces when submerged to the "load line."

Demand-response: A transit mode comprised of passenger cars, vans, or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations.

Directional route-miles: The sum of the mileage in each direction over which transit vehicles travel while in revenue service.

Directly operated service: Transportation service provided directly by a transit agency, using their employees to supply the necessary labor to operate the revenue vehicles.

Distribution pipeline: Delivers natural gas to individual homes and businesses.

E85: A gasoline-ethanol mixture that may contain anywhere from 51 to 85 percent ethanol. Because fuel ethanol is denatured with approximately 2 to 3 percent gasoline, E85 is typically no more than 83 percent ethanol.

Energy intensity: The amount of energy used to produce a given level of output or activity, e.g., energy use per passenger-mile of travel. A decline in energy intensity indicates an improvement in energy efficiency, while an increase in energy intensity indicates a drop in energy efficiency.

Enplanements: Total number of revenue passengers boarding aircraft.

Expressway: A controlled access, divided arterial highway for through traffic, the intersections of which are usually separated from other roadways by differing grades.

Ferry boat: A vessel that provides fixed-route service across a body of water and is primarily engaged in transporting passengers or vehicles.

Flex fuel vehicle: A type of alternative fuel vehicle that can use conventional gasoline or gasoline-ethanol mixtures of up to 85 percent ethanol (E85).

Footprint (vehicle): The size of a vehicle defined as the rectangular "footprint" formed by its four tires. A vehicle's footprint is its track (width) multiplied by its wheelbase (length).

For-hire (transportation): Refers to a vehicle operated on behalf of or by a company that provides services to external customers for a fee. It is distinguished from private transportation services in which a firm transports its own freight and does not offer its transportation services to other shippers.

Freeway: All urban principal arterial roads with limited control of access not on the interstate system.

Functionally obsolete bridge: does not meet current design standards (for criteria such as lane width), either because the volume of traffic carried by the bridge exceeds the level anticipated when the bridge was constructed and/or the relevant design standards have been revised.

GDP (gross domestic product): The total value of goods and services produced by labor and property located in the United States. As long as the labor and property are located in the United States, the suppliers may be either U.S. residents or residents of foreign countries.

General aviation: Civil aviation operations other than those air carriers holding a Certificate of Public Convenience and Necessity. Types of aircraft used in general aviation range from corporate, multiengine jets piloted by a professional crew to amateur-built, single-engine, piston-driven, acrobatic planes.

Heavy rail: High-speed transit rail operated on rights-of-way that exclude all other vehicles and pedestrians.

Hybrid vehicle: Hybrid electric vehicles combine features of internal combustion engines and electric motors. Unlike 100% electric vehicles, hybrid vehicles do not need to be plugged into an external source of electricity to be recharged. Most hybrid vehicles operate on gasoline.

In-house (transportation): Includes transportation services provided within a firm whose main business is not transportation, such as grocery stores that use their own truck fleets to move goods from warehouses to retail outlets.

Interstate: Limited access divided facility of at least four lanes designated by the Federal Highway Administration as part of the Interstate System.

International Roughness Index (IRI): A scale for roughness based on the simulated response of a generic motor vehicle to the roughness in a single wheel path of the road surface.

Lane-mile: Equals one mile of one-lane road, thus three miles of a three-lane road would equal nine lane-miles.

Large certificated air carrier: Carriers operating aircraft with a maximum passenger capacity of more than 60 seats or a maximum payload of more than 18,000 pounds. These carriers are also grouped by annual operating revenues: majors—more than $1 billion; nationals—between $100 million and $1 billion; large regionals—between $20 million and $99,999,999; and medium regionals—less than $20 million.

Light-duty vehicle: Passenger cars, light trucks, vans, pickup trucks, and sport/utility vehicles regardless of wheelbase.

Light-duty vehicle, long wheelbase: Passenger cars, light trucks, vans, pickup trucks, and sport/utility vehicles with wheelbases longer than 121 inches.

Light-duty vehicle, short wheelbase: Passenger cars, light trucks, vans, pickup trucks, and sport/utility vehicles with wheelbases equal to or less than 121 inches and typically with a gross weight of less than 10,000 lb.

Light rail: Urban transit rail operated on a reserved right-of-way that may be crossed by roads used by motor vehicles and pedestrians.

Linked trip: A trip from the origin to the destination on the transit system. Even if a passenger must make several transfers during a journey, the trip is counted as one linked trip on the system.

Local road: All roads not defined as arterials or collectors; primarily provides access to land with little or no through movement.

Long-distance travel: As used in this report, trips of more than 50 miles. Such trips are primarily served by air carriers and privately owned vehicles.

Major collector: Collector roads that tend to serve higher traffic volumes than other collector roads. Major collector roads typically link arterials. Traffic volumes and speeds are typically lower than those of arterials.

Minor arterial: Roads linking cities and larger towns in rural areas. In urban areas, they are roads that link, but do not enter neighborhoods within a community.

Minor collector: Collector roads that tend to serve lower traffic volumes than other collector roads. Traffic volumes and speeds are typically lower than those of major collector roads.

Motorcoach: A vehicle designed for long-distance transportation of passengers, characterized by integral construction with an elevated passenger deck located over a baggage compartment. It is at least 35 feet in length with a capacity of more than 30 passengers.

Motorcycle: A two- or three-wheeled vehicle designed to transport one or two people, including motorscooters, minibikes, and mopeds.

Multiple Modes and Mail: the Freight Analysis Framework (FAF) and the Commodity Flow Survey (CFS) use "Multiple Modes and Mail" rather than "Intermodal" to represent commodities that move by more than one mode. Intermodal typically refers to containerized cargo that moves between ship and surface modes or between truck and rail, and repeated efforts to identify containerized cargo in the CFS have proved unsuccessful. Multiple mode shipments can include anything from containerized cargo to bulk goods such as coal moving from a mine to a railhead by truck and then by rail to a seaport. Mail shipments include parcel delivery services where shippers typically do not know what modes were involved after the shipment was picked up.

National Highway System (NHS): This system of highways designated and approved in accordance with the provisions of 23 United States Code 103b Federal-aid systems.

Nominal dollars: A market value that does not take inflation into account and reflects prices and quantities that were current at the time the measure was taken.

Nonself-propelled vessels: Includes dry cargo, tank barges, and railroad car floats that operate in U.S. ports and waterways.

Oceangoing vessels: Includes U.S. flag, privately owned merchant fleet of oceangoing, self-propelled, cargo-carrying vessels of 1,000 gross tons or greater.

Offshore gathering line: A pipeline that collects oil and natural gas from an offshore source, such as the Gulf of Mexico. Natural gas is collected by gathering lines that convey the resource to transmission lines, which in turn carry it to treatment plants that remove impurities from the gas. On the petroleum side, gathering pipelines collect crude oil from onshore and offshore wells. The oil is transported from the gathering lines to a trunk-line system that connects with processing facilities in regional markets.

Offshore transmission line (gas): A pipeline other than a gathering line that is located offshore for the purpose of transporting gas from a gathering line or storage facility to a distribution center, storage facility, or large volume customer that is not downstream from a distribution center.

Onshore gathering line: A pipeline that collects oil and natural gas from an onshore source, such as an oil field. Natural gas is collected by gathering lines that convey the resource to transmission lines, which in turn carry it to treatment plants that remove impurities from the gas. On the petroleum side, gathering pipelines collect crude oil from onshore and offshore wells. The oil is transported from the gathering lines to a trunk-line system that connects with processing facilities in regional markets.

Onshore transmission line (gas): A pipeline other than a gathering line that is located onshore for the purpose of transporting gas from a gathering line or storage facility to a distribution center, storage facility, or large volume customer that is not downstream from a distribution center.

Particulates: Carbon particles formed by partial oxidation and reduction of hydrocarbon fuel. Also included are trace quantities of metal oxides and nitrides originating from engine wear, component degradation, and inorganic fuel additives.

Passenger-mile: One passenger transported one mile. For example, one vehicle traveling 3 miles carrying 5 passengers generates 15 passenger-miles.

Person-miles: An estimate of the aggregate distances traveled by all persons on a given trip based on the estimated transportation-network-miles traveled on that trip. For instance, four persons traveling 25 miles would accumulate 100 person-miles. They include the driver and passenger in personal vehicles, but do not include the operator or crew for air, rail, and transit modes.

Person trip: A trip taken by an individual. For example, if three persons from the same household travel together, the trip is counted as one household trip and three person trips.

Personal vehicle: A motorized vehicle that is privately owned, leased, rented or company-owned and available to be used regularly by a household, which may include vehicles used solely for business purposes or business-owned vehicles, so long as they are driven home and can be used for the home to work trip (e.g., taxicabs, police cars, etc.).

Planning Time Index (PTI): The ratio of travel time on the worst day of the month compared to the time required to make the same trip at free-flow speeds.

Post Panamax vessel: Vessels exceeding the length or width of the lock chambers in the Panama Canal. The Panama Canal expansion project, slated for completion in 2015, is intended to double the canal's capacity by creating a new lane of traffic for more and larger ships.

Real dollars: Value adjusted for changes in prices over time due to inflation.

Self-propelled vessels: Includes dry cargo vessels, tankers, and offshore supply vessels, tugboats, pushboats, and passenger vessels, such as excursion/sightseeing boats, combination passenger and dry cargo vessels, and ferries.

Short ton: A unit of weight equal to 2,000 pounds.

Structurally deficient (bridge): Characterized by deteriorated conditions of significant bridge elements and potentially reduced load-carrying capacity. A "structurally deficient" designation does not imply that a bridge is unsafe, but such bridges typically require significant maintenance and repair to remain in service, and would eventually require major rehabilitation or replacement to address the underlying deficiency.

TEU (twenty-foot equivalent unit): A TEU is a nominal unit of measure equivalent to a 20' x 8' x 8' shipping container. For example, a 50 ft. container equals 2.5 TEU.

Tg CO_2 Eq.: Teragrams of carbon dioxide equivalent, a metric measure used to compare the emissions from various greenhouse gases based on their global warming potential.

Ton-mile: A unit of measure equal to movement of 1 ton over 1 mile.

Trainset: One or more powered cars mated with a number of passenger or freight cars that operate as one entity.

Transit bus: A bus designed for frequent stop service with front and center doors, normally with a rear-mounted diesel engine, low-back seating, and without luggage storage compartments or rest room facilities. Includes motor and trolley bus.

Transmission line: A pipeline used to transport natural gas from a gathering, processing, or storage facility to a processing or storage facility, large volume customer, or distribution system.

Transportation Services Index (TSI): A monthly measure indicating the relative change in the volume of services over time performed by the for-hire transportation sector. Change is shown relative to a base year, which is given a value of 100. The TSI covers the activities of for-hire freight carriers, for-hire passenger carriers, and a combination of the two. See www.rita.dot.gov for a detailed explanation.

Travel Time Index (TTI): The ratio of the travel time during the peak traffic period to the time required to make the same trip at free-flow speeds.

Trip-chaining: The practice of adding daily errands and other activities, such as shopping or going to a fitness center, to commutes to and from work.

Trolley bus: See transit bus.

Unlinked trips: The number of passengers who board public transportation vehicles. Passengers are counted each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination.

Vehicle-mile: Measures the distance traveled by a private vehicle, such as an automobile, van, pickup truck, or motorcycle. Each mile traveled is counted as one vehicle-mile regardless of number of passengers.

Extent and Use

Condition and Performance

Moving People

Moving Goods

Transportation Economics

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Transportation Energy Use and Environmental Impacts

The State of Transportation Statistics

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