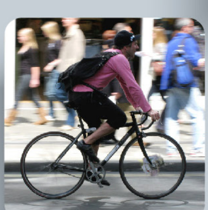
U.S. Department of Transportation
Bureau of Transportation Statistics

Transportation Statistics Annual Report

2016



U.S. Department of Transportation
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Data Sources

The data used throughout this document reflect the latest numbers available at the time of publication. Data and statistics compiled in this report were obtained from a wide range of U.S. Department of Transportation operating administrations and other statistical agencies throughout the Federal Government.

Notice

Introduction

The *Transportation Statistics Annual Report* describes the Nation's transportation system, the system's performance, its contributions to the economy, and its effects on people and the environment. This 21st edition of the report is based on information collected or compiled by the Bureau of Transportation Statistics (BTS), a principle Federal statistical agency at the U.S. Department of Transportation.

Nearly 4.2 million miles of roads, more than 19,000 public and private use airports, about 140,000 miles of freight and passenger railroads, 25,000 miles of navigable waterways, and nearly 2.7 million miles of oil and gas pipelines connect the Nation's people and businesses across the continent and with the rest of the world.

The estimated value of U.S. transportation assets in 2014 was approximately $8.1 trillion. The public owns 50.5 percent of the total transportation asset value, mostly highways and streets, but also publicly held transit facilities, airports, and numerous seaports, inland ports and terminals, and other facilities related to water transportation. Private companies own 31.5 percent of transportation assets, including railroads, pipelines, trucks, planes, and ships. Personal motor vehicles account for the remaining 18.0 percent.

The average person travels about 13,000 miles per year, and domestic businesses shipped 56 tons of freight annually per person in the United States.

The transportation sector accounted for:

- About $1.422 trillion in purchases and investments in transportation goods and services—or 8.9 percent of U.S. gross domestic product in 2014,
- $134.3 billion in public and private expenditures on transportation construction in 2015,
- 13.1 million jobs in transportation-related industries—or 9.4 percent of the U.S. labor force in 2014,
- $1,184 billion in transportation expenditures by U.S. residents—or 9.6 percent of all personal consumption expenditures in 2015.

- 36,982 lives lost and roughly 2.44 million nonfatal injuries in 2015,
- 70.1 percent of total petroleum consumption in the United States, and
- about 26 percent of total U.S. greenhouse gas emissions.

BTS compiled these and other statistics under Section 52011: *Moving Ahead for Progress in the 21st Century Act* (Public Law No. 112-141), which requires information on:

- transportation safety across all modes and intermodally—Chapter 6;
- the state of good repair of United States transportation infrastructure—Chapters 1 and 4;
- the extent, connectivity, and condition of the transportation system, building on the BTS national transportation atlas database—Chapters 1, 2, and 3;
- economic efficiency across the entire transportation sector—Chapters 3, 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 2 and 3;
- 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 2, 3, 4, and 5;
- intermodal and multimodal passenger movement—Chapters 1 and 2;
- intermodal and multimodal freight movement—Chapters 1 and 3; and
- consequences of transportation for the human and natural environment—Chapter 7.

See Appendix A in this report for a list of specific tables and figures that provide information on each of these topics, and Appendix B for a glossary of terms used throughout this report.

This report of the BTS Director to the President and the Congress summarizes the Bureau's findings through 2016.

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CHAPTER 1

Extent and Physical Condition of the U.S. Transportation System

Highlights

- The Nation's transportation assets were valued at approximately $8.1 trillion in 2014, an increase of 17.7 percent over 2010 estimates. Publicly owned infrastructure and equipment accounted for over one-half of transportation capital stock.
- Highway lane-miles as well as highway travel as measured by person-miles and vehicle-miles traveled increased by 2.0 to 3.0 percent over the 2010 to 2014 time period.
- The condition of the U.S. transportation infrastructure is improving, but additional work is needed. The percentage of structurally deficient bridges declined from 12.0 percent in 2010 to 9.6 percent in 2015.
- One impact of bridge deterioration is reduced load limits. In 2015, 11.3 percent of all bridges had load limits reduced, which caused commercial vehicle operators to carry smaller loads or take circuitous routes, increasing their costs.
- The average age of the highway light-duty vehicle fleet increased by 28 percent over the 2000 to 2014 period and stood at about 11.4 years in 2014. The average age of commercial trucks was 14.8 years in 2015, up from 12.5 years in 2007.
- The average age of inland waterway navigation locks, adjusted for the date of the most recent rehabilitation, is more than 50 years. Maintenance dredging of navigation channels decreased by 22 percent in 2 years, which could result in operators having to reduce tonnage.
- The majority of airport runways (commercial service, reliever, and select general aviation) are in good condition; only 2 percent are considered poor.
- Class 1 freight railroad capital expenditures totaled $15.1 billion in 2014, about 2.5 times the spending in 2000.
- There is a general lack of data on vehicle and traffic control system condition (regardless of mode), parking infrastructure, and on most aspects of intermodal connections.

The U.S. transportation system serves more than 321 million Americans—including those who may not own a vehicle or rarely travel. Transportation allows us to commute to work, obtain goods and services, call on family and friends, and visit distant places. It also drives our economy, connecting 7.5 million businesses with customers, suppliers, and workers [USDOC CENSUS SUSB 2016]. The system allows almost 75 million foreign visitors to travel to our country (see chapter two of this publication), resulting in a sizable contribution to the U.S. economy. The system serves a large and diverse set of users, as highlighted throughout this report.

This chapter examines both the extent and condition of the principal transportation modes, including infrastructure, vehicles and control systems, and the estimated cost of keeping or bringing the system into a state of good repair. Interconnections that link one mode with one or more other modes are also important system elements, but a lack of public data on these connections prevents meaningful analysis of their condition.

Assets and Investments

Transportation capital stock includes structures (e.g., roadways, bridges, and stations) and equipment (e.g., automobiles, aircraft, and ships). According to the Bureau of Economic Analysis, U.S. transportation capital stock was valued at an estimated $8.1 trillion in 2014, an increase of about $1.2 trillion (17.7 percent) over 2010 estimates.[1]

[1] Subtracted out from the reported totals are the amount of depreciation of aging equipment and structures and the value of assets taken out of service.

Table 1-1 shows the estimated value of transportation capital stock increased steadily from 2000 to 2014.

Transportation assets are owned by both the public and private sectors. Freight railroad facilities and equipment are almost entirely owned by the private sector, while state and local governments own highways and bridges, airports, seaports, and transit structures. In total, publicly owned transportation accounted for slightly over one-half of transportation capital stock; public highways and streets accounted for the largest share (41.8 percent) of this stock and much of the growth over the past few years. "Other" publicly owned transportation, such as airports, seaports, and transit structures, accounted for 8.7 percent.

In-house transportation is the largest category among the private-sector businesses. It accounted for 16.1 percent of transportation capital stock in 2014, most of which was highway related (e.g., truck fleets owned by grocery chains). Railroads, the next largest private sector category, accounted for 5.0 percent of U.S. transportation capital stock, followed by air with 3.1 percent. Motor vehicles owned by households and individuals, some of which are used for business purposes, accounted for 18.0 percent of capital stock.

The total value of public and private sector transportation construction put in place in 2015 was about $134 billion. Transportation construction of publicly owned transportation accounted for about $121 billion, or about 90 percent, of

TABLE 1-1 Estimated Value of Transportation Capital Stock by Mode: 2000 and 2010–2014
Billions of current dollars

	2000	2010	2011	2012	2013	2014
Publicly owned capital stock						
Public highways and streets	1,398	2,936	3,132	3,267	3,344	3,374
Other publicly owned transportation	249	586	631	663	686	700
Privately owned capital stock						
Personal vehicles and parts	1,051	1,288	1,319	1,362	1,400	1,454
In-house transportation	820	985	1,040	1,133	1,196	1,298
Railroad transportation	288	360	376	385	393	403
Air transportation	185	220	225	228	238	250
Pipeline transportation	74	165	185	194	209	225
Other privately owned transportation	110	123	127	129	128	129
Commercial truck transportation	71	108	116	124	131	141
Private transit and ground passenger transportation	37	43	43	43	45	47
Water transportation	37	41	42	42	44	46
TOTAL	**4,319**	**6,854**	**7,236**	**7,571**	**7,814**	**8,065**

NOTES: Data include only privately owned capital stock except for those otherwise noted. Capital stock data are reported after deducting depreciation. *Personal vehicles* are considered consumer durable goods. *In-house transportation* includes transportation services provided within a firm whose main business is not transportation. For example, grocery companies often use their own truck fleets to move goods from their warehouses to their retail outlets. *In-house transportation* figures cover the the current cost net capital stock for fixed assets (e.g., autos, aircraft, ships, etc.) owned by a firm. *Other publicly owned transportation* includes publicly owned airway, waterway, and transit structures but does not include associated equipment. *Other privately owned transportation* includes sightseeing, couriers and messengers, and transportation support activities, such as freight transportation brokers. *Locks and dams* may be included under *Other publicly owned transportation*. Details may not add to totals due to rounding. Data for 2010 through 2013 differ from those published in the 2015 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 3.1ES, 7.1B, 8.1; and *Nonresidential Detailed Estimates*, net stocks, current cost table. Available at http://www.bea.gov/ as of May 2016.

spending on transportation infrastructure [USDOC CENSUS 2016]. Approximately three-quarters of government-funded investment was for highways; the remainder supported the construction of transportation facilities and infrastructure, such as airport terminals and runways, transit facilities, water transportation facilities, and pedestrian and bicycling infrastructure. In 2015 private transportation construction was about $13 billion, or about 10 percent, of spending on transportation infrastructure. Chapter 5 details transportation infrastructure spending and the revenues generated by each transportation mode.

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

Roads

Public roads, including interstate highways, other major arterials, and local routes, totaled 4.2 million miles in 2014, changing little from 2010 (as shown in table 1-2). Lane-miles increased slightly more than 2 percent over that period. Local roads are by far the most extensive, amounting to 2.9 million miles (69.5 percent of total system-miles). However, interstate highways, which accounted for almost 48,000 miles (1.1 percent of total

TABLE 1-2 Public Roads and Bridges: 2000, 2010, 2013, and 2014

	2000	2010	2013	2014
Public road and street mileage by functional type (miles)				
Interstate	46,427	46,900	47,575	47,662
Other freeways and expressways	9,140	14,619	16,445	17,250
Other principal arterial	152,233	157,194	156,915	157,034
Minor arterial	227,364	242,815	243,872	244,961
Collectors	793,124	799,226	803,807	808,363
Local	2,707,934	2,806,322	2,846,848	2,901,804
TOTAL, mileage	**3,936,222**	**4,067,076**	**4,115,462**	**4,177,073**
Lane-miles	**8,224,245**	**8,581,158**	**8,656,070**	**8,766,049**
Bridges	**587,135**	**604,460**	**607,708**	**610,749**

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. Available at http://www.bts.gov/ as of May 2016.

system miles), handled the highest volumes of traffic as measured by vehicle-miles traveled—24.8 percent in 2014 [USDOT FHWA 2015a]. Large Western and Midwestern states, such as Texas, California, Illinois, Kansas, and Minnesota, have the most public road mileage.[2] The District of Columbia, followed by Hawaii, Rhode Island, Delaware, and Vermont, had the lowest public road and street mileage [USDOT FHWA 2015a]. Figure 1-1 shows the annual average daily traffic on the National Highway System.

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 the condition of highways and bridges.[3] Table 1-3 provides summary data on the percentage of rough surface mileage for different functional classes of highways. 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 functional class decreases from interstates down to collectors the percentage of rough roads increases, and this is true over the entire time period shown. This is likely the result of road maintenance and rehabilitation programs and budgets that favor the higher throughput classes of roadway.

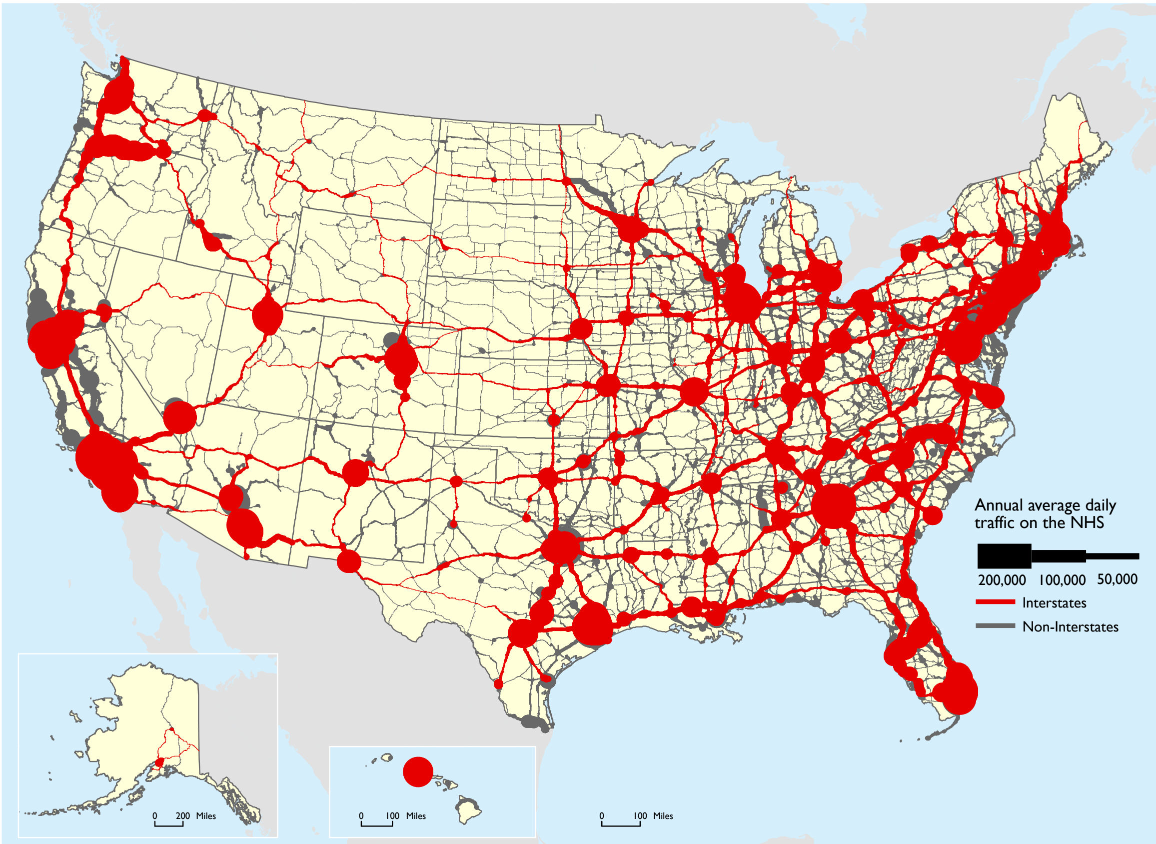
Bridges

About 610,750 highway bridges were in use in 2014, ranging in size from rural one-lane bridges crossing creeks to urban multilane and multilevel interstate bridges and major river crossings. Rural local bridges accounted for

[2] Alaska, the largest state by land area, has relatively few miles of roads, which reflects the lightly populated and relatively undeveloped character of the large landmass that lies outside of the Anchorage to Fairbanks corridor.

[3] A highway that has a roughness rating greater than 170 inches per mile is considered in poor condition.

FIGURE 1-1 Annual Average Daily Traffic on the National Highway System, 2012



SOURCE: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 4.2, 2016.

TABLE 1-3 Condition of the U.S. Highway System: 2000, 2011, 2013, and 2014
Highway surface condition

	2000	2011	2013	2014
Percent of mileage with International Roughness Index[a] over 170 (poor condition)				
Rural Routes				
Interstates	2.1	1.8	2.4	2.2
Other principal arterials	4.0	3.2	4.9	3.8
Minor arterials	7.0	6.6	7.2	7.2
Collectors	22.1	18.6	19.7	20.3
Urban Routes				
Interstates	6.5	5.2	5.1	5.4
Other freeways and expressways	10.9	7.8	7.2	8.5
Other principal arterials	30.0	28.1	25.8	26.3
Minor arterials	33.7	37.3	38.2	36.1
Collectors	52.3	53.7	53.7	49.8

[a] International Roughness Index values are based on objective measurements of pavement roughness. A low IRI represents a smooth riding roadway.

NOTE: 2010 highway surface condition data are unavailable, thus 2011 is used.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, as reported in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 1-27 (Highway surface condition). Available at www.bts.gov as of May 2016.

TABLE 1-4 Condition of U.S. Highway Bridges: 2000, 2010, and 2013–2015

	2000	2010	2013	2014	2015
Condition of highway bridges, percent					
Urban structurally deficient	10.2	8.3	7.0	6.7	6.3
Rural structurally deficient	16.7	13.3	11.7	11.3	10.9
All structurally deficient bridges	**15.2**	**12.0**	**10.5**	**10.0**	**9.6**
Urban functionally obsolete	25.2	24.2	23.8	23.6	23.4
Rural functionally obsolete	12.7	10.7	10.2	10.2	10.1
All functionally obsolete	**15.5**	**14.2**	**13.9**	**13.8**	**13.7**

SOURCES: 2000-2014: U.S. Department of Transportation, Federal Highway Administration, as reported in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 1-28 (Bridges). Available at www.bts.gov as of May 2016.
2015: U.S. Department of Transportation, Federal Highway Administration, National Bridge Inventory. Available at https://www.fhwa.dot.gov/bridge/nbi.cfm as of May 2016.

about 33.4 percent of the total bridge network. By comparison, bridges in the urban and rural interstate system accounted for about 9.3 percent of all bridges in 2014, but they carried the highest volumes of motor vehicle traffic. Texas had the most bridges, accounting for 8.7 percent of the entire U.S. bridge network, followed by Ohio and Illinois, each with about 4.4 percent [USDOT FHWA 2015a].

There has been slow but steady improvement in the condition of highway bridges, as shown in table 1-4.[4] Two categories of bridge deficiency are tabulated: structurally deficient and functionally obsolete.

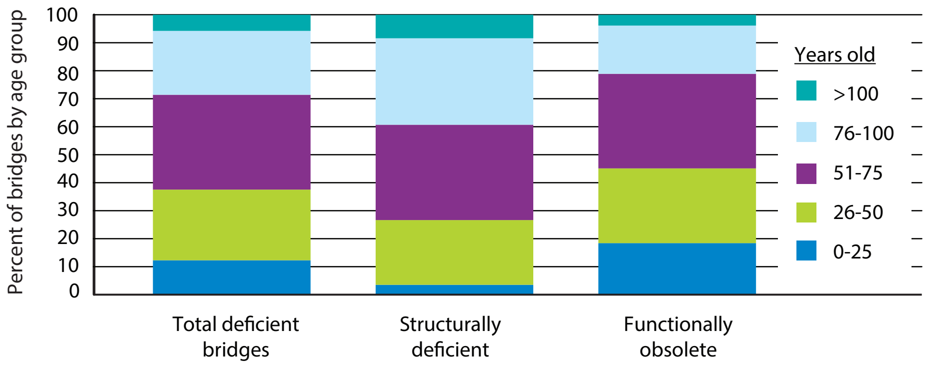
Structurally deficient bridges have reduced load bearing capacity due to the deterioration of one or more bridge elements. Such bridges are not necessarily unsafe, but they do require maintenance and repair to remain in service and will eventually require rehabilitation or replacement.

Functionally obsolete bridges, while structurally sound, often carry traffic volumes that exceed their design limits and may need to be widened or replaced. The percentages of both structurally deficient and functionally obsolete bridges declined from 2000 to 2015, with the largest declines recorded for rural bridges. Despite the improvement, 23.4 percent of urban bridges were functionally obsolete in 2015.

Figure 1-2 provides additional information on deficient bridges by age group, although age alone is not an automatic indicator of structural integrity. For example, the 133-year-old Brooklyn Bridge, due to consistent maintenance and several major rehabilitations, is still deemed safe for daily use, while the I-95 Mianus River Bridge in Connecticut collapsed in 1983 after only 25 years of service. The trend, however, is clear—the likelihood that a

[4] Bridge inventory and condition data were available through 2015 [USDOT FHWA 2016], so that year is included here. There were about 611,840 bridges in operation in 2015.

FIGURE 1-2 Bridge Condition by Age Group: 2015



	Years old (as of 12/31/2015)				
	0-25	**26-50**	**51-75**	**76-100**	**>100**
Total bridges	**170,125**	**208,806**	**147,763**	**72,898**	**12,241**
Total deficient bridges					
Number	17,536	36,087	48,406	32,647	8,236
Percent	10.3	17.3	32.8	44.8	67.3
Structurally deficient					
Number	2,062	13,615	20,009	18,146	4,959
Percent	1.2	6.5	13.5	24.9	40.5
Functionally obsolete					
Number	15,474	22,472	28,397	14,501	3,277
Percent	9.1	10.8	19.2	19.9	26.8

NOTES: Excludes four bridges with no recorded age. Bridges with a year built or reconstructed within the past 10 years will not be assigned a deficient status. Therefore, when referring to the deficiency being calculated not using the 10-year rule, the status will be calculated without taking into consideration the year built or the year reconstructed. U.S. totals include the 50 states, the District of Columbia, and Puerto Rico. Table includes: rural–interstate, principal arterial, minor arterial, major collector, minor collector and local roads; urban–interstate, other freeways or expressways, other principal arterial, minor arterial, collector, and local roads.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Bridge Inventory*. Available at https://www.fhwa.dot.gov/bridge/nbi.cfm as of May 2016.

bridge will be found deficient increases with the age of the bridge. About 62 percent of deficient bridges are more than 50 years old, and nearly one-half of bridges 75 years or older are rated as deficient.

The more prevalent negative impact of bridge deterioration is the imposition of reduced load limits. In 2015 there were 69,417 bridges in the National Bridge Inventory with some type of load restriction, comprising 11.3 percent of all bridges listed [USDOT FHWA 2016]. These load limit reductions can cause commercial vehicle operators to either use trucks with smaller payloads or take circuitous routes, both of which increase delivery costs.

Vehicles

Government, businesses, private individuals, and nongovernmental organizations owned and operated about 260 million motor vehicles in 2014, up by 4.1 percent over the 2010 low, which occurred while the country was slowly recovering from the recession that began in December 2007 (table 1-5). [NBER 2012]

TABLE 1-5 Motor Vehicles and Travel: 2000, 2010, 2013, and 2014

Motor vehicle registrations by type

	2000	2010	2013	2014
Light-duty vehicle, short wheel base	U	190,202,782	184,497,490	187,554,928
Passenger Car	133,621,420	U	U	U
Motorcycle	4,346,068	8,009,503	8,404,687	8,417,718
Light-duty vehicle, long wheel base	U	40,241,658	51,512,740	52,600,309
Other 2-axle 4-tire vehicles	79,084,979	U	U	U
Truck, single-unit 2-axle 6-tire or more	5,926,030	8,217,189	8,126,007	8,328,759
Truck, combination	2,096,619	2,552,865	2,471,349	2,577,197
Bus	746,125	846,051	864,549	872,027
TOTAL, registered vehicles	**225,821,241**	**250,070,048**	**255,876,822**	**260,350,938**
Average age of vehicles (years)				
Passenger cars	9.1	10.8	11.4	11.4
Light trucks	8.4	10.5	11.3	11.4
All light vehicles	8.9	10.6	11.4	11.4
Person-miles traveled (PMT) (millions)				
Light duty vehicle, short wheel base	U	2,814,055	2,882,221	2,878,905
Passenger cars	3,107,729	U	U	U
Motorcycle	15,463	19,886	21,937	21,510
Light duty vehicle, long wheel base	U	831,312	805,997	852,983
Other 2-axle 4-tire vehicles	851,762	U	U	U
Truck, single-unit 2-axle 6-tire or more	100,486	110,674	106,582	109,301
Truck, combination	161,238	175,911	168,436	169,830
Bus	313,897	292,319	321,539	339,177
TOTAL, highway PMT	**4,550,574**	**4,244,157**	**4,306,653**	**4,371,706**
Vehicle-miles traveled (VMT) (millions)				
Light duty vehicle, short wheel-base	U	2,025,745	2,074,423	2,072,021
Passenger cars	1,600,287	U	U	U
Motorcycle	10,469	18,513	20,366	19,970
Light duty vehicle, long wheel-base	U	622,712	603,313	638,484
Other 2-axle 4-tire vehicles	923,059	U	U	U
Truck, single-unit 2-axle 6-tire or more	70,500	110,738	106,582	109,301
Truck, combination	135,020	175,789	168,436	169,830
Bus	7,590	13,770	15,167	15,999
TOTAL, highway VMT	**2,746,925**	**2,967,266**	**2,988,281**	**3,025,656**

KEY: U = Data are unavailable.

NOTE: PMT and VMT for 2000 are not comparable to data for later years. Motor bus and demand response figures are also included in the bus figure for highway.

SOURCES: *Vehicle Registrations, Age, PMT, VMT:* 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 1-11, 1-26, 1-35, 1-40. Available at http://www.bts.gov/ as of May 2016.

Motor vehicle registrations have grown at a faster rate than licensed drivers and the population since the 1960s (figure 1-3). This growth produced an increase in the average number of motor vehicles owned by households. However, compared to rapidly industrializing countries, U.S. vehicle registrations have changed relatively little since 2005. For example, vehicle registrations in China grew from 13.4 million to 120 million over the 2000 to 2013 period and presently account for about 10.4 percent of the world total, up from 1.8 percent in 2000 [USDOE ORNL 2015].

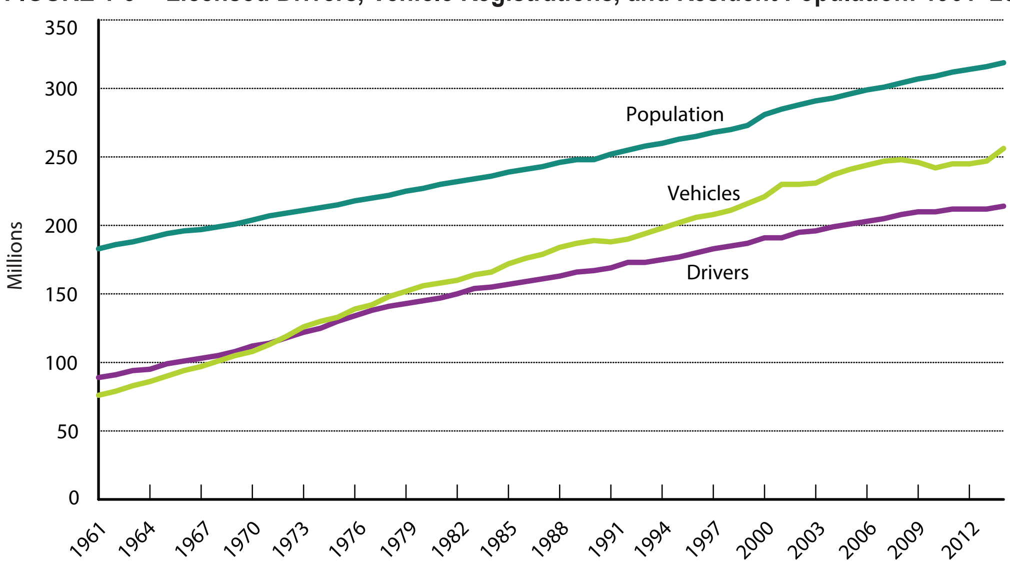
Increases in vehicle registrations from 2010 to 2014 varied widely by vehicle type. For example, among passenger vehicles, registrations for light-duty short-wheelbase vehicles[5] decreased by 1.4 percent, while those for light-duty long-wheelbase vehicles[6] increased by 31 percent. Motorcycle registrations rose by 5 percent, continuing a long-term upward trend. The numbers of single-unit and combination trucks registrations were up 1.3 and 1.0 percent, respectively, between 2010 and 2014. The number of buses increased by 3.1 percent between 2010 and 2014.

Bus registrations grew from 2000 to 2010 and, after a temporary dip, now stand at their

[5] Light-duty short-wheelbase vehicles includes passenger cars, light trucks, vans, and sport utility vehicles with a wheelbase equal to or less than 121 inches (e.g., Ford Explorer).

[6] Light-duty long-wheelbase vehicles includes large passenger cars, vans, pickup trucks, and sport/utility vehicles with wheelbases larger than 121 inches (e.g., Dodge Ram Pickup).

FIGURE 1-3 Licensed Drivers, Vehicle Registrations, and Resident Population: 1961–2014



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2014*. Tables DL-1C and MV-1. Available at http://www.fhwa.dot.gov/policyinformation/statistics/2013 as of May 2016.

highest level over the period shown. Buses owned by schools, churches, and other groups accounted for 74 percent of the registrations in 2014 [USDOT FHWA 2015a]. About 3,600 carriers operated 36,500 motorcoaches (or over-the-road buses) in the United States and Canada in 2014 [ABA 2016]. The motor coach industry is discussed further in chapter 2.

While total vehicle registrations increased by 4.1 percent from 2010 to 2014, highway travel did not quite keep pace. Person-miles of travel (PMT) increased by 3.0 percent, and vehicle-miles of travel (VMT) increased by 2.0 percent over that period. And while commercial vehicles (trucks and buses) were only about 4.5 percent of the registered vehicles, they accounted for between 9.7 and 10.1 percent of the VMT. Both PMT and VMT are discussed in more detail in chapter 2.

There is no organized database on the operating condition of vehicles traveling on the Nation's highways. Table 1-5 shows that the average age of the light-duty vehicle fleet increased by 28 percent over the 2000 to 2014 period and stood at about 11.4 years in 2014. The commercial truck fleet is even older. The average age of the commercial trucks was 14.8 years in 2015, up from 12.5 years in 2007 [IHS 2015].[7] However, age is not necessarily an indicator of vehicle condition.

Parking

The parking infrastructure in the United States is both vast and largely unmeasured. Parking spaces range from a single driveway or curbside spot adjacent to a private residence, up to thousands of spaces in large parking structures at high-density developments such as urban centers, airports, and universities. While there is no official estimate of the number of parking spaces in the United States, a recent research paper employs a number of scenarios to reach a mid-range estimate on the order of 800 to 850 million spaces [CHESTER 2010].

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 level transportation issues that require data on parking supply. For example, 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 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 when drivers must wait for their destination to open and accept deliveries [USDOT FHWA 2015b]. This topic is discussed in chapter 6, box 6-D.

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. An estimated 311,000 traffic signals have been installed in

[7] IHS Automotive acquired R.L. Polk & Co. in 2013 and continues the former Polk automotive registrations proprietary data series.

the United States, with an aggregate public capital investment of $83 billion [NTOC 2012]. There are no comparable estimates of the numbers of other types of traffic control devices.

Public Transit

Public transit provided 10.5 billion unlinked trips in 2014, up by 1.8 billion (20.5 percent) over the 2000 total. Over 850 urban transit agencies and more than 1,700 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. Buses accounted for nearly half (about 47.3 percent) of the 132,000 transit vehicles in 2014 (table 1-6). In 2014 these transit agencies operated over 5,200 stations, 78 percent of which comply with the *Americans with Disabilities Act* (Pub.L. 101-336), and 1,700 maintenance facilities. Transit agencies vary widely in size, ranging from 1 to 12,500 vehicles (e.g., the New York City Metropolitan Transportation Authority) [USDOT FTA 2015]. Box 1-A shows the 69 U.S. cities with bike-share systems, which often extend the reach of existing public transit systems (bus, ferry, and rail). Bike-share systems are discussed further in chapter 2.

The average age of transit vehicles over the 2000 to 2014 period is shown in table 1-6. Commuter rail passenger coaches had the greatest increase in average age of all rail vehicles over that period and are among the oldest of all transit equipment. The heavy-rail car fleet age decreased by 2.5 years between 2000 and 2014, but was still 20.4 years old on average. Light-rail vehicles maintained an average age of less than 17 years and transit buses 7 to 8 years over the reporting period, indicating that many transit agencies retired and replaced older vehicles on a regular basis or added new vehicles to the fleet. As would be expected, the transit bus fleet remained considerably newer than the rail fleet, which has locomotives and cars that typically last for decades. The average age of ferry boats dropped by 1.8 years, but they remained the oldest part of the transit vehicle population.

In 2014 transit riders made 10.5 billion trips and traveled 57.0 billion miles, which were increases of 5.5 and 8.2 percent, respectively, since 2010 (table 1-6). Rail transit (heavy, commuter, and light rail) comprised only 15.3 percent of the transit vehicles, but captured 46.6 percent of the trips and produced an even greater 57.2 percent of the person-miles of travel. Buses recorded the highest share of transit trips, 47.9 percent, and 37.9 percent of the person-miles. The nature of demand response systems, which are largely social service agency trip providers, is clearly shown in the table. These systems operated 23.8 percent of the transit vehicles in 2014, but provided 1.0 percent of the trips and 1.5 percent of the person-miles.

According to USDOT's biennial conditions and performance report, the current total investment across all transit systems is $16.5 billion annually. Bringing all systems to a state of good repair would require an increase to $18.5 billion per year. However, increasing system capacity to accommodate higher transit ridership would require an estimated $22.0 billion to support a 1.4 percent annual ridership growth rate versus an estimated $24.5 billion

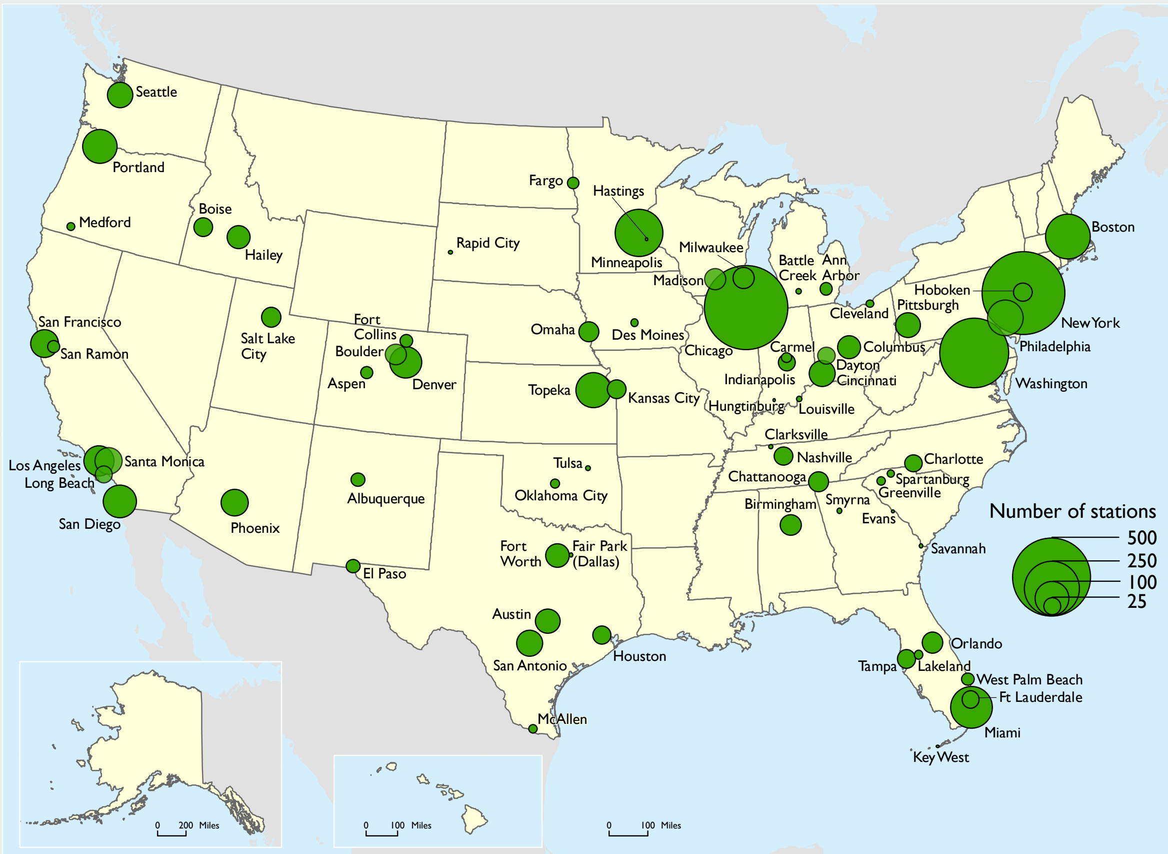
TABLE 1-6 Transit Vehicles and Ridership: Revenue Years 2000, 2010, 2013, and 2014

	2000	2010	2013	2014
Number of transit vehicles				
Heavy rail cars	10,311	11,510	10,380	10,551
Commuter rail cars and locomotives	5,497	6,768	7,150	7,177
Light rail cars	1,306	2,096	2,842	2,444
TOTAL, rail transit vehicles	**17,114**	**20,374**	**20,372**	**20,172**
Motor bus	59,230	63,679	66,823	62,449
Demand response	22,087	33,555	31,433	31,359
Ferry boat	98	134	156	144
Other	7,607	18,066	17,793	17,850
TOTAL, non-rail transit vehicles	**89,022**	**115,434**	**116,205**	**111,802**
TOTAL, transit vehicles	**106,136**	**135,808**	**136,577**	**131,974**
Average age of vehicles				
Heavy-rail passenger cars	22.9	18.7	20.2	20.4
Commuter-rail passenger coaches	16.9	18.9	20.8	18.8
Full-size transit buses	8.1	7.9	8.1	7.2
Light-rail vehicles	16.1	16.8	16.4	16.7
Transit vans	3.1	3.4	3.5	3.5
Ferry boats	25.6	20.5	21.4	23.8
Person-miles (millions)				
Heavy rail	13,844	16,407	18,005	18,339
Commuter rail	9,400	10,774	11,736	11,600
Light rail	1,339	2,173	2,565	2,675
TOTAL, rail transit PMT	**24,583**	**29,353**	**32,305**	**32,614**
Motor bus	18,999	20,739	21,414	21,587
Demand response	588	874	852	864
Ferry boat	298	389	402	414
Other	632	1,315	1,449	1,534
TOTAL, non-rail transit PMT	**20,517**	**23,317**	**24,117**	**24,399**
TOTAL, transit PMT	**45,100**	**52,670**	**56,422**	**57,013**
Unlinked passenger trips (billions)				
Heavy rail	2.63	3.55	3.82	3.93
Commuter rail	0.41	0.46	0.48	0.49
Light rail	0.32	0.46	0.52	0.48
TOTAL, rail transit UPT	**3.36**	**4.47**	**4.81**	**4.90**
Motor bus	5.16	5.24	5.33	5.04
Demand response	0.07	0.10	0.11	0.10
Ferry boat	0.05	0.06	0.06	0.06
Other	0.08	0.10	0.09	0.40
TOTAL, non-rail transit UPT	**5.36**	**5.49**	**5.60**	**5.61**
TOTAL, transit UPT	**8.72**	**9.96**	**10.41**	**10.51**

NOTES: *Motor bus* includes Bus (MB), Commuter Bus (CB), Bus Rapid Transit (RB), and Trolley Bus (TB). *Light Rail* includes Light Rail (LR), Streetcar Rail (SR), and Hybrid Rail (YR). *Demand response* includes Demand Response (DR) and Demand Response Taxi (DT). *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 and 1-29. Available at http://www.bts.gov/ as of May 2016. *Person-miles travelled*: USDOT/FTA/NTD as cited in USDOT/BTS/NTS. Table 1-40. Available at http://www.bts.gov/ as of May 2016. *Unlinked passenger trips*: USDOT/FTA/NTD, Table 19. Available at http://www.ntdprogram.gov/ as of May 2016.

Box 1-A U.S. Cities with Bike-Share Systems: 2016



NOTE: Cities not labeled: Redwood City, CA; Mountain View, CA; and Palo Alto, CA (all part of Bay Area Bike share along with San Francisco, CA and San Jose, CA); Santa Monica, CA and Los Angeles, CA (all part of Breeze Bike Share along with Santa Monica); Ashland, OR and White City, OR (all part of Zagstar Jackson County along with Medford, OR); Mesa, AZ (part of Grid Bike Share along with Phoenix, AZ); Elkhorn Village, ID; Ketchum, ID; and Sun Valley, ID (all part of MR Bike Share along with Hailey, ID); Covington, KY; Newport, KY; and Bellevue, KY (all part of Red Bike along with Cincinnati, OH); St. Paul, MN (part of Nice Ride Minnesota along with Minneapolis, MN); Council Bluffs (part of Heartland B-cycle along with Omaha, NE); Pompano Beach, FL; Lauderdale by the Sea, FL (all part of Broward B-cycle); Kissimmee, FL and Winter Park, FL (all part of Juice Bike share along with Orlando, FL); Rockville, MD; Bethesda, MD; Silver Spring, MD; North Potomac, MD; Takoma Park, MD; Derwood, MD; Redland, MD; Chevy Chase, MD; Alexandria, VA; and Arlington, VA (all part of the Capital Bikeshare system along with Washington DC); Brookline, MA; Cambridge, MA; and Somerville, MA (all part of Hubway along with Boston, MA); Jersey City (part of Citi Bike NYC along with New York, NY).

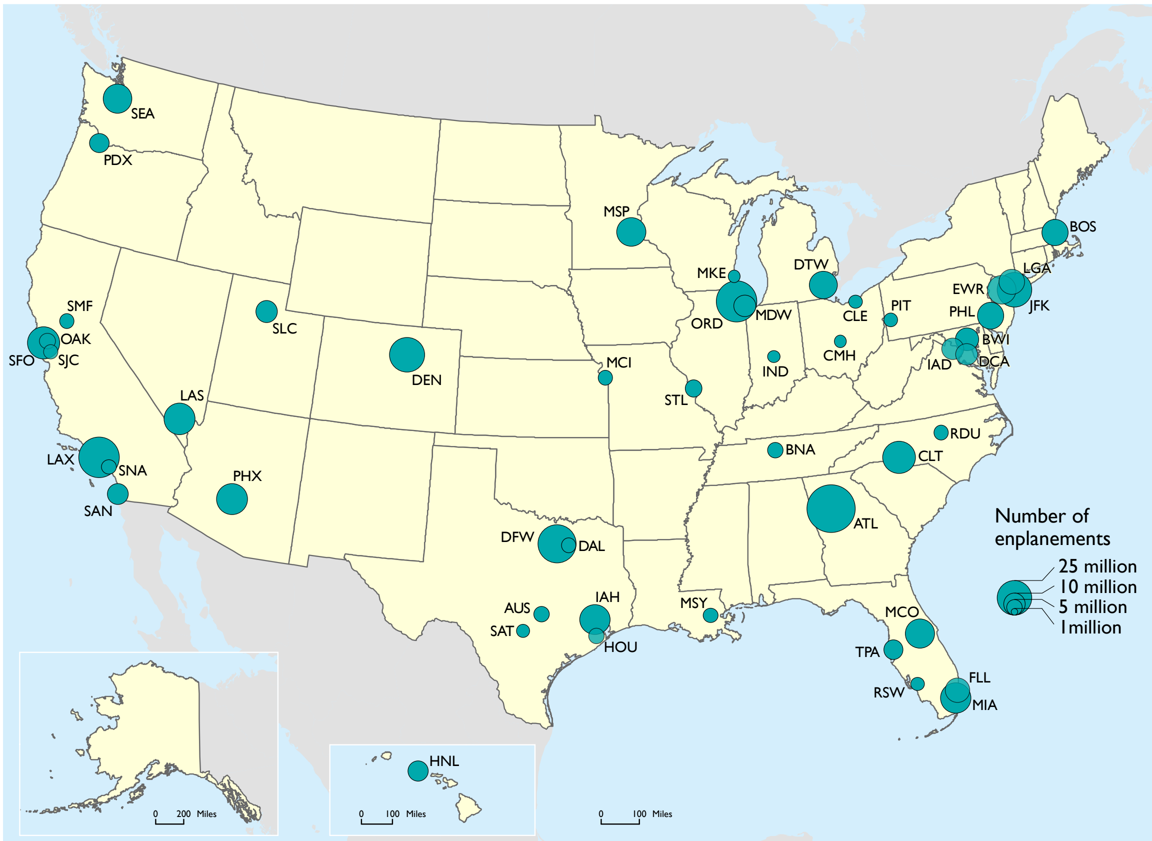
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Intermodal Passenger Connectivity Database as of October 2016

to support a 2.2 percent annual ridership growth rate [USDOT FHWA and FTA 2013].

Aviation

The main elements of the aviation system include airport runways and terminals, aircraft, and air traffic control systems. Table 1-7 shows that in 2014 the United States had about 19,300 airports, ranging from rural grass landing strips, to urban rooftop heliports, to large paved multiple-runway airports. Most of the 5,145 public-use facilities are general aviation airports, serving a wide range of users. In addition, there are almost 14,000 private airports, which are relatively small. Figure 1-4 shows the passenger boardings at the top 50 U.S. airports in 2015. These airports accounted

FIGURE 1-4 Enplanements at the Top 50 U.S. Airports: 2015



NOTES: 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, Office of Airline Information, *T-100 Market Data*, available at www.transtats.bts.gov as of June 2016.

for 81.0 percent (about 686 million) of the U.S. passenger enplanements in 2015 [USDOT BTS 2016a]. The number of U.S. airports with nonstop international service increased from 72 in 1993 to 128 in 2015, offering more locations throughout the country with commercial air service to the world [USDOT BTS 2016a].

The Federal Aviation Administration (FAA) compiles data on runway pavement conditions, which are presented in table 1-6. Most airport pavements (commercial service, reliever, and select general aviation) were in good condition between 2000 and 2014, with only 2 percent rated as poor. There are no similar data for other elements of aviation infrastructure.

Table 1-7 shows average ages of U.S. commercial airline aircraft in 2000, 2010, 2013, and 2014. The aircraft flown by the major and national airlines are roughly half the age of the smaller planes used by regional airlines. Overall the aircraft fleet became a bit younger between 2013 and 2015. There are no public data to indicate the physical condition of the aircraft fleet.

TABLE 1-7 U.S. Air Transportation System: 2000, 2010, 2013–2015[a]

	2000	2010	2013	2014
Number of U.S. airports				
Public use	5,317	5,175	5,155	5,145
Private use	13,964	14,353	14,009	13,863
Military	NA	274	289	286
TOTAL, airports	**19,281**	**19,802**	**19,453**	**19,294**
Number of U.S. aircraft				
General aviation aircraft	217,533	223,370	199,927	204,408
Commercial aircraft	7,826	7,185	6,733	6,676
TOTAL, aircraft	**225,359**	**230,555**	**206,660**	**211,084**
Pilots	**625,581**	**627,588**	**599,086**	**593,499**
Passenger enplanements (thousands)				
Domestic flights	NA	629,500	645,700	663,161
International flights of U.S. carriers	NA	91,000	97,500	99,990
TOTAL, passenger enplanements	**NA**	**720,500**	**743,200**	**763,151**
Passenger-miles (million)				
Domestic, revenue passenger-miles (RPM)	NA	552,900	577,900	607,772
International on U.S. carriers, RPM	NA	245,200	262,500	272,146
TOTAL, air RPM	**NA**	**798,000**	**840,400**	**879,918**
Ton-miles (million)				
Domestic, enplaned revenue ton-miles	15,200	12,500	12,400	12,900
International on U.S. carriers, enplaned revenue ton-miles	41,200	52,500	49,500	52,300
TOTAL, enplaned revenue ton-miles	**56,400**	**65,000**	**61,900**	**65,200**
Airport runway condition				
All NPIAS Airports, percent				
Good condition	73	79	81	80
Fair condition	22	18	17	17
Poor condition	5	3	2	2
Commercial service airports, percent				
Good condition	79	82	83	83
Fair condition	19	16	15	15
Poor condition	2	2	2	2
Average age of aircraft				
	2000	**2010**	**2013**	**2015**
Major[b] airline aircraft	NA	14.1	13.3	13.3
National[b] airline aircraft	NA	9.1	11.6	10.7
Regional airline aircraft	NA	28.2	26.9	24.8

KEY: NPIAS = National Plan of Integrated Airport Systems. NA = not available.

NOTES: *General aviation* includes air taxis. Enplaned revenue ton-miles data reporting changed in 2002, so 2003 is the first year shown here. Aircraft age data were compiled for 2015 rather than 2014.

[a]2015 data only available for average aircraft age.

[b] Major carriers have annual operating revenue exceeding $1 billion. National carriers have annual operating revenues between $100 million and $1 billion.

SOURCES: *Airports and aircraft*: U.S. Department of Transportation (USDOT). Federal Aviation Administration (FAA) as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics.*Tables 1-3 , 1-11, and 1-25. Available at http://www.bts.gov/ as of May 2016. *Pilots*: USDOT/FAA. FAA Aerospace Forecast, Fiscal Years (multiple issues). Available at www.faa.gov as of May 2016. *Passenger enplanements*: USDOT, Bureau of Transportation Statistics (BTS), Office of Airline Information (OAI), *T-100 market data*. Available at http://www.transtats.bts.gov/ as of May 2016. *RPM and Enplaned revenue ton-miles*: USDOT, BTS, OAI, T-100 Segment data. Available at http://www.transtats.bts.gov/ as of May 2016. Aircraft age: USDOT, BTS, Office of Airline Information, TranStats Database, Form 41, Schedule B-43, special tabulation, May 2016.

The FAA is in the midst of a major effort to upgrade the U.S. air traffic control (ATC) system to increase its capacity. Current efforts are focused on developing the Next Generation Air Transportation System (NextGen), which will utilize GPS satellite technology and related communications and information technology improvements. A major reason for this effort is that the ATC system relies on ground-based radar and voice communication technologies, some of which date back to the 1940s, limiting its ability to increase capacity in keeping with increasing air traffic demand. U.S. airports handled about 5.8 million commercial airline flights in 2015, about the same number as in 2014.

New approach procedures using the Wide Area Augmentation System (WAAS) increase access to general aviation airports, especially during low visibility. The FAA has published 3,534 WAAS-enabled approach procedures at 1,725 airports as of April 2015 [USDOT FAA 2015].

Railroads

The United States had almost 140,000 railroad route-miles in 2014 [AAR 2015], including about 94,400 miles owned and operated by

TABLE 1-8 Rail Transportation System: Fiscal Years 2000, 2010, 2013, and 2014

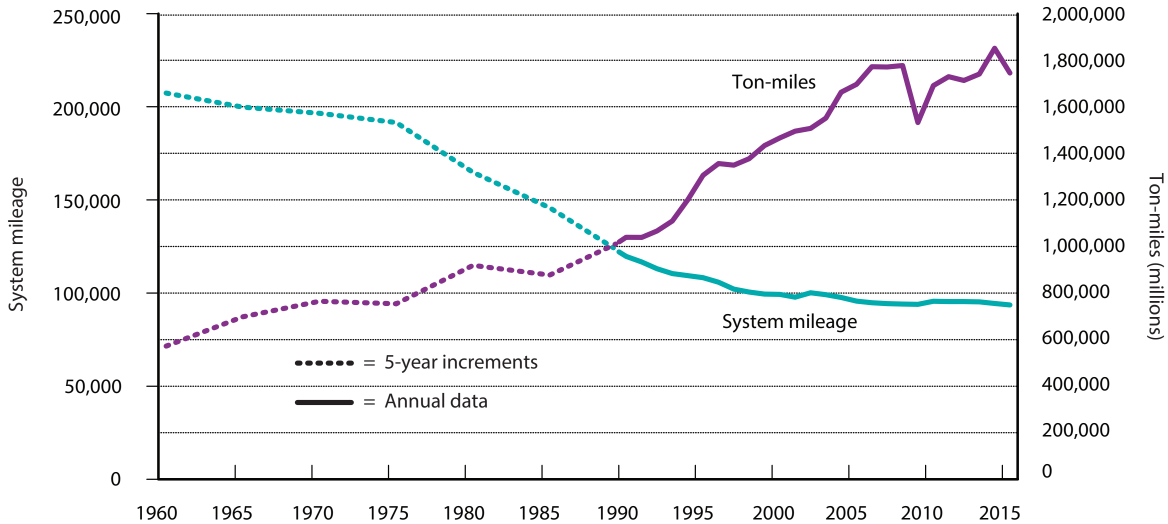
	2000	2010	2013	2014
Equipment and mileage operated by Amtrak				
Locomotives	378	282	418	428
Passenger cars	1,894	1,274	1,447	1,419
System mileage	23,000	21,178	21,356	21,356
Stations	515	519	516	518
Passengers (millions)	20.9	28.7	30.9	31.0
Passenger-miles travelled (millions)	5,498	6,420	6,810	6,675
Equipment and mileage operated by Class I				
Locomotives	20,028	23,893	25,033	25,916
Freight cars	560,154	397,730	373,838	371,642
Car companies and shippers freight cars[a]	688,194	809,544	873,679	1,184,929
System mileage	99,250	95,700	95,235	94,372
Ton-miles (trillion)	1.47	1.69	1.74	1.85
Freight rail maintenance and upgrades				
New rail and crossties laid				
Rail, thousand tons	690	564	620	673
Crossties, million	11.5	15.6	16.2	15.4
Capital expenditures, $billion				
Roadway and structures	$4.55	$7.86	$9.32	$10.01
Equipment	$1.51	$1.91	$3.77	$5.07
TOTAL	**$6.06**	**$9.77**	**$13.09**	**$15.08**

KEY: FY = Fiscal Year

NOTES: Fiscal year ending in September. aData for 2014 incudes totals for Canada and Mexico. North American freight cars have totaled 1.5 to 1.6 million over the period shown.

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 May 2016. *Passengers*: USDOT, Federal Railroad Administration, Office of Safety Analysis, as cited in USDOT, BTS, Multimodal Transportation Indicators. Available at www.bts.gov as of May 2016. *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 May 2016. *Ton-miles, rail, crossties, and capital expenditures*: Association of American Railroads, Railroad Facts (Annual issues), as of May 2016.

FIGURE 1-5 Class I Railroad System Mileage and Ton-miles of Freight: 1960–2015



SOURCE: Association of American Railroads, Railroad Facts, Statistical Highlights (Washington, DC: Annual Issues).

the seven Class I railroads.[8] Amtrak, local, and regional railroads operated the remaining 45,000 miles. Class I railroads owned and operated over 25,000 locomotives and 372,000 freight railcars (table 1-8).

Over the past 50 years, Class I railroads and connecting facilities have developed increasingly efficient ways to carry and transfer cargo (e.g., double-stack container railcars and on-dock rail), allowing more cargo to be carried with fewer railcars. Figure 1-5 shows that the system mileage of Class I railroads in 2015 was less than one-half the mileage in 1960. However, freight rail ton-miles nearly tripled to 1.8 trillion during the same period (despite a decline during the last recession).

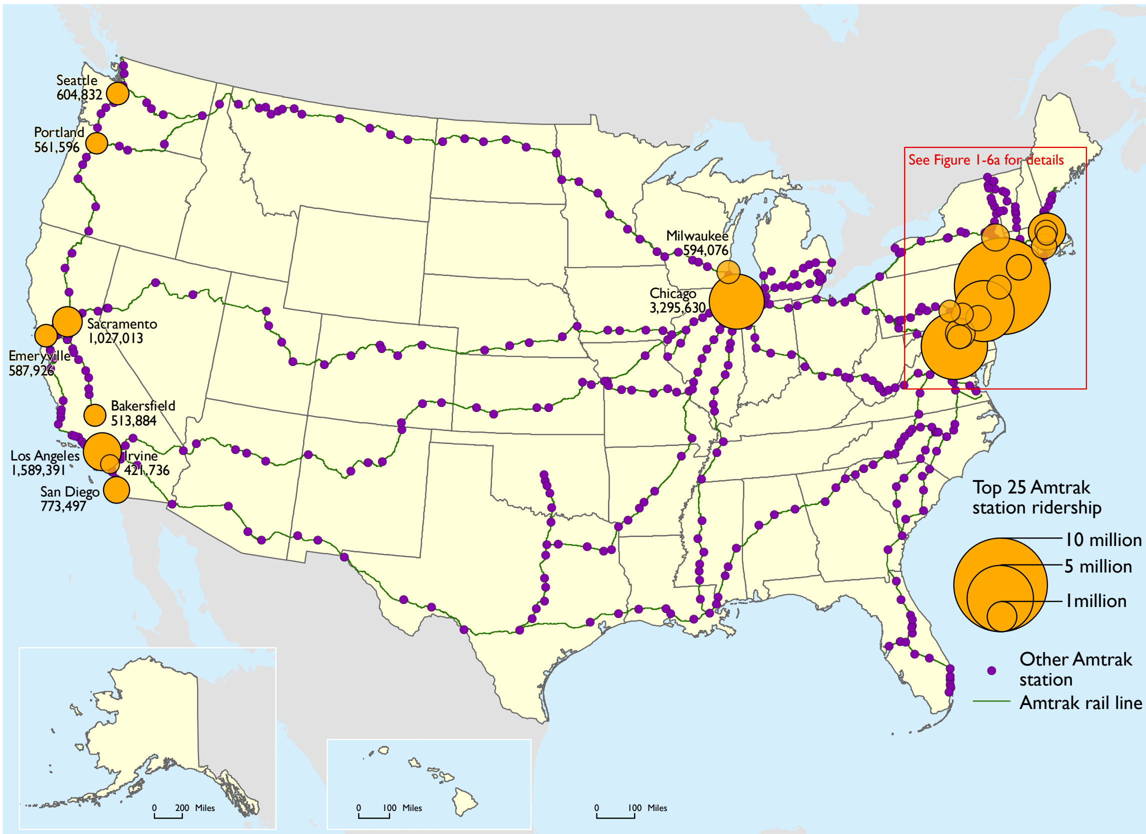
[8] Includes BNSF Railway, CSX Transportation, Grand Trunk Corp. (Canadian National operations in the United States), Kansas City Southern, Norfolk Southern, Soo Line (Canadian Pacific operations in the United States), and Union Pacific.

Intercity Passenger Rail

The National Rail Passenger Corp. (Amtrak) is the primary operator of intercity passenger rail service in the United States. Amtrak operated 21,300 route miles in 2015 and more than 500 stations that served 46 states and Washington, DC. Figure 1-6a shows the top 25 stations by ridership across the country, and figure 1-6b shows the stations by ridership in the Northeast Corridor (NEC). Ridership was also high around Chicago as well as at several locations in California and the Pacific Northwest.

Amtrak owns a small fraction of its route miles, primarily 363 of the 456-mile NEC between Boston, MA, and Washington, DC, plus three other shorter segments totaling 261 miles [Amtrak 2016]. The vast majority of passenger train services outside the NEC are provided over tracks owned by and shared with the Class I freight railroads. Hence, the condition of the infrastructure Amtrak uses is

FIGURE 1-6a Top 25 Busiest Amtrak Stations: FY2015



SOURCE: Amtrak, *State Fact Sheets*, available at www.amtrak.com as of February 2016.

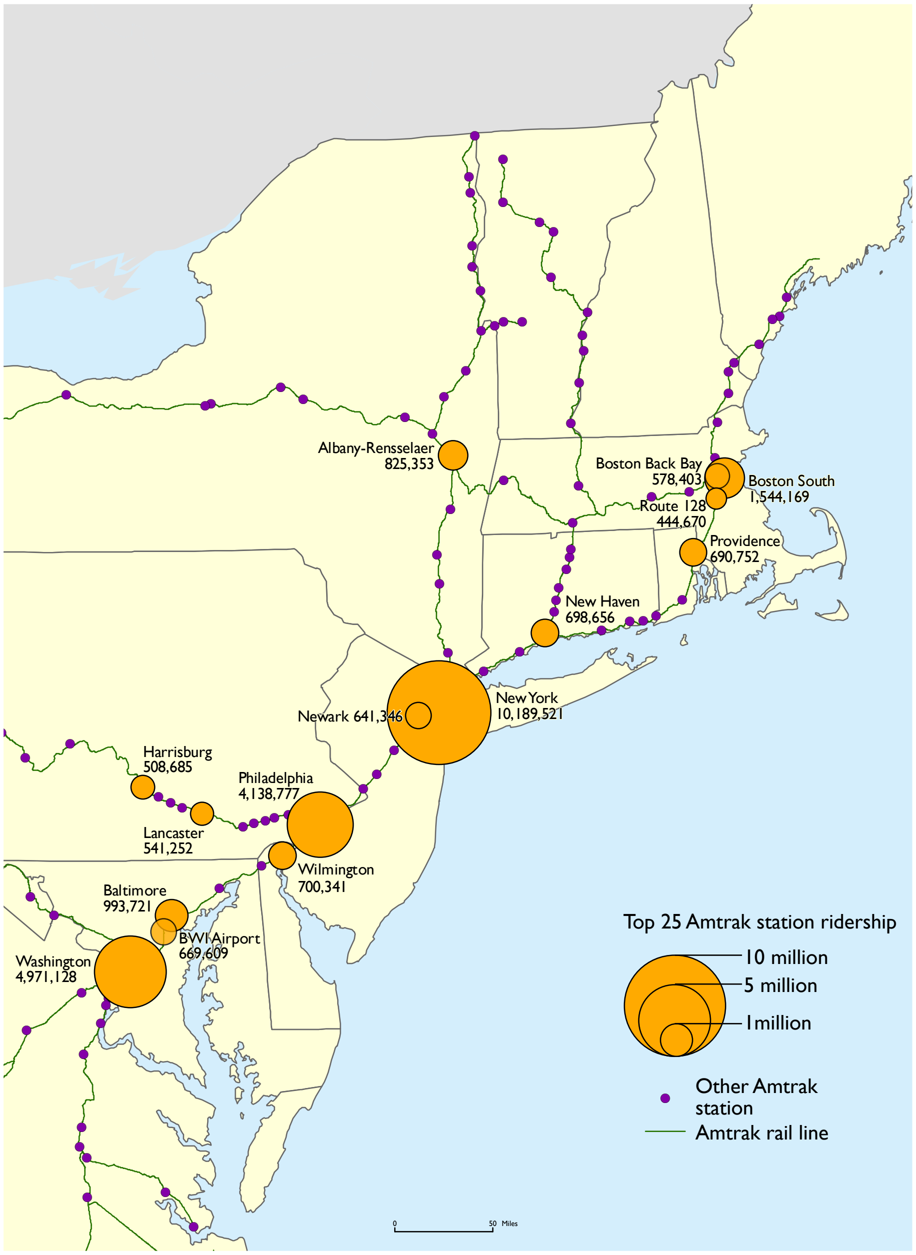
largely dependent on the condition of the host railroads, with the exception of the NEC.

Freight Rail

The U.S. freight rail system is privately owned and operated, and rail carriers are under no obligation to report freight track conditions to public sector agencies. Thus universal track condition reports are unavailable. Railroads regularly inspect their track and perform necessary repairs to ensure track safety. The 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. Presently there is no regular program for assembling and analyzing the many thousands of inspection reports that are prepared each year.

There is, however, one FRA program that generates systematic data on track condition. The Automated Track Inspection Program (ATIP) utilizes a small fleet of highly instrumented track geometry inspection cars

FIGURE 1-6b Amtrak Stations Along the Northeast Corridor: FY2015



SOURCE: Amtrak, *State Fact Sheets*, available at www.amtrak.com as of February 2016.

TABLE 1-9 Automated Track Inspection Program (ATIP) Exceptions[1] per 100 Miles: 2004–2015

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Profile	4.2	3.4	3.5	3.2	2.4	1.9	2.1	2.4	1.4	17.4	9.9	1.5
Alignment	2.7	1.6	1.3	1.7	1.4	1.8	2.0	2.0	1.5	18.4	10.6	1.8
Gage	13.6	8.5	6.6	5.1	12.2	7.2	3.1	2.1	4.4	5.9	2.1	5.5
Crosslevel	8.7	5.2	5.6	2.0	2.0	2.2	1.2	1.3	1.1	6.9	4.0	1.3
Warp	8.1	11.2	6.7	4.7	3.7	4.0	2.8	1.8	1.7	10.9	4.6	1.3
Runoff	0.1	0.8	0.7	0.4	0.6	0.7	0.6	0.8	0.4	10.0	8.4	0.7
Twist	0.6	5.5	1.9	1.8	1.7	1.5	1.3	1.0	0.8	5.6	3.0	NA
Limited speed	6.8	6.3	5.9	9.9	9.7	8.7	11.8	3.1	2.6	2.5	1.4	2.2
Total per 100 miles	38.0	36.1	26.3	28.7	33.7	27.9	24.8	14.5	14.1	77.6	44.0	14.3
Miles	34,699	29,051	26,886	59,165	52,997	74,715	83,013	74,541	70,049	62,882	74,202	61,753

KEY: ATIP = Automated Track Inspection Program. NA = not available.

[1] Exceptions mean track did not meet normal operation standards

NOTES: 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. The FRA implemented upgrades to the inspection and collection technology in the ATIP fleet in 2013 which allowed for increased sensitivity of exception detection. Multiple cars surveying except for 2005. Defects are briefly defined as variations from design values for the following track geometry properties:

Profile - rail surface elevations
Alignment - track direction (tangent or curvature)
Gage - distance between rails
Cross-level - elevation difference between the rails
Warp - maximum change in cross-level over a specified distance
Runoff - elevation (ramp) difference of a line along the top of the rail is used for the projection
Twist - rate of introduction and removal of cross-level on transitions from straight to curved track alignment
Limited speed - reduced operating speed due to track geometry constraints

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.

SOURCE: U.S. Department of Transportation, Federal Railroad Administration, Office of Safety, *ATIP Statistics*, special tabulation, May 2016.

to survey tens of thousands of miles of high traffic density and other high priority routes each year. Table 1-9 provides a summary of track inspection results for the years 2004 to 2015. Of the eight track inspection exceptions that are monitored, the incidences of gage, cross-level, warp, and limited speed have generally tended to decrease over time. The FRA implemented upgrades to the inspection and collection technology in the ATIP fleet in 2013, which allowed for increased sensitivity of exception detection, so results before then may not be comparable to those for the most recent years. Inspection locations vary by year due to the limited number of surveying cars and are prioritized by factors such as safety risk analysis and operation types.

The installation of new rail and crossties is one indicator of how track conditions are maintained and improved. The Association of American Railroads (AAR) reported that the Class I railroads installed 673 thousand tons of rail and 15.4 million crossties in 2014, which is more than the annual average of 546 thousand tons of rail and 13.4 million crossties from 2001 to 2005 (table 1-8) [AAR 2015].

The AAR also provides data on the age of the seven Class I railroad locomotive fleets. [AAR 2015] The fleet has become slightly newer overall since 2000. The percentage of locomotives that were less than 10 years old was 28 percent in 2014, versus about 33 percent in 2000, but the median age decreased from 17 to about 16 years. No comparable compilation of the age distribution of railcars is available.

Table 1-8 shows railroad capital expenditures, which totaled $15.1 billion in 2014, about 2.5 times the spending in 2000. In contrast, revenue ton-miles increased 26 percent over that period. Freight rail is a profit-making enterprise that self-funds its investments, and carriers have a strong incentive to maintain, rehabilitate, and upgrade their systems as needed to remain competitive in the market place and earn returns for their investors.

Ports and Waterways

There were more than 8,200 U.S. water transportation facilities, including cargo handling docks, in 2014. Of these facilities, 2,000 handled both foreign and domestic cargo, less than 80 handled foreign cargo only, and nearly 6,100 handled domestic cargo only. About 69 percent of cargo-handling facilities are located on the coasts— Gulf coast facilities accounted for 26.2 percent of the total, followed by the Atlantic coast (21.8 percent), and the Pacific coast (20.6 percent). The remaining 31.4 percent of cargo-handling facilities are situated along the Great Lakes or inland waterways. These facilities are served by a fleet of 40,000 domestic vessels—31,000 barges and 9,000 self-propelled vessels, including almost 3,000 towboats used to move the barges [USACE IWR NDC 2015].

Dams and navigation locks are two of the principal infrastructure features of the U.S. domestic waterway transportation system. They enable shallow draft operations on most rivers. The principal exceptions are the Lower Mississippi River and the Missouri River, which are free-flowing but still require some types 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. The average age of all locks is over 63 years (table 1-10). A recent Transportation Research Board (TRB) report [TRB 2015] shows that, when adjusted for the dates of major rehabilitation projects, the effective average age of locks is about 10 years less, but that still puts the average age at over 50 years. The USACE maintains comprehensive data on lock traffic, lockage time and delay, and lock outages for waterway performance analysis.

Table 1-11 provides data on representative locks throughout the inland waterway system. These data show some of the relationships between lock age and performance factors, such as tow delay and lock chamber downtime. For example, the Emsworth Lock on the Ohio River is one of the oldest structures in the system and is considered functionally obsolete. It has lock chambers designed for vessels of an earlier era and has lengthy out-of-service delays. The newer locks on the Ohio River, such as John T. Myers, are larger and have relatively low average tow delays and only short-duration service outages. Lock 52 on the Ohio River is the busiest and also one of the oldest with chambers that are 47 and 88 years old, respectively. It had one of the higher average tow delays in the entire inland waterway system in 2015, 7.7 hours per tow.

TABLE 1-10 Water Transportation System: 2000, 2010, 2013, and 2014

	2000	2010	2013	2014
U.S.-flag privately owned merchant fleet (1,000 GT or over)	282	221	187	179
Recreational boats, millions	12.8	12.4	12.0	11.8
Lock chambers	276	239	239	239
Lock sites	230	193	193	193
Waterway facilities (including cargo handling docks)	9,309	8,060	8,231	8,229
Ports (handling over 250,000 tons)	197	178	182	183
Miles of navigable waterways	25,000	25,000	25,000	25,000
Average age of locks, years	50.2	59.5	62.5	63.5
U.S.-Flag Vessels				
Barge/non-self-propelled vessels	33,152	31,412	31,081	31,043
Self-propelled vessels	8,202	9,078	8,918	9,039
TOTAL, Vessels	**41,354**	**40,512**	**39,999**	**40,082**
Age of U.S.-flag vessels, percent				
< 6 years old	19.6	18.5	19.3	17.7
6 to 10 years old	9.2	11.5	12.1	14.1
11 to 15 years old	5.1	17.0	14.3	12.4
16 to 20 years old	19.6	8.7	13.6	15.1
21 to 25 years old	18.3	4.2	7.7	8.3
> 25 years old	27.7	39.3	32.6	31.9

KEY: GT = gross tons.

NOTE: *U.S.-flag privately owned merchant fleet* includes only oceangoing self-propelled, cargo-carrying vessels of 1,000 GT and above. *Total, Vessels* includes unclassified vessels.

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 May 2016. *Recreational boats*: U.S. Department of Homeland Security. Coast Guard. Recreational Boating Statistics as cited in USDOT. BTS. *National Transportation Statistics*. Table 1-11. Available at http://www.bts.gov/ as of May 2016. *Waterways and Vessels*: U.S. Army Corps of Engineers. Institute for Water Resources. Navigation Data Center. The U.S. Waterway System: Transportation Facts and Information (Annual issues). as cited in USDOT. BTS. National Transportation Statistics. Tables 1-1 and 1-11. Available at http://www.bts.gov/ as of May 2016. *Locks, Facilities, and Seaports*: U.S. Army Corps of Engineers. Institute for Water Resources. Navigation Data Center. General Characteristics of Locks, and The U.S. Waterway System: Transportation Facts and Information (Annual issues). Available at http://www.navigationdatacenter.us/ as of May 2016.

TABLE 1-11 Characteristics of Selected Inland Waterway Locks: 2015

River	River mile[a]	Lock chamber name	Length, feet	Width, feet	Age, years	Tons in 2015, million[b]	Avg. delay per tow, hr[b]	Outages in 2015[b] Number	Hours	Avg. hr. per outage
Ohio	6.2	Emsworth Lock & Dam Aux.	360	56	95					
Ohio	6.2	Emsworth Lock & Dam	600	110	95	17.5	4.91	61	523	8.58
Ohio	846	John T. Myers Lock & Dam Aux.	600	110	41					
Ohio	846	John T. Myers Lock & Dam	1,200	110	41	56.5	0.84	129	377	2.93
Ohio	938.9	Lock & Dam 52 Aux.	600	110	88					
Ohio	938.9	Lock & Dam 52	1,200	110	47	80.8	7.66	38	106	2.78
Mississippi	200.8	Melvin Price Lock & Dam Aux.	600	110	22					
Mississippi	200.8	Melvin Price Lock & Dam	1,200	110	26	53.7	1.76	27	21	0.77
Mississippi	185.5	Chain of Rocks Lock & Dam 27 Aux.	600	110	63					
Mississippi	185.5	Chain of Rocks Lock & Dam 27	1,200	110	63	59.6	3.22	6	20	3.34
GIWW East	7	Inner Harbor Navigation Canal Lock	640	75	93	15.3	17.04	382	814	2.13
Columbia	292	McNary Lock & Dam	675	86	63	4.8	0.19	2	3	1.33

[a] Miles from the 0.0 milepoint reference location, usually at the mouth of the river, except on the Ohio River where mile 0.0 is at the source of the river at Pittsburgh, PA.

[b] Includes all lock chambers at sites with more than one chamber.

KEY: Aux = Auxiliary; GIWW = Gulf Intracoastal Waterway.

SOURCES: U.S. Army Corps of Engineers, Institute for Water Resources, Navigation Data Center, *Locks by Waterway*, *Tons Locked by Commodity Group, CY 1993 - 2013*. Available at http://www.navigationdatacenter.us/lpms/cy2013comweb.htm as of June 2015. U.S. Army Corps of Engineers, Institute for Water Resources, Navigation Data Center, *Locks by Waterway, Lock Usage, CY 1993 - 2013*. Available at http://www.navigationdatacenter.us/lpms/lock2013web.htm as of June 2015. U.S. Army Corps of Engineers, Institute for Water Resources, Navigation Data Center. *Locks by Waterway, Lock Unavailability, CY 1993 - 2013*. Available at http://www.navigationdatacenter.us/lpms/data/lock2013webunavail-021914.htm as of June 2015. U.S. Army Corps of Engineers, Institute for Water Resources, Navigation Data Center, *Lock Characteristics General Report*. Available at http://www.navigationdatacenter.us/lpms/pdf/lkgenrl.pdf as of June 2015.

On the Upper Mississippi River, the Melvin Price Lock has the two newest lock chambers listed in table 1-11. It passes over 50 million tons of freight per year with moderate delay and downtime. Just 15 miles downstream, Lock 27, with two identical size but much older chambers (63 years), has an average tow delay that exceeds 3 hours. The Inner Harbor Navigation Lock, in New Orleans, is one of the principal bottlenecks in the Gulf Intracoastal Waterway. The small chamber size of the 93-year-old lock results in an average tow delay of more than 17 hours.

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, the vast majority of which are privately owned and serve specific cargo-handling needs (e.g., coal loading and petrochemical transfers). Deep draft ports are large and capital-intensive facilities, typically with extensive docks, wharves, cranes, warehouses, and other cargo transfer equipment and intermodal connections that integrate ocean transport with inland connectors. Private terminal operators do not routinely release data publicly on the condition of their facilities. The USACE maintains an extensive database of marine terminals, both shallow draft and deep draft, but it is largely static and does not include condition or performance data and summary tabulations.

Many of the coastal seaports are served by post-Panamax vessels[9] that continue to increase in size. Containerships calling at U.S. ports had an average capacity of 3,542 TEU (20-foot equivalent units) in 2013 [USDOT MARAD 2015]. Today's largest containerships can carry upwards of 18,000 TEU. Larger vessels afford greater economies of scale and cost savings. However, they require investments in U.S. ports, such as increasing bridge clearances, channel depths, landside access, and port and terminal infrastructure [USACE IWR 2012].

The main characteristic of navigation channels that relates to condition is whether the authorized depth is actually available. Nearly all channels need periodic dredging to maintain the authorized depth. Most channel dredging occurs under the auspices of the U.S. Army Corps of Engineers. In 2014 the USACE's and contractor's dredges removed 186 million cubic yards of material, down from 197 million in 2013. Maintenance dredging accounted for 81.5 percent of the removed material; the average cost per cubic yard increased 20 percent to $5.33, bringing the 2-year increase in dredging cost up to 34.2 percent [USACE IWR NDC 2015]. This was the second consecutive year of decrease from the 238 million cubic yards dredged in 2012, representing a drop of 22 percent in just two years. Decreased dredging of navigation channels could reduce their depth to a point where operators would need to reduce the tonnage loaded into vessels in order to maintain safe operations. The USACE maintains detailed dredging data, but it does not produce summary tabulations that differentiate the work by deep or shallow draft channels.

U.S. flag vessels operate on both shallow and deep draft waterways, and numerous foreign flag vessels call at deep draft ports. Table 1-10 provides age distributions of U.S. flag vessels for the 2000 to 2014 period. The fleet got a bit younger over that period. The percent of vessels younger than 16 years increased from 34 to 44 percent. Inland waterway towboats and barges account for the largest share (85 percent) of U.S. vessels. Towboats are the oldest vessels in this assemblage; 68 percent are older than 25 years [USACE IWR NDC 2015]. In contrast, barges are among the youngest vessels due to a combination of retirement and replacement of older dry cargo barges and acquisition of new tank barges. This is largely in response to the *Oil Pollution Act of 1990* (Pub. L. 101-380) that decreed tank barges and vessels must have double hulls by January 1, 2015.

In 2013 U.S. ferries carried an estimated 115 million passengers and over 30 million vehicles [USDOT BTS 2016b]. There were 124 ferry operators working in 38 states, 2 in U.S. territories and 2 between U.S. and non-U.S. locations (e.g., Canada).[10] The U.S. ferry

[9] Vessels exceeding the length and width of the lock chambers in the Panama Canal. The Canal expansion project is scheduled to be completed in 2016, so vessels that exceed its new larger lock chamber size are referred to as "new Panamax." The Panama Canal expansion and its impacts on U.S. trade and port infrastructure are discussed in detail in chapter 3.

[10] The total number of operators in 2013 was actually larger than the 128 stated here. This number represents those who responded to the census.

fleet comprised 499 vessels, 476 of which were in active service. California had the most ferry vessels with 53, followed by Massachusetts (49), Washington State (46), and New York (45). Nearly all of the vessels carried passengers (95.0 percent), while just under half (47.1 percent) carried vehicles, and less than a quarter carried freight (22.2 percent). Operators participating in the 2014 National Census of Ferry Operators reported that there were 441 terminals in the U.S. ferry system in 2013. Nearly two-thirds (65.8 percent) had parking onsite or nearby, and nearly one-third (30.8 percent) were accessible by local bus service.

Pipelines

Natural gas was transported via about 320,000 miles of natural gas transmission and gathering pipelines and over 2.1 million miles of natural gas distribution main and service pipelines in 2014 (table 1-12). These pipelines connect to 67 million households and 5 million commercial businesses as well as the 1,900 electrical generating units that supply approximately 25 percent of U.S. electricity [AGA 2016]. There were over 199,000 miles of crude/refined oil and hazardous liquid pipelines in 2014, and this system carried over 2.4 billion barrels across the United States [USDOE EIA 2016a].

Table 1-12 Pipeline System: 2000, 2010, 2013, and 2014

Gas Distribution Systems Mileage

	2000	2010	2013	2014
Distribution, main mileage	1,050,802	1,229,538	1,254,773	1,266,265
Distribution, estimated service mileage	737,298	872,384	894,609	902,878
TOTAL, gas distribution	**1,788,100**	**2,101,921**	**2,149,382**	**2,169,143**

Natural Gas Transmission & Gathering Systems Mileage

	2000	2010	2013	2014
Onshore transmission	293,716	299,343	298,336	297,909
Offshore transmission	5,241	5,432	4,490	3,896
TOTAL, transmission	**298,957**	**304,775**	**302,827**	**301,805**
Onshore gathering	21,879	12,940	11,288	11,424
Offshore gathering	5,682	6,699	6,080	6,089
TOTAL, gathering	**27,561**	**19,640**	**17,369**	**17,513**
TOTAL, gas transmission & gathering	**326,518**	**324,415**	**320,196**	**319,318**

Hazardous Liquid or Carbon Dioxide Systems Mileage

	2000	2010	2013	2014
Crude oil	U	54,631	61,087	66,724
Petroleum / refined products	U	64,800	63,351	61,763
Highly volatile liquids	U	57,980	62,768	65,826
CO2 or other	U	4,560	5,195	5,280
Fuel grade ethanol	U	16	16	16
TOTAL, hazardous liquid or CO2 systems	**U**	**181,986**	**192,417**	**199,609**

KEY: U = Data are unavailable

SOURCE: U.S. Department of Transportation, Pipeline Hazardous Material Safety Administration. Annual Report Mileage Summary Statistics. Available at http://www.phmsa.dot.gov/ as of May 2016.

In 2015 U.S. natural gas production reached 28.8 trillion cubic feet (tcf). Pipelines deliver about 35 percent of natural gas production to power plants to produce electricity, 27 percent to the industrial sector, and nearly 17 percent to homes for heating [USDOE EIA 2016b].

Natural gas can be converted to a liquid by cooling to a temperature of -260 degrees Fahrenheit. The liquefied natural gas (LNG) is 1/600th of its gaseous volume, making it easier to transport by vessel over long distances. LNG vessels are double-hulled and specifically designed to handle LNG's low temperature, prevent damage or leaks, and limit LNG evaporation. Short LNG pipelines are used to move the product from the vessel to special LNG terminals. Alaska has been the primary U.S. LNG exporter, primarily to Pacific Rim countries, but the volume has been small. EIA reported that the first LNG export shipment produced in the lower 48 states was shipped on February 24, 2016, from the Sabine Pass LNG terminal in Louisiana. LNG also can be transported by cryogenic tanker trucks and railway tanker cars [USDOE EIA 2016c].

The Pipeline and Hazardous Materials Safety Administration (PHMSA) collects annual report data from pipeline operators, covering their system mileage, commodities transported, and inspection activities, but there is no publicly available database that tracks pipeline condition. A serious failure, such as the Santa Barbara, CA, crude petroleum pipeline failure in May 2014, serves as a reminder that this part of the transportation system has the same problems with aging infrastructure as the other modes profiled in this chapter [USDOT PHMSA 2015].

Challenges

With the largest transportation system in the world, the United States faces a continuing challenge of maintaining system conditions in sufficiently good shape to meet the enormous mobility requirements of the American economy and society. As indicated earlier, the condition of transportation infrastructure is improving, but additional improvements are needed. The average age of all inland waterway navigation locks is more than 50 years, and 9.6 percent of highway bridges are considered structurally deficient. If these and other condition issues are not addressed, they could affect system performance and safety in the coming years.

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CHAPTER 2

Moving People

Highlights

- In 2014 U.S. person-miles of travel (including air travel to, from, and within the United States) totaled about 5.4 trillion—an increase of over 100 billion miles from 2013. About 70 percent of these travel-miles was in cars and other personal vehicles, while air travel accounted for 23 percent.
- Person-miles of travel on highways in 2014 were below the prerecession peak set in 2007. Annual data for 2015 were not available when this report was completed, but a monthly indicator of highway traffic showed vehicle-miles growing beyond 2014 levels throughout 2015. Person-miles and vehicle-miles of travel often rise in tandem.
- By comparison, following a record setting year in 2014, new air travel records were again set in 2015 for both domestic air travel and international air travel to and from the United States. Total U.S enplanements in 2015 were 894 million, compared to 801 million in 2005 and 768 million in the recession year of 2009.
- Total air revenue passenger-miles were nearly 1.3 trillion in 2015, including U.S. and foreign carrier flights to and from the United States. International passenger-miles surpassed passenger-miles on domestic flights for the third consecutive year.
- International visitors to the United States rose from 60 million in 2010 to nearly 75 million in 2014, generating $221 billion in export revenue—the highest in this century.
- In 2014 about 4.5 percent of workers (or 6.2 million) worked primarily at home (e.g., people who are self-employed with a home office)—up from 4.2 million in 2000.
- About 4.8 million workers (or 3.3 percent of commuters) walked or biked to work, about 517,000 more people than in 2000.
- In October 2016 there were 3,923 bike share clocking stations in 125 U.S. cities, 75.1 percent of which were near local public transportation stops.
- Ridership on Amtrak passenger trains and intercity bus transportation remained below 2012 levels in 2015, but ridership on Amtrak's Northeast Corridor trains reached a record 11.7 million.

The Nation's transportation system accommodates extensive local and long-distance travel to meet the demands of more than 321 million U.S. residents and 75 million foreign visitors. In 2014 person-miles of travel (PMT) in the United States was roughly 5.4 trillion, nearly 70 percent of which was in cars or other personal vehicles, while domestic and international air travel to and from this country accounted for about 23 percent—with 11 percent domestic and 12 percent international (table 2-1).[1] Transit, intercity rail, and bus services accounted for the remaining PMT. Walking and biking also tallied a large number of local trips and travel-miles, with nearly 5 million people getting to work under their own power daily [USDOC CENSUS 2016a].

The number of commercial air passengers and airline revenue passenger-miles reached a new high in 2015, as discussed in the long-distance travel section, rebounding fully from sharp declines during and after the 2008 and 2009 economic recession. Highway PMT by cars and other personal vehicles in 2014 has rebounded somewhat but remains well below the 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.

[1] Previous editions of this annual report only included domestic flights in annual PMT counts and did not include air travel to and from the United States.

TABLE 2-1 Person Travel by Selected Travel Modes

Million person-miles

	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	558,054	313,357	23,034	55,169	6,752
2013	3,688,161	578,723	588,185	321,539	21,937	56,467	7,283
2014	3,731,888	595,970	621,435	339,177	21,510	54,998	6,675

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, Research and Innovative Technology Administration, Bureau of Transportation Statistics, Scheduled Passenger Data Tool, available at http://www.transtats.bts.gov as of April 2016. *All other categories*: Various sources as cited in U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, National Transportation Statistics, table 1-40, available at http://www.bts.gov/publications/national_transportation_statistics/ as of April 2016.

Local Travel

As illustrated in table 2-2 and figure 2-1, local travel often involves repetitive daily trips (e.g., the daily commute to and from work or school). Social/recreational activities, family/personal errands, and shopping accounted for nearly 60 percent of household travel and 70 percent of household trips. U.S. households averaged about 9.6 trips per day, with the average trip slightly under 10 miles in length in 2009 (table 2-2). Total travel per household was about 33,000 miles, or 13,200 miles per capita that year. These 2009 benchmarks are from the last National Household Transportation Survey (NHTS) [USDOT FHWA NHTS 2011].[2] The Federal Highway Administration's new travel survey was underway in 2016.

[2] The National Household Transportation Survey (NHTS) or similar national surveys have been conducted every 8 to 10 years since 1969.

Work commutes and work-related trips are typically longer than other types of local travel, making up about one-fourth of total mileage traveled but less than one-fifth of total trips. The shorter trips were typically for shopping, personal business, and social/recreation—each with greater shares of the number of trips but a lower share of PMT than the work commute (table 2-3).

Personal vehicles were used for 86 to 88 percent of journeys-to-work in the 2000 to 2014 period. However, driving alone continued to rise in share and numbers, while carpooling declined. Nearly 11 million more people drove alone to work in 2014 than in 2000, while the number of carpoolers fell by 2, as shown in figure 2-2. Transit ridership increased by over 1 million in the 15-year period, with transit's share of commuters rising to 5.1 percent, up from 4.7 percent in 2000. About 517,000 more people walked or biked to work in 2014 than in

TABLE 2-2 Person Trips, Trip Length, and PMT by Trip Purpose: 2009 NHTS
Annual average, 2009

Purpose	Total household trips in year	Average trip length (miles)	Person-miles traveled per household
Work	541	11.8	6,256
Work-related	106	20.0	2,078
Shopping	725	6.5	4,620
Family/personal errands	748	7.0	5,134
School/church	333	6.3	2,049
Social and recreational	952	10.7	9,989
Other	61	51.5	2,878
TOTAL	**3,466**	**9.7**	**33,004**

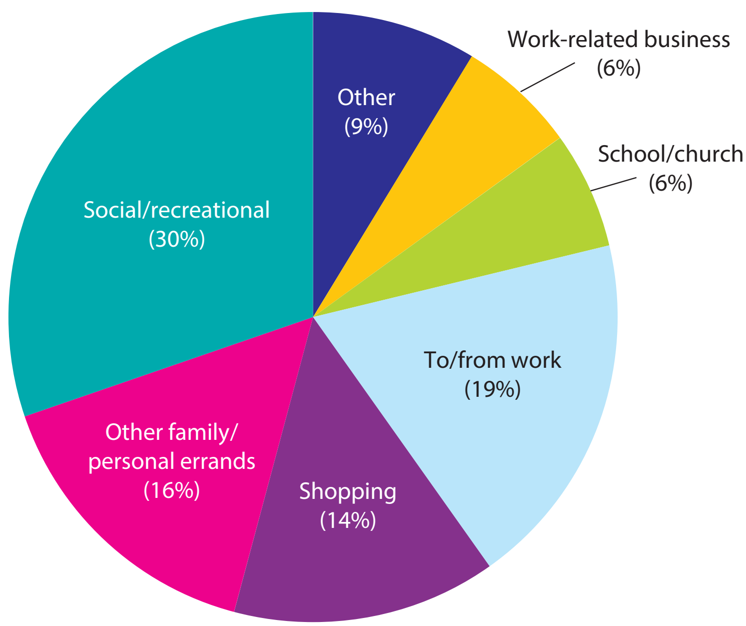
KEY: PMT = Person-miles of travel; NHTS = National Household Travel Survey.

NOTE: Family/personal Errands includes personal business, shopping, and medical/dental appointments.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey, *Summary of Travel Trends*. Table 5. Available at http://nhts.ornl.gov/ as of April 2016.

FIGURE 2-1 Average Annual PMT per Household by Trip Purpose: NHTS 2009

Average annual household PMT = 33,000 miles.



KEY: PMT = Person-miles of travel.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey, *Summary of Travel Trends*. Table 5. Available at http://nhts.ornl.gov/ as of April 2016.

TABLE 2-3 Average Length of Person Trips by Trip Purpose: 1990 and 1995 NPTS, 2001 and 2009 NHTS

Average person trip length (miles)

	1990	1995	2001	2009
All purposes	**9.5**	**9.1**	**10.0**	**9.7**
To/from work	10.7	11.6	12.1	11.8
Work related business	28.2	20.3	28.3	20.0
Shopping	5.4	6.1	7.0	6.5
Other family/personal errands	8.6	7.6	7.8	7.0
School/church	5.4	6.0	6.0	6.3
Social and recreational	13.2	11.3	11.4	10.7
Other	10.3	22.8	43.1	51.5

KEY: NHTS = National Household Travel Survey; NPTS = National Personal Travel Survey.

NOTES: Average person trip length is calculated using only those records with trip mileage information present. *Other Family/Personal Errands* includes personal business and medical/dental.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey, *Summary of Travel Trends*. Table 5. Available at http://nhts.ornl.gov/ as of April 2016.

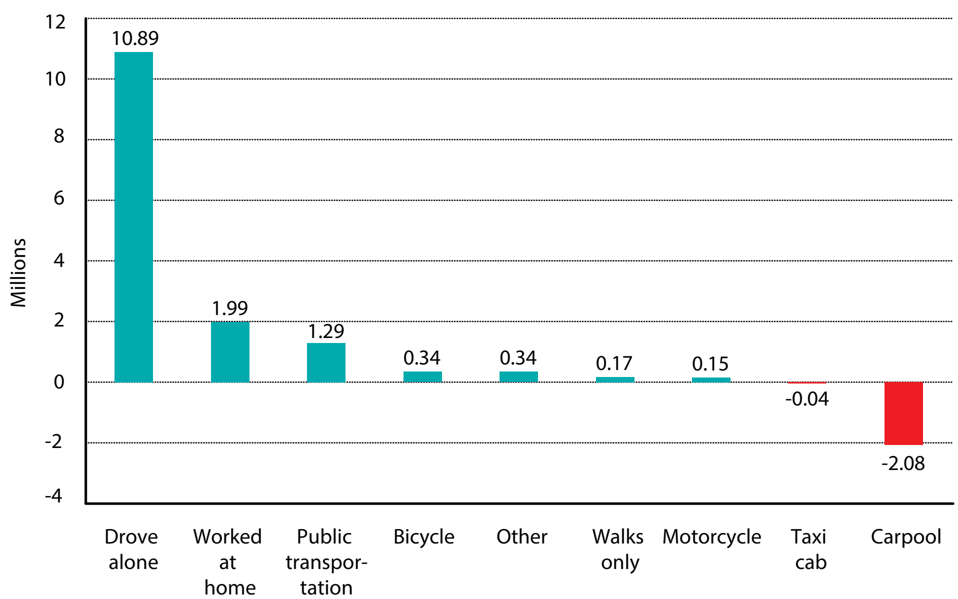
2000, accounting for about 3.3 percent (or 4.8 million) of all commuters in 2014.

The geography of commuting has changed:

- Workers live farther from their places of work than in earlier decades.
- Workers leaving their home county to work in another county increased from 23.5 million to 40.1 million between 1990 and 2014; their percentage share of the workforce grew from 20.4 to 27.5 percent.
- More people are working at home. Advanced communication and information technologies have increased the ability of people to work at home while performing their job responsibilities. Part of the longer term growth in working at home had been masked in earlier decades by the number of people who worked on the farm where they also lived [AASHTO 2013].

In 2014 about 4.5 percent of workers (or 6.2 million) worked primarily at home. The 2014 number does not count those who work one or two days per week at home, spending the other days at a job site. A 2010 Census survey found that 13.4 million people worked from home at least 1 day per week. Monday and Friday are

FIGURE 2-2 Net Change in Number of Workers by Mode of Transportation: 2000 to 2014



NOTES: *Drove alone* includes people who usually drove alone to work as well as people who were driven to work by someone who then drove back home or to a non-work destination. *Public transportation* refers to bus, streetcar, subway, railroad, and elevated trains for 2000. Other include ferryboats, surface trains, and van service and other means not classified for years 2000.

SOURCE: *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 June 2015. *2014*: USDOC/CB as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 1-41. Available at http://www.bts.gov as of April 2016.

the most likely days to telework and Thursday is the least likely[3] [USDOC CENSUS 2013a].

The NHTS survey found that about one-fifth of trips involve trip-chaining in which people sandwich in daily errands and activities, such as dropping off and picking up children at school/day care or stopping at a fitness center, while on the way to and from work [USDOT FHWA NHTS 2011].

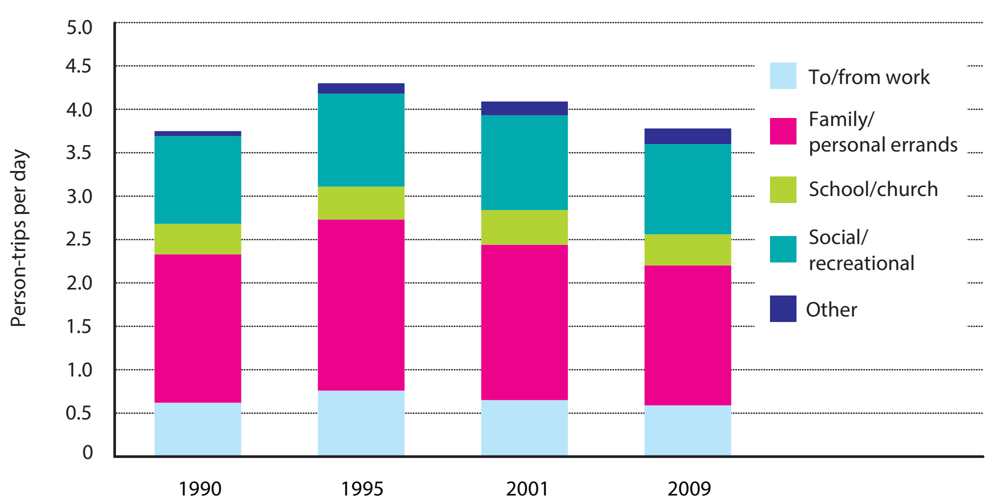
[3] The findings of the two Census Bureau surveys are not comparable because, among other matters, they use different definitions. The 2014 estimate is from the American Community Survey and the 2010 estimates are from the Survey of Income and Program Participation. Yet another survey, the American Time Use Survey, conducted by the U.S. Bureau of Labor Statistics, found that 23 percent of employed persons did some or all of their work at home, and 85 percent did some or all of their work at their workplace in 2014 [USDOL BLS 2015b].

Figure 2-3 traces the average number of daily trips per person by major purposes as reported in the four national travel surveys completed since 1990. The number of work trips has been stable, but the share has declined relative to other trips as travel for other trip purposes increased.

The number of trips varies throughout the week (figure 2-4). Friday accounted for the most trips, because of more social/recreational and family/personal/errand trips, and Sunday for the least. Reduced numbers of work trips and errands on Saturday and Sunday are partially offset by shopping and social/recreational trips, as well as travel to religious services.

As shown in figure 2-5, the overwhelming majority of person trips for all purposes

FIGURE 2-3 Person Trips per Day by Purpose: 1990, 1995, 2001, and 2009 NHTS

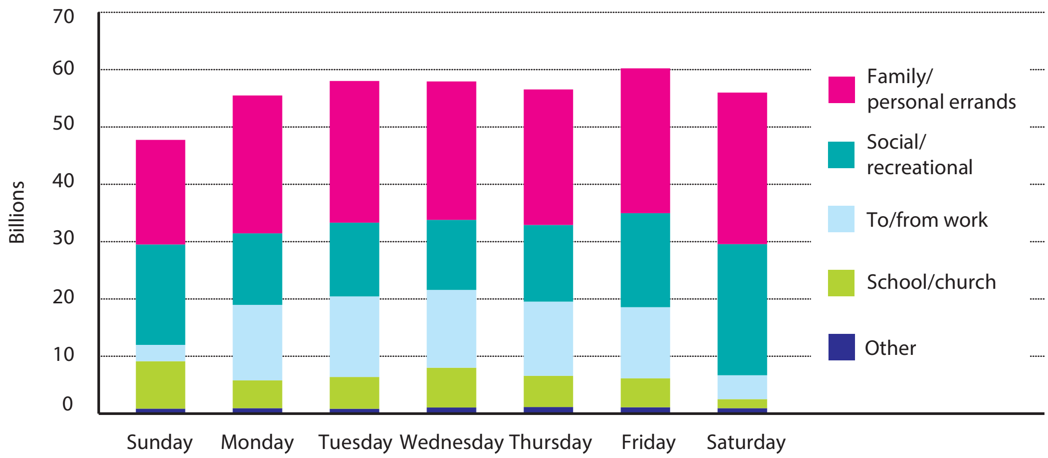


KEY: NHTS = National Household Travel Survey

NOTES: 1990 data have been adjusted to make them more comparable with later data in the series. 1995 "To or From Work" person trips and person miles are believed to be overstated (see Appendix 2 of the *1995 Summary of Travel Trends*). *Person trip* is a trip by one person in any mode of transportation. *Family/Personal Errands* includes personal business, shopping, and medical/dental appointments. *Other* includes trips for work-related business.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey, *Summary of Travel Trends*. Table 11. Available at http://nhts.ornl.gov/ as of April 2016.

FIGURE 2-4 Annual Number of Person Trip Purpose by Day of Week: 2009 NHTS

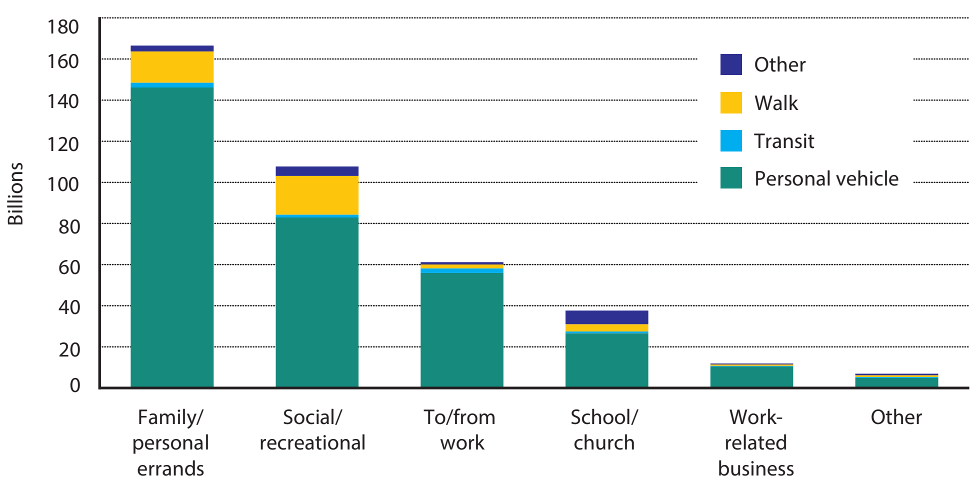


KEY: NHTS = National Household Travel Survey

NOTES: *Person trip* is a trip by one person in any mode of transportation. *Family/Personal Errands* includes personal business, shopping, and medical/dental appointments. *To or From Work* includes work-related business trips.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey (NHTS), *Online Analysis Tool*. Available at http://nhts.ornl.gov as of April 2016.

FIGURE 2-5 Annual Number of Person Trips by Mode and Purpose: 2009 NHTS



KEY: NHTS = National Household Travel Survey

NOTES: *Person trip* is a trip by one person in any mode of transportation. *Family/Personal Errands* includes personal business, shopping, and medical/dental appointments.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey (NHTS), *Online Analysis Tool*. Available at http://nhts.ornl.gov as of April 2016.

are taken in cars or other personal vehicles. Walking is used for a substantial number of errands and social/recreational trips. Family/personal errands and social/recreational activities accounted for more than two-thirds of trips, followed by trips to and from work, which accounted for 15.6 percent.

Supporting the high percentage of travel by personal vehicle, 9 out of 10 households have access to automobiles and other vehicles. The share of households without a vehicle declined from over 11.5 percent in 1990 to 8.7 percent in 2007. The most recent data indicate that roughly 10.7 million households, 9.1 percent of all households in 2014, did not have access to a vehicle. The number of households without vehicles has stayed about the same, at 10 to 11 million for several decades, despite a growing number of households [AASHTO 2013].

About 14.8 percent of workers with no available vehicle walked to work, roughly four times the percentage for workers with one available vehicle. Similarly, 2.8 percent of those without a vehicle biked to their workplace, compared with 0.8 percent for workers with one available vehicle. Specifically, households with no workers accounted for two-thirds of the households with no vehicles [USDOC CENSUS 2016a]. Only 4.5 percent of households with workers had no vehicle in 2014, but this represents 6 million workers [MCKENZIE 2015].

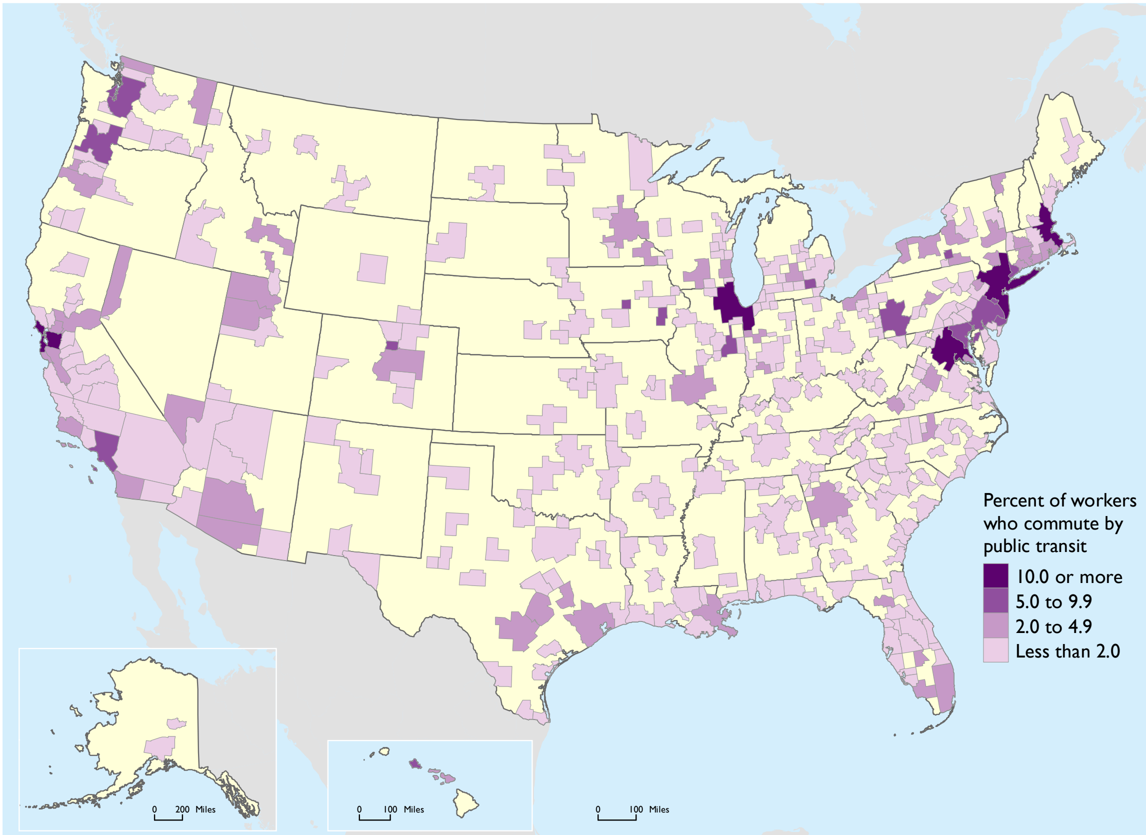
About 11.6 percent of households have more workers than vehicles. The other 88.4 percent are about evenly split (about 44 percent each) between households with more vehicles than workers and households where the number of vehicles equals the number of workers [AASHTO 2013].

National trends do not portray travel in individual metropolitan areas. For example, transit serves a higher share of work trips in larger metropolitan areas: 11.0 percent in areas with a population over 5 million, 4.0 percent in areas between 2.5 and 5 million, and 2.2 percent in areas between 1 and 2.5 million (figure 2-6). Transit ridership is highest in the New York-Newark-Jersey City, NY-NJ-PA; San Francisco-Oakland-Fremont, CA; Washington-Arlington-Alexandria, DC-VA-MD-WV; Boston-Cambridge-Quincy, MA-NH; Chicago-Naperville-Elgin, IL-IN-WI metropolitan areas.

Walking and Biking to Work

Nationally, only a small percentage of people walk or bike to work. However, these nonmotorized modes of commuting are important in many cities of all sizes, as shown by the 2008–2012 American Community Survey. In the 50 largest U.S. cities, 5.0 percent of workers walked to work and another 1.0 percent biked. Over 15 percent of workers in Boston, MA, walked to work, as did more than 10 percent of commuters in Washington, DC, Pittsburgh, PA, and New York City. Portland, OR (6.1 percent) and Minneapolis, MN (4.1 percent) had the highest percentage of bicycle commuters. These cities have also invested in infrastructure to facilitate biking (e.g., building dedicated bike lanes). Some small cities have higher rates of walking and biking, especially where colleges and universities are located. For example, about 42 percent of workers in Ithaca, NY, walk to work and nearly 19 percent in Davis, CA, commute by bike [MCKENZIE 2014].

Figure 2-6 Average Percent Commuting by Public Transportation in Metro Areas: 2010–2014



SOURCE: U.S. Department of Commerce, Census Bureau, 2010-2014 American Community Survey 5-Year Estimates, available at www.census.gov/acs as of February 2016.

Among regions, the Northeast has the highest rate of walking to work, while the West had the highest rate of biking. The South had the lowest rate of walking and bicycling to work for most city-size categories.

People walking or biking to work spend less time on their commute than those using other modes—walkers average 11.5 minutes and bikers 19.3 minutes, compared to 25.9 minutes for other modes. Women were slightly less likely to walk to work than men, but less than half as likely to commute by bike. People who walk or bike to work also tend to be younger than the average commuter. Many people walk or bike to work in part for the exercise it provides in contrast to less active means of commuting [MCKENZIE 2014].

Some people combine biking and transit to make their commutes and other trips. Box 2-A discusses bike-share programs, now common in many cities that offer expanded mobility options.

Box 2-A Proximity of Bike-Share Stations to Public Transportation

Bike-share programs make bicycles available for shared use to individuals on a short-term basis. While the programs differ, users of the programs most often pay a monthly or annual membership fee to grab a bike at any outdoor docking location in the system and then return the bike within a specified time limit, for no extra fee, to any outdoor docking location within that system. Docks with bicycles often are seen outside train stations or on public plazas in many cities in the United States and worldwide.

The Bureau of Transportation Statistics (BTS Intermodal Passenger Connectivity Database (IPCD) provides locations and other information for 3,378 bike-share stations in 104 cities across the United States as of April 2016. In a recent report, BTS measured the proximity of these bike-share stations to scheduled public passenger transportation, such as transit bus stops, commuter train stations, and airports [FIRESTINE 2016]. Of the 3,378 bike-share stations, 77.0 percent (2,600) were within one block of a scheduled public transportation mode and another 13.4 percent were within two blocks. Transit bus is the most typical connection, with 74.9 percent (2,531) of bike-share stations located a block or less from a transit bus stop. These bike-share programs help people connect with public transportation, such as heavy rail stations and local bus stops, and in some cases reach places not well served by public transportation. (IPCD is discussed more fully at the end of this chapter.)

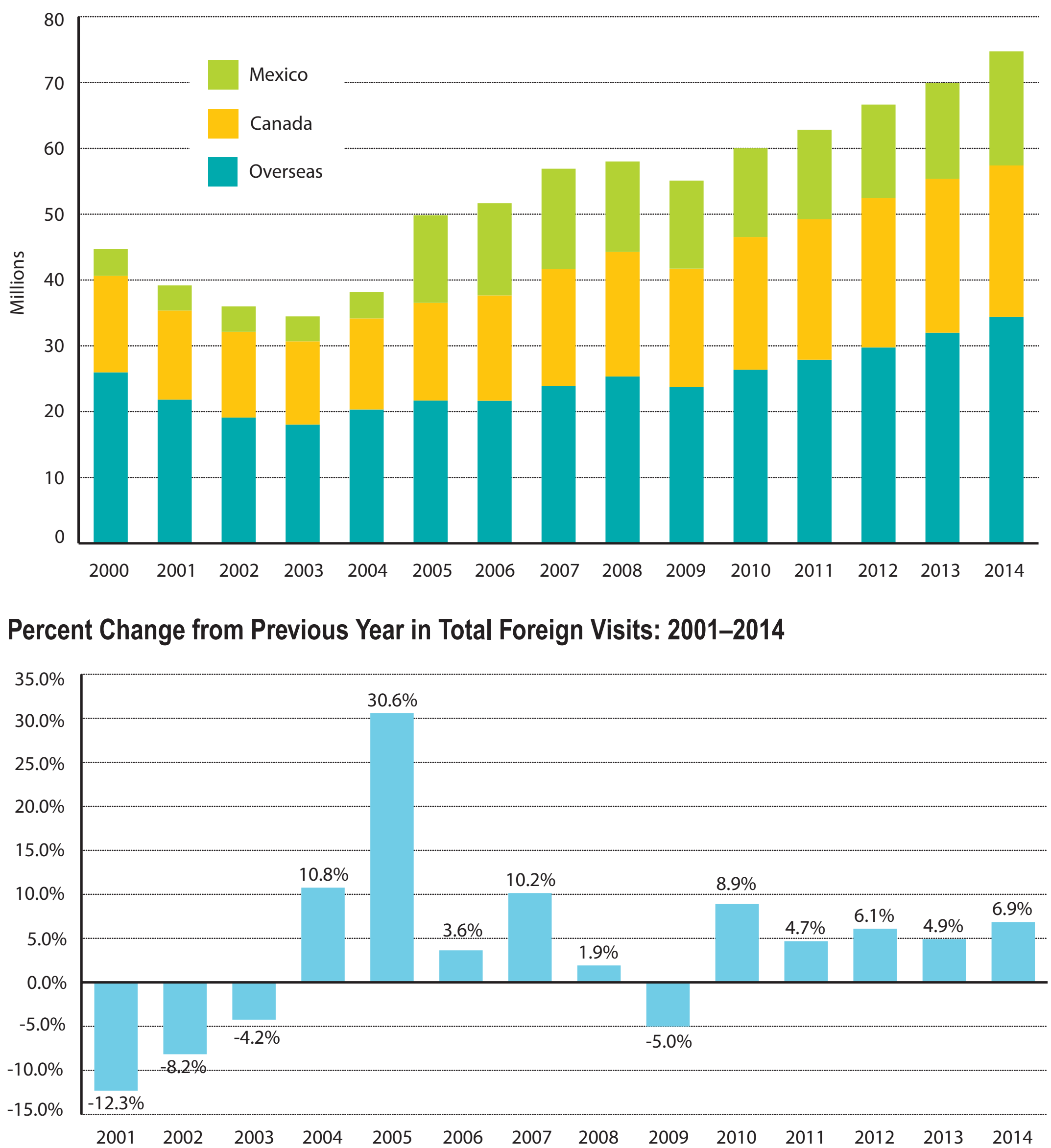
Long-Distance and International Travel

In many places the daily rhythms of local travel are affected by long-distance travel. Highway traffic between distant places contributes to local congestion on intercity highways. Traffic to and from airports also contributes to local congestion. Personal travel in recreational areas is dominated by seasonal variation (e.g., holidays, such as Memorial Day) as out-of-town visitors increase traffic counts along interstates that connect major cities and on local roads that lead to resort areas [DELDOT 2014].

Americans primarily use personal vehicles and airlines for their long-distance travel. There is no longer a comprehensive data source for long-distance travel (usually considered as trips to places at least 50 miles away). Although totals can be estimated from a variety of sources, the end result is incomplete—in terms of system usage for long-distance trips, trip purpose and length, and traveler characteristics. The missing pieces include trips by car or other personal motor vehicle (used by most people for their long-distance trips), general aviation, and cruise ships. Vehicle-miles of travel on rural interstate highways are occasionally used as a surrogate for long-distance highway travel, but there is no methodology for separating local from long-distance travel within rural areas. Takeoffs and landings of general aviation aircraft are not a good indicator because many flights take off and land at the same airport rather than carry people to distant destinations. Numbers of passengers boarding and debarking from cruise ships in each port are counted, but detailed statistics on cruises, cruise passengers, departure ports, and destination have not been compiled since June 2012.

Long-distance travelers include international visitors to the United States. Approximately 75 million foreign visitors came to the United States in 2014, an increase of 15 million from 2010. This was the fifth consecutive year of growth (figure 2-7). By contrast, in the 2000 to 2009 period, there were three consecutive years of declining numbers of foreign visitors after the September 2001 terrorist attacks and also a decline in 2009 during the global economic recession [USDOC OTTI 2015].

FIGURE 2-7 Foreign Visits by Main Markets: 2000–2014



SOURCE: U.S. Department of Commerce, Office of Travel and Tourism Industries, *U.S. Monthly Arrivals Trend Line: Overseas, Canada, Mexico & International*, available at travel.trade.gov as of March 2015.

U.S. and foreign airlines carried 894 million passengers on domestic flights and international flights to and from the United States in 2015 (table 2-4). Passenger enplanements were up by about 44 million from 2014, the previous peak year. In 2015 domestic enplanements accounted for 78 percent of passengers, while international enplanements on U.S. and foreign airlines accounted for 22.0 percent [USDOT BTS OAI 2016]. U.S. airlines carried just over half (51.2 percent) of passengers traveling between the United States and international points.

Total (domestic and international flights in the United States) revenue passenger-miles also set all-time records in 2015, surpassing the previous record set in 2014, reaching nearly 1.3 trillion. Of this, international flights accounted for 51 percent of passenger-miles, the third year in a row that passenger-miles on these flights exceeded those on domestic flights [USDOT BTS 2016].

The number of domestic and international flights (9.5 million in both 2014 and 2015) has been trending downward since the peak of over 11.3 million flights in 2005, but these flights are carrying more passengers and have higher load factors than a decade ago. As shown in table 2-4, planes have become more crowded since 2005 as measured by load factors. Domestic flights were, in general, more crowded than international flights. Domestic flights in 2014 and also in 2015 accounted for roughly 85 percent of total U.S. flights, while international flights of U.S. and foreign carriers accounted for about 15 percent [USDOT BTS OAI 2015].

TABLE 2-4 Annual Airline (U.S. and Foreign Carriers) Passenger Enplanements: 2005–2015
Scheduled flights only

	Enplanements (millions)			Load factor (percent)		
	Domestic	International	Domestic and international	Domestic	International	Domestic and international
2005	657.3	143.6	800.8	77.2	78.7	77.8
2006	658.4	149.7	808.1	79.1	78.6	78.9
2007	679.2	156.3	835.4	79.9	79.1	79.5
2008	651.7	157.7	809.4	79.7	77.6	78.7
2009	618.1	149.7	767.8	81.1	78.3	79.7
2010	629.5	157.9	787.5	82.2	81.6	81.9
2011	638.2	163.9	802.1	82.9	80.3	81.6
2012	642.3	170.8	813.1	83.4	81.7	82.5
2013	645.7	179.3	825.0	83.5	82.1	82.8
2014	662.8	187.7	850.5	84.5	81.1	82.7
2015	696.2	198.1	894.2	85.0	80.5	82.7

NOTE: *International enplanements* include U.S. and foreign carriers. *Load factor* is calculated by dividing demand, as measured by revenue passenger-miles (RPMs), by capacity, as measured in available seat-miles (ASMs).

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, *Airline Data and Statistics*, Passengers. Available at http://www.bts.gov/programs/airline_information/ as of March 2016.

Long-distance railroad travel in the United States is primarily on Amtrak (also known as the National Rail Passenger Corp.). Amtrak ridership grew for 15 consecutive years between 1997 and 2012, rising from 19.7 million annual person-trips in its fiscal year 1997 to a peak of 31.2 million in 2012. While ridership has subsequently fallen a bit (to 30.8 million in 2015), ridership on its Northeast Corridor trains reached a record of 11.7 million in 2015 [AMTRAK 2015]. On the smaller Alaska Railroad, annual ridership peaked in 2007 at more than one-half million trips, and had not regained this level as of 2014. Customers traveling aboard railcars owned by cruise lines and pulled by the Alaska Railroad accounted for about half of the 2014 Alaska Railroad passengers [ARRC 2015].

Long-distance travel by motorcoach, including charter as well as scheduled service buses, declined somewhat in 2013 and 2014, compared to 2012 (table 2-5). There were about 604 million person trips in the United States and Canada in 2014, roughly 33 million fewer trips than in 2012 but slightly more than in 2010, when there were more carriers and coaches but fewer passenger trips per coach.

Just under half of all bus passengers in 2014 were either students or senior citizens [ABA 2016]. Charter service accounted for about 47.5 percent of motorcoach mileage, and scheduled service accounted for another 32.3 percent. The remaining miles were for commuting (4.6 percent); packaged tours (6.6 percent); transport to and from airports (3.7 percent); sightseeing (3.5 percent); and special operations, such as regular-route service to fairs, sports, and other events, and employee transport to work sites (1.8 percent).

Forces of Change in Travel

After decades of predictable growth, recent trends of U.S. travel behavior have become less clear. Many factors, such as the travel preferences of the aging baby boom generation,[4] the younger millennial generation, the increasing popularity of shared mobility, the uncertainties about future levels of immigration, and the diminishing but possibly lingering effects of the economic recession

[4] In a formal demographic sense, people born from mid-1946 to mid-1964, but more generally, people born in the post-World War II period.

TABLE 2-5 Motorcoach Carriers, Coaches, Trips, and Passenger Miles: 2010–2014

	2010	2011	2012	2013	2014	Percent change, 2010–2014
Carriers	4,011	3,984	3,954	3,801	3,628	-9.55
Coaches	40,709	40,141	39,607	36,903	36,520	-10.29
Passenger trips (millions)	601	627	637	605	604	0.44
Passenger trips per coach	14,800	15,600	16,100	16,400	16,500	11.49
Passenger miles (billions)	69	76	76	63	62	-10.87
Passenger miles per coach	1,703,200	1,897,400	1,912,500	1,710,000	1,700,000	-0.19

NOTE: The *Motorcoach Census* measures the size and activity of the motorcoach industry in the U.S. and Canada.

SOURCE: American Bus Association, *Motorcoach Census*, available at www.buses.org as of March 2016.

spanning December 2007 to June 2009, affect local, long-distance, and international travel behavior.

Such factors have affected the demand for travel in the United States. Among the most important are population, employment, car ownership, household income, and economic conditions. The discussion below highlights some aspects of these factors.

Economics and Recession

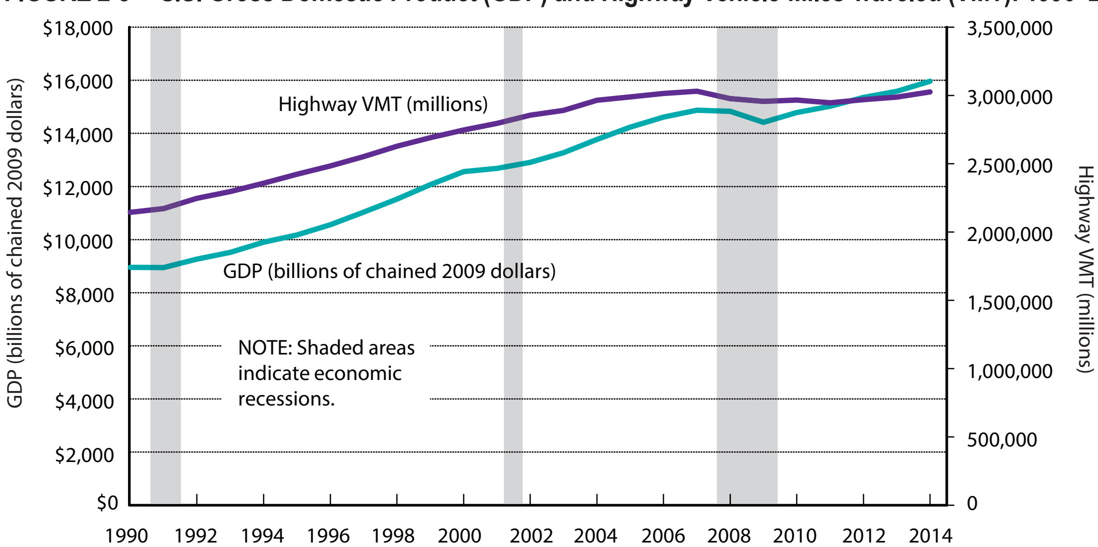
U.S. gross domestic product (GDP) grew at about 3 percent per year in the early 2000s, but declined 0.3 percent in 2008 and 2.8 percent in 2009, before again growing each year from 2010 through the end of 2015.

Figure 2-8 charts GDP and highway vehicle-miles of travel (VMT) over the last 25 years, during which three recessions occurred. VMT[5] remained stable or grew in the first two recessions, which were of relatively short duration and relatively mild. VMT shows a different pattern during the longer and more severe 2007–2009 recession. As the figure illustrates, VMT peaked in 2007, just as the recession began, then dropped in 2008 and 2009 and again in 2011 before beginning to rebound [USDOT FHWA 2015].

Airline travel was also adversely affected by the 2007–2009 economic recession. While the number of passengers on international

[5] Vehicle-miles of travel, or VMT, is a key measure of travel activity that is used, among other things, to estimate person-miles of travel, or PMT. VMT is multiplied by estimates of vehicle occupancy to measure PMT. Because the national vehicle occupancy rates used to estimate PMT were last estimated in the 2009 NHTS, there is more uncertainty surrounding estimates of PMT than of VMT.

FIGURE 2-8 U.S. Gross Domestic Product (GDP) and Highway Vehicle-Miles Traveled (VMT): 1990–2014



SOURCE: *GDP*: U.S. Department of Commerce, Bureau of Economic Analysis as cited U.S. Department of Transportation (DOT), Bureau of Transportation Statistics (BTS), *National Transportation Statistics*, Tables 1-35 and 3-10, available www.bts.gov as of April 2016. *VMT*: DOT, Federal Highway Administration as cited in DOT, BTS. *National Transportation Statistics*, Table 1-35. Available www.bts.gov as of April 2016.

flights to and from the United States returned to prerecession levels beginning in 2011, it was not until 2014 that enplanements on domestic flights finally exceeded their 2007 levels (figure 2-9). Only urban transit and intercity rail passenger volumes grew during and immediately after the recession (with the previously mentioned exception of the Alaska Railroad). Transit ridership was stimulated in part by rising gas prices in the 2002 to 2008 period (when average annual gas prices rose $1.91 per gallon nationwide) [USDOE EIA 2016].[6] The recent decline in gas prices—a nationwide average decline of $1.19 per gallon between 2012 and 2015, with $0.91 of the decline occurring in 2015—raises the question of whether people who switched to transit when gas prices were high will go back to driving if gas prices remain low.

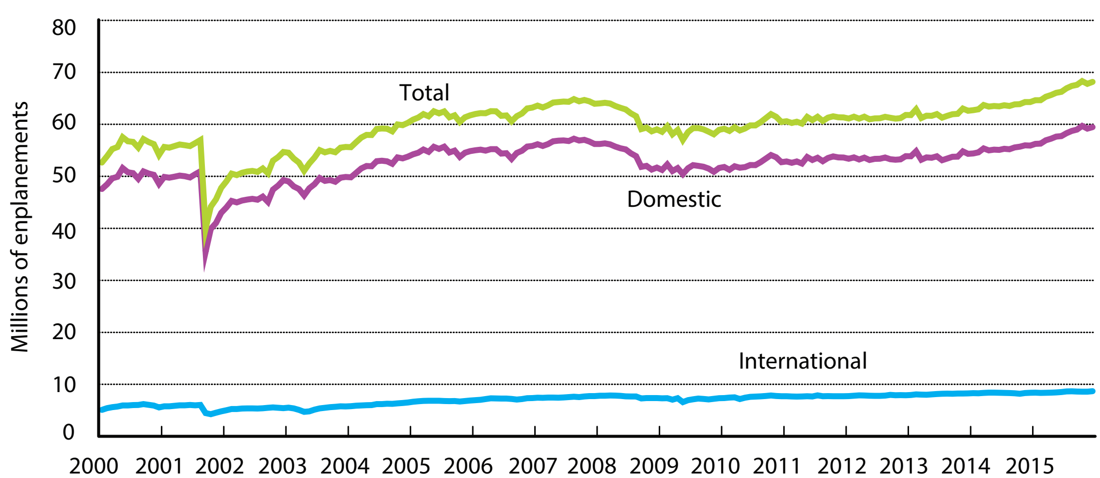
[6] A 2014 report, *Net Effects of Gasoline Price Changes on Transit Ridership in U.S. Urban Areas*, examines the impact of gasoline price increases on transit ridership in 10 U.S. urbanized areas [ISEKI; ALI 2014]. The report is discussed in *Transportation Statistics Annual Report 2015*, chapter 2.

As shown in figure 2-10, person-miles of travel increase with household income. With the last national household travel survey completed in 2009, at the end of the recession, it remains to be seen what the next travel survey now underway will show about the trip-making propensities of the public.

Demographic and Geographic Shifts

Demographic factors underlie long-term travel demand. Between 1990 and 2015, the U.S. population grew by 70 million people, reaching 321 million, placing additional travel demands on the transportation system

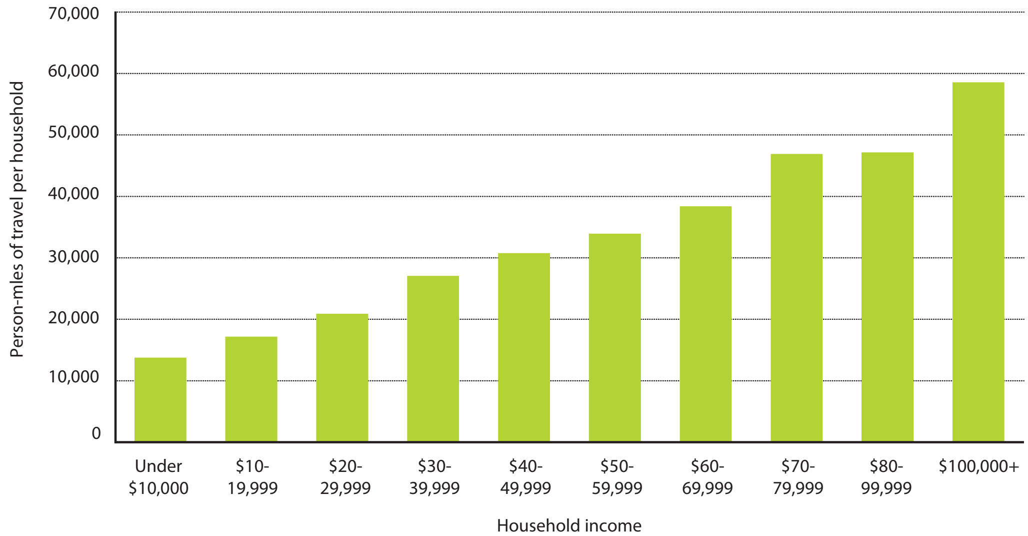
FIGURE 2-9 U.S. Air Carrier Monthly Enplanements: 2000–2015



NOTES: Includes enplanements on scheduled services. International enplanements include only U.S. carriers.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, *T-100 Market Data*. Available at www.transtats.bts.gov as of April 2016.

FIGURE 2-10 Person-Miles of Travel per Household by Income Level: 2009 NHTS



KEY: NHTS = National Household Travel Survey

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *2009 National Household Travel Survey*, Online Analysis Tool. Available at http://nhts.ornl.gov/ as of April 2016.

[USDOC CENSUS 2016b]. All census regions added population, but growth was not even across the country. More than 80 percent of the 1990 to 2015 population gain was in the South and West, continuing a decades-long trend [USDOC CENSUS 2001, 2011, and 2016]. About 60 percent of the Nation's 3,143 counties, including nearly 80 percent of metropolitan counties, gained population from 2000 to 2015, with a total gain of about 42 million people. This contrasts with population losses of 2.7 million residents in the other 40 percent of counties [USDOC CENSUS 2016c, d]. These regional and metropolitan population changes affect transportation infrastructure needs and travel patterns.[7]

[7] For a more detailed discussion of demographic trends and travel from 1950 forward, see *Transportation Statistics Annual Report 2013,* pages 56–58.

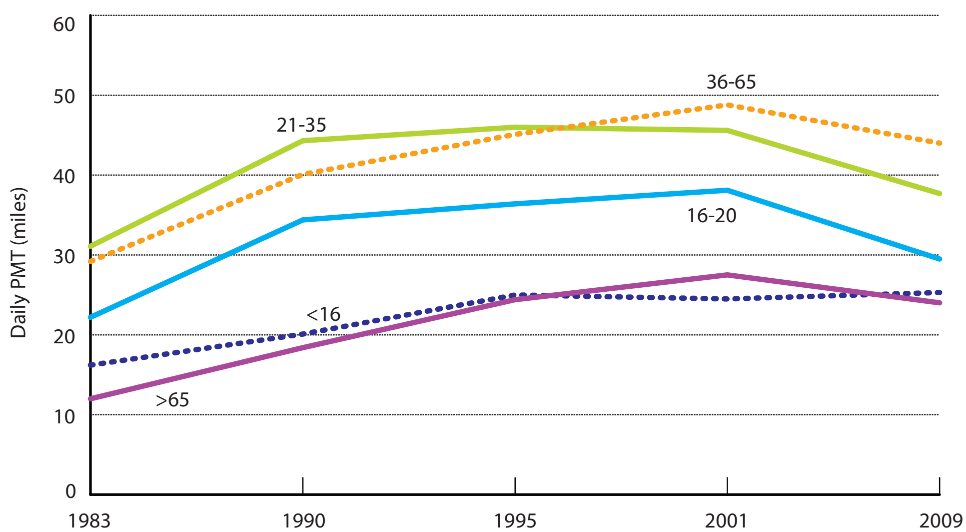
Demographic factors and the economy combine to affect travel demand through the growth of the labor force and the subsequent increase in journeys-to-work, and through growth in the income generated by the labor force, some of which is spent not only on essential travel, but also on discretionary trips. The number of people in the workforce increased by nearly 40 million, growing from about 119 million in 1990 to nearly 158 million in 2015 [USDOL BLS 2016].

Age is closely associated with the progression of the household life cycle (e.g., single person, married couple, households with small children and/or school age children, empty nesters, and retired individuals). Both the youngest (under 16 years of age) and the oldest (over 65 years of age) traveled the least compared to other age groups. The in-between age groups, particularly those between 36 and 65 years of age, accounted for the majority of person-miles traveled (PMT). This is a harbinger of future trends as older members of the labor force move toward the 65-year-age threshold where many people move into retirement.

As shown in figure 2-11, travel across all age groups (except those 16 years old and under) showed declines from 2001 to 2009. The youngest and oldest age cohorts seemed least affected by the December 2007 to June 2009 economic recession and its aftermath, while the working age groups were most affected, particularly those between 16 and 35 [NBER 2013]. Whether this is cyclical or a fundamental change in travel trends is not clear.

The baby boom generation, people born between mid-1946 and mid-1964, has generated much of the travel activity at the local and intercity level for many decades. Today, even as the trailing edge of the baby boom generation approaches early retirement age, boomers are still affecting travel patterns. They are the first generation in which both women and men have been close to reaching the saturation point in terms of driver licenses and vehicle availability. Thus, retired baby boomers could be expected to be more mobile in their retirement years than previous generations, as indicated by an increase in PMT among those aged 65 and older [AASHTO 2013].

FIGURE 2-11 Daily Person-miles of Travel (PMT) by Age Group: 1983, 1990, and 1995 NPTS, and 2001 and 2009 NHTS



KEY: NHTS = National Household Travel Survey; NPTS = National Personal Travel Survey.

NOTES: 1990 person trips were adjusted to account for survey collection method changes. Please see Appendix 2 of 2001 *Summary of Travel Trends* for specifics.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Household Travel Survey* (multiple years), 2009 Summary of Travel Trends. Table 14. Available at http://nhts.ornl.gov/ as of June 2015.

The millennial generation, born after 1980, is often described as having very different attitudes toward location and transportation than their baby boomer parents. Millennials are described as less dependent on the automobile and more likely to live in central cities [SAKARIA STEHFEST 2013]. National data do not corroborate this description; among 16-to-24 year old members of the U.S. labor force who migrated between suburbs and principal cities, 250,000 left the suburbs for cities and 450,000 left the cities for suburbs, for a net loss of approximately 200,000 from 2011 to 2012 [AASHTO 2013]. Young people have been delaying the time when they acquire a driver's license and purchase their first new car, but the delay may have far more to do with the economy and availability of jobs than with shifting preferences of today's teenagers [AAA 2012]. Transportation as a share of spending is higher for people under the age of 35 than for any other age group [USDOL BLS 2012].

Time Spent Traveling

On weekdays in 2015, the average person spent 82.0 minutes per day traveling for a variety of activities. Examining the 44.7 percent of people who engaged in travel for work, the average person spent 46.7 minutes per day on this activity, the most for all activities.

On weekends and holidays, people spent an average of 85.9 minutes per day engaged in various travel activities, 3.9 minutes more than on weekdays. Out of all selected activities, the average person spent the most time (45.7 minutes) traveling for activities related to personal care, about 18.7 minutes per day more than on weekdays. Travel related to eating and drinking on weekends and holidays accounted for 33.3 minutes—about 8 minutes more than on weekdays [USDOL BLS 2016].

People spent less time traveling in 2015 than in 2003, according to the American Time Use Survey.[8] On weekdays in 2015, people spent 4.8 fewer minutes traveling per day, a decrease of 5.6 percent from 2003. On weekends and holidays, people spent 4.5 fewer minutes traveling per day, a 5.0 percent decrease (figure 2-12).

Time spent traveling reached a low in 2014, falling below levels reached in the last recession. Due to a post-recession increase in weekday travel time combined with a continued decline in weekend travel time, average weekday and weekend/holiday travel time were almost equal in 2011. On average, people traveled nearly 4.0 minutes more on weekends and holidays than on weekdays.

Challenges for Travel

An important component of accessibility is having access to transportation options, in particular for those groups in society who have the most difficulty traveling or those who have limited access to transportation services. This section begins with a discussion of the degree of connectivity[9] between public transportation modes, using data from the

[8] The time use survey asks individuals to identify how they spent their time on certain days. The survey results should not be compared to results from other measurement instruments, such as congestion indices based on vehicle time/distance estimates discussed in chapter 4.

[9] Connectivity puts travelers in closer proximity to additional transportation alternatives that unconnected, parallel systems do not offer.

FIGURE 2-12 Total Time Spent Traveling on Weekdays and Weekends: 2003–2013

NOTES: Activities are based on *American Time Use Survey Activity Lexicon 2011* definitions. Weekdays exclude holidays. *Weekends and holidays* includes the following: New Year's Day, Easter, Memorial Day, the Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *American Time Use Survey*. Available at www.bls.gov as of April 2015.

Bureau of Transportation Statistics' (BTS') Intermodal Passenger Connectivity Database. Other challenges discussed include access to transportation for people without a personal vehicle and transportation options for the elderly and for people with disabilities.

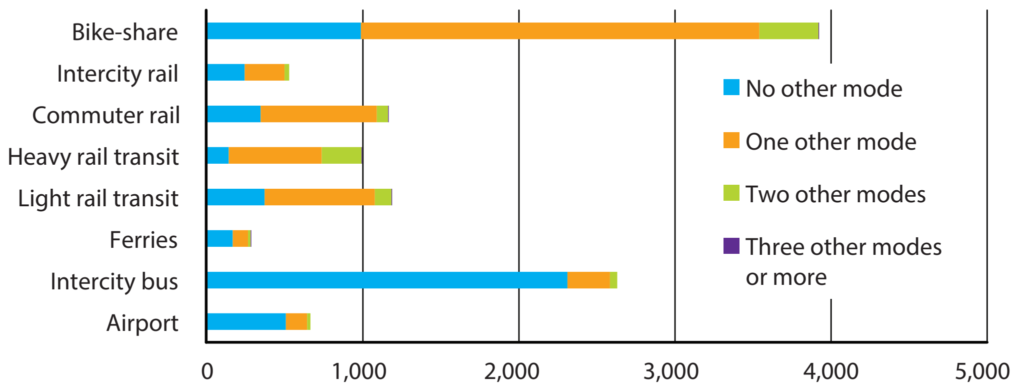
Passenger Access and Connectivity

People using public transportation (e.g., Amtrak, intercity bus, or commercial aviation) often need or wish to connect to another mode of transportation to reach their destinations. According to the 2009 National Household Travel Survey (NHTS), 99 percent of all transit trips used at least two transportation modes. Intermodal links between transportation modes (e.g., transit, intercity bus, or train station access at airports) give travelers more mobility options.

The BTS Intermodal Passenger Connectivity Database (IPCD) inventories the connectivity of passenger transportation facilities (e.g., air, long-distance bus and ferry, and intercity rail service), certain transit facilities (e.g., local ferry and heavy, light, and commuter rail), and bike-share. There are over 10,000 unique passenger travel facilities (figure 2-13), of which 44.4 percent do not offer connections to other transportation modes, 47.5 percent connect to one other mode, 8.1 percent connect to two other modes of transportation, and 0.1 percent connect to three other modes of transportation (e.g., bus, air, rail, ferry, or bike-share).

Specifically, 85.5 percent of the heavy rail-stations (high-speed transit rail on an exclusive right-of-way) offered connections to other modes and are the most connected of all travel

FIGURE 2-13 Intermodal Passenger Facilities by Mode: October 2016



Number of Connections by Facility Type

Number of facilities:	No other mode	One other mode	Two other modes	Three other modes	Grand total
Airport	508	137	21	0	666
Intercity bus	2,312	273	47	0	2,632
Ferries	168	99	15	4	286
Light rail transit	371	706	109	2	1,188
Heavy rail transit	144	596	254	2	996
Commuter rail	347	744	71	2	1,164
Intercity rail	247	253	29	0	529
Bike-share	990	2,552	377	4	3,923
Total (unique facilities)	**5,087**	**5,360**	**923**	**14**	**11,384**

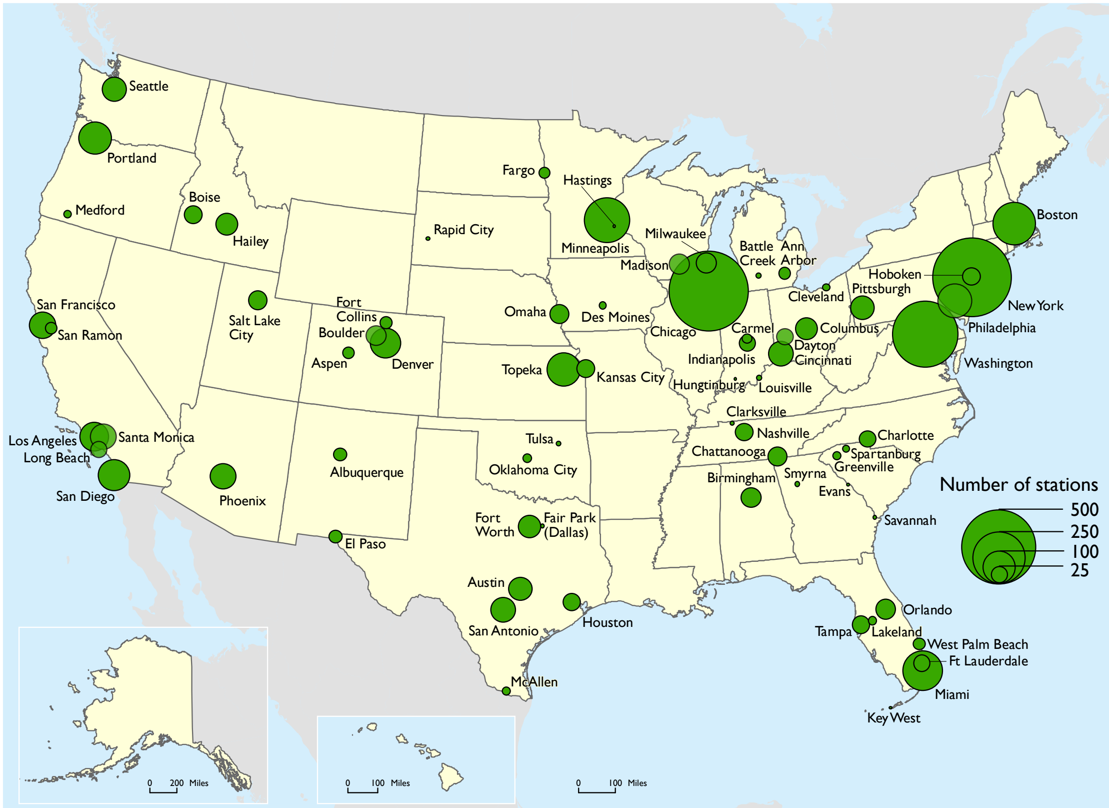
NOTES: *Intercity bus connection* includes: intercity, code share, and supplemental bus service. *Transit rail connection* includes: light rail, heavy rail, and commuter rail. *Ferries* includes both transit ferry and intercity ferry.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Intermodal Passenger Connectivity Database* (as of 10/19/2016). Available at www.bts.gov as of October 2016.

options, followed by bike-share (with 74.8 percent), commuter rail (with 70.2 percent), light-rail transit (with 68.8 percent), and Amtrak/intercity rail (with 53.3 percent). About a quarter (23.7 percent) of airports with scheduled passenger service connect with other transportation modes. Only 12.2 percent of intercity bus facilities have connections to other modes (figure 2-13).

Bike-share systems that connect with other transportation modes extend the transportation network and increase modal options. A bike-share facility, for example, located within a block of a transit bus stop offers an alternative to taking transit and provides access to locations off the transit bus route. A total of 72 bike-share systems operate 3,923 stations in 125 U.S. cities as of October 2016 (figure 2-14). Most bike-share docking stations (75.1 percent) can be found near local public transportation stops (transit bus, commuter rail, heavy rail, light rail, and/or transit ferry). Transit bus is the most typical connection, with 73.2 percent of bike-share stations located a block or less from a transit bus stop. [USDOT BTS 2016b]

FIGURE 2-14 U.S. Cities with Bike-Share Systems: 2016



NOTE: Cities not labeled: Redwood City, CA; Mountain View, CA; and Palo Alto, CA (all part of Bay Area Bike share along with San Francisco, CA and San Jose, CA); Santa Monica, CA and Los Angeles, CA (all part of Breeze Bike Share along with Santa Monica); Ashland, OR and White City, OR (all part of Zagstar Jackson County along with Medford, OR); Mesa, AZ (part of Grid Bike Share along with Phoenix, AZ); Elkhorn Village, ID; Ketchum, ID; and Sun Valley, ID (all part of MR Bike Share along with Hailey, ID); Covington, KY; Newport, KY; and Bellevue, KY (all part of Red Bike along with Cincinnati, OH); St. Paul, MN (part of Nice Ride Minnesota along with Minneapolis, MN); Council Bluffs (part of Heartland B-cycle along with Omaha, NE); Pompano Beach, FL; Lauderdale by the Sea, FL (all part of Broward B-cycle); Kissimmee, FL and Winter Park, FL (all part of Juice Bike share along with Orlando, FL); Rockville, MD; Bethesda, MD; Silver Spring, MD; North Potomac, MD; Takoma Park, MD; Derwood, MD; Redland, MD; Chevy Chase, MD; Alexandria, VA; and Arlington, VA (all part of the Capital Bikeshare system along with Washington DC); Brookline, MA; Cambridge, MA; and Somerville, MA (all part of Hubway along with Boston, MA); Jersey City (part of Citi Bike NYC along with New York, NY).

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Intermodal Passenger Connectivity Database as of October 2016

Access to Transportation for People Without a Vehicle

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. As previously discussed, roughly 9 percent of households do not have access to a personal vehicle. In the most densely populated parts of cities (10,000 plus people per square mile), 28.4 percent of households had no vehicle in 2009 [USDOT FHWA NHTS 2011].

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 increased from 12.2 to 14.8

percent between 2000 and 2014 as the number of poverty stricken persons increased from 33.3 million to 46.7 million[10] [USDOC CENSUS 2013b, 2015]. BTS analysis of the 2009 NHTS found that households with annual incomes less than $25,000 were eight times more likely, on average, to be zero-vehicle households than households with annual incomes above that level [USDOT FHWA NHTS 2011]. Of workers below the poverty level, 64.3 percent drive to work compared to 76.8 percent of workers overall in 2014. Compared to commuters as a whole, people below the poverty level are more likely to carpool, take public transportation, walk, or use other transportation modes (compare in figure 2-15).

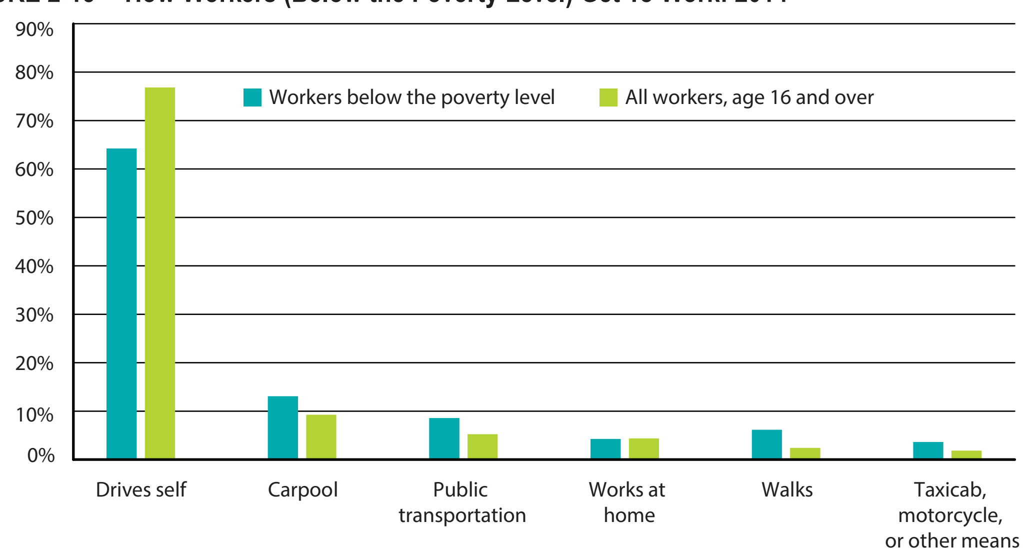
[10] There is no statistically significant difference in the poverty rate between 2011 and 2014, while the poverty rate increased each year in the four years prior to 2011.

Transportation Access for Elderly and Disabled Passengers

Access to transportation options also is a challenge for many people who are elderly and for those with physical or cognitive impairments. The American Association of Retired Persons Public Policy Institute estimated that 12 percent of all trips and 10 percent of all miles traveled in the United States in 2009 were taken by persons age 65 and older [AARP 2011]. Transit use by people age 65 and older as a share of all the trips they took increased by 40 percent between 2001 and 2009, which represented more than 1 billion trips on public transportation in 2009 (a 55 percent increase from what was reported in 2001).

Over the last two decades, the Nation's transit fleet has made notable progress in

FIGURE 2-15 How Workers (Below the Poverty Level) Get To Work: 2014



NOTES: Percents may not add to 100 due to rounding. For additional information, please refer to the *American Community Survey's 2014 Subject Definitions*, available at http://www.census.gov/acs/. Workers are civilians and members of the Armed Forces, 16 years and older, who were at work the previous week. Persons on vacation or not at work the prior week are not included.

SOURCE: U.S. Department of Commerce, Census Bureau, 2014 American Community Survey, 1-year estimates, table B08122. Available at http://www.census.gov/acs/www/index.html as of March 2016.

Box 2-B Transportation and Health

Transportation and public health interact in several ways, such as in the areas of public safety and exposure of the public to air pollution. Chapters 6 and 7 indicate improvement in some critical indicators of transportation's health impacts over the last several decades, but challenges remain.

As discussed in chapter 6, transportation fatalities and injuries have declined in recent decades, yet every day in 2014, on average, about 95 people die and nearly 6,500 people are injured in transportation accidents—primarily on the highway. Air pollution from transportation also adversely affects health, as discussed in chapter 7. Here, too, there has been a reduction in transportation emissions over the last few decades, resulting in corresponding reductions in public health impacts.

Perhaps the most dramatic improvement has been the virtual elimination of lead from gasoline. U.S. air quality has improved as lead concentrations have decreased from a mean of 1.84 µg/m3 (micrograms, or one-millionth of a gram, per cubic meter of air) in 1980 to 0.02 in 2015 [USEPA]. This phase out brought major public health benefits, particularly for children and populations living near major highways who were no longer exposed to unhealthy levels of lead from gasoline emitted into the air. Lead when inhaled or ingested from soil was shown to produce elevated lead levels in the blood, with multiple health effects such as lowering IQs for exposed children, and cardiovascular problems for adults [WORLD BANK 1998].

The mode of transportation people use also impacts health. Americans increasingly have an obesity problem, in part because of diet and sedentary lifestyles, and in many cases lack of exercise. During the last half century, people as a whole spend less time each day walking and bicycling to workplaces or other places, while spending more time sitting in vehicles [AJPH 2011]. Census Bureau reports show that in 1960, 10.3 percent of people walked to work, compared to 3.9 percent in 1990 and 2.7 percent in 2014. People also are less likely today than in the 1960s to use public transit, which generally involves walking a block or so to and from a bus stop or transit station.

The interactions between transportation and public health are increasingly recognized as an aspect of transportation planning. The Federal Government and several states and communities are explicitly addressing these connections in their statewide transportation plans. At the Federal level, in November 2015, the USDOT and the Centers for Disease Control launched an online tool to promote health through transportation. This site provides a variety of health-related transportation indicators to measure progress states are making and how states rank with each other. Examples of indicators include, among others, how much people walk or bike in their daily trips; traffic fatalities per 100,000 residents; seat belt use; alcohol-related traffic fatalities; and percentage of population residing within 200 meters of a road that carries, at least, 125,000 vehicles per day (thus exposing nearby people to pollution and noise). The site also identifies strategies that could be used to improve performance on transportation health issues [USDOT 2016].

making transit service accessible to those with disabilities. Through the installation of lifts and ramps or improvements in station infrastructure, people using wheelchairs or who have other travel disabilities now find it easier to access transit than in the recent past. All but a few transit bus stations are now reported to be compliant with the Americans with Disabilities Act (ADA), the 1990 law that focused attention on transportation needs of people with disabilities, as are nearly all transit buses (at least among those services that report to the Federal Transit Administration). Almost all cars in the heavy rail transit fleet are now ADA complaint, but just 52.7 percent of heavy rail stations (like subway stations). Similarly, in the case of commuter rail, 87 percent of the train cars are compliant, but only 68.5 percent of the commuter rail stations. As for demand-response transit vehicles, where vehicles can be assigned based on a passenger's individual needs, about 87 percent of the fleet is reported to be accessible [APTA no date, APTA 2016]. Box 2-B examines the interactions between transportation and public health.

After decades of predictable growth, recent indicators of U.S. travel have become less clear. Many factors, such as the travel predilections of the aging baby boom and the younger millennial generations, uncertainties about future levels of immigration, and the duration of continuing effects of the recent recession on travel, will enter into the equation. In order to understand possible changes in travel dynamics, good data about local, long-distance, and international travel will need to be collected on a regular basis. The central question for data development will be to distinguish what changes are cyclical phenomena, and therefore transient, from those that are structural and a fundamental part of a new era of travel behavior.

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CHAPTER 3

Moving Goods

Highlights

- In 2015 freight tonnage and value rose by 6.5 and 8.2 percent, respectively, over 2012 levels, fully rebounding from declines during the December 2007–June 2009 economic recession.
- The U.S. freight transportation system moved 49.5 million tons of goods valued at more than $52.7 billion each day in 2015—about 56 tons of freight per year for every man, woman, and child in the United States, an increase of 4.0 percent over 2012 per capita tons.
- Historically, trucks carry the largest shares by value, tons, and ton-miles for shipments of 750 miles or less. Rail dominates in tons and ton-miles for shipments of 750 to 2,000 miles, while air, modal combinations, and other / unknown modes account for the majority of the value of shipments of 2,000 miles or more.
- The value of U.S.-international merchandise trade increased from more than $2.4 trillion in 2000 to approximately $3.5 trillion in 2015, a 40.1 percent increase. Trade with Canada and Mexico increased by 26.7 percent over the same period. This growth in trade has created additional traffic between international gateways and domestic destinations.
- More than 400 freight transportation gateways, including airports, border crossings, and seaports, handled international cargo in 2015, while the latest available data show that in 2014 the top 25 freight gateways handled the greatest share of U.S. international merchandise trade—$2.5 trillion in current dollars, or 63.0 percent of the more than $3.9 trillion in total U.S.-international merchandise in that year.
- Alaska, North Dakota, and Wyoming are major producers of energy commodities—oil in Alaska and North Dakota and coal in Wyoming. Alaska and North Dakota had the highest ratios of domestic export to domestic import shipments by value, while Alaska and Wyoming accounted for the highest ratios by tonnage.
- Shifts in oil production have affected transportation patterns of energy commodity movements in recent years. Although pipelines continue to be the predominant mode for moving oil, rail shipments of crude oil have risen substantially, from less than 1 percent in 2010 to 21.5 percent in 2015. Domestic oil production has declined slightly in 2016.

The U.S. freight transportation system moved nearly 18.1 billion tons of goods valued at more than $19.2 trillion in 2015, according to Freight Analysis Framework (FAF) estimates (table 3-1). This means the freight transportation system carried, on average, about 49.5 million tons of goods worth more than $52.7 billion each day, or about 56 tons of freight annually per capita in the United States in 2015, a 4.0 percent increase from 2012. See box 3-A for information about the FAF and its foundation, the Commodity Flow Survey (CFS).

In 2015 freight tonnage and value rose 6.5 and 8.2 percent, respectively, over 2012. Table 3-1 shows that the total weight and value of freight in 2015 surpassed 2012 levels in all categories, except import tonnage. The most recent long-range FAF forecasts show that freight tonnage will grow about 1.2 percent annually between 2015 and 2045. The value of goods transported, in real dollars, is projected to

TABLE 3-1 Weight and Value of Shipments by Transportation Mode: 2012, 2015, and 2045

Weight

	2012				2015				2045			
Millions of tons	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]
Total	16,953	14,953	864	1,136	18,056	16,045	912	1,099	25,345	20,914	2,190	2,241
Truck	10,166	9,970	107	89	10,859	10,649	110	100	14,866	14,270	291	305
Rail	1,613	1,487	52	74	1,607	1,458	54	85	1,921	1,597	108	216
Water	933	506	68	359	936	553	94	289	1,158	614	189	355
Air, air & truck	10	2	4	4	11	2	4	5	38	4	16	18
Multiple modes & mail	1,320	311	596	413	1,353	327	613	412	2,971	434	1,519	1,018
Pipeline	2,870	2,641	36	194	3,258	3,017	37	204	4,361	3,978	63	319
Other & unknown	41	37	1	3	33	29	1	3	31	16	4	11

Value

	2012				2015				2045			
Billions of 2012 dollars	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]
Total	17,805	14,058	1,532	2,215	19,258	15,072	1,699	2,487	37,080	22,499	6,474	8,106
Truck	11,011	10,333	367	311	11,718	10,994	382	342	18,735	16,270	1,247	1,218
Rail	569	417	59	93	617	451	62	104	1,058	652	153	253
Water	617	274	71	272	636	304	99	233	1,021	345	272	405
Air, air & truck	1,044	138	434	472	1,194	152	466	576	5,133	330	2,449	2,354
Multiple modes & mail	3,275	1,752	573	949	3,599	1,875	658	1,065	9,152	3,404	2,262	3,485
Pipeline	1,250	1,143	9	97	1,410	1,295	10	105	1,656	1,498	15	144
Other & unknown	40	1	17	22	83	1	21	61	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 2015 data are provisional estimates that are based on selected modal and economic trend data. 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. Multiple modes and mail also includes some air movements. As a consequence, some totals in this table are less than other published sources.

SOURCE: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics, and USDOT, Federal Highway Administration, Freight Analysis Framework, version 4.2, 2016.

Box 3-A The Commodity Flow Survey and the Freight Analysis Framework

The Commodity Flow Survey (CFS) is conducted every 5 years 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 tonnage shipped from a domestic origin to a domestic destination.

The CFS is the foundation for the Freight Analysis Framework (FAF), a freight database produced through a partnership between BTS and the Federal Highway Administration (FHWA). The FAF incorporates domestic shipments measured in the CFS (covering mining, manufacturing, wholesale, and other selected industries). It augments the CFS data with foreign trade statistics from Census, 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 type, mode, origin, and destination for years the CFS is conducted, provides annual estimates for years in between the CFS, and 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 to provide a picture of freight truck volumes.

FAF forecasts are based on long-term U.S. economic projections, including real gross domestic product growth, nonfarm business productivity, real oil prices, and the Federal budget deficit. Detailed information on CFS data and methodologies are available at www.bts.gov/publications/commodity_flow_survey. Information on FAF data and methodologies are available at www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm. It is important to note that while the FAF is more complete in coverage of freight flows, the CFS provides greater commodity detail and additional shipment characteristics, such as hazardous materials class.

It is important to note that the input sources for the FAF4 base year of 2012 are final, but each updated version of FAF incorporates continuous improvements to data quality. As a result, the latest data available online may not precisely match the data in this chapter.

increase faster than tonnage and might nearly double during this time span as higher value goods are moved [USDOT BTS and FHWA FAF 2016].

U.S. exports and imports accounted for 5.1 and 6.1 percent of the weight and 8.8 and 12.9 percent of the value of freight transported in 2015, respectively. FAF forecasts that U.S. exports and imports will account for an even greater share of freight movements in 2045, reaching 17.5 percent of the weight and 39.3 percent of the value of goods shipped throughout the country [USDOT BTS and FHWA FAF 2016].

Population growth and economic activity continue to be the primary factors that determine freight demand. As population increases or economic activity expands, more goods are produced and used, resulting in additional freight movement. Between 2010 and 2015, the U.S. population increased by 3.9 percent [USDOC CENSUS American Fact Finder], and U.S. gross domestic product grew by 10.9 percent in terms of chained 2009 dollars [USDOC BEA 2016]. In addition, changes in the composition of goods demanded and shifts of economic centers to Asia had an effect on what goods were moved, what modes were used to transport them, and where they were shipped. Freight carried by the for-hire transportation industry rose as the economy rebounded from the past recession. With a freight Transportation Services Index of 122.3, freight shipments in June 2016 were 29.1 percent above the index low of 94.7 recorded in April 2009, during the recession, and are up by 8.2 percent in the 10 years from June 2006 [USDOT BTS 2016a].

How Domestic Freight Moves

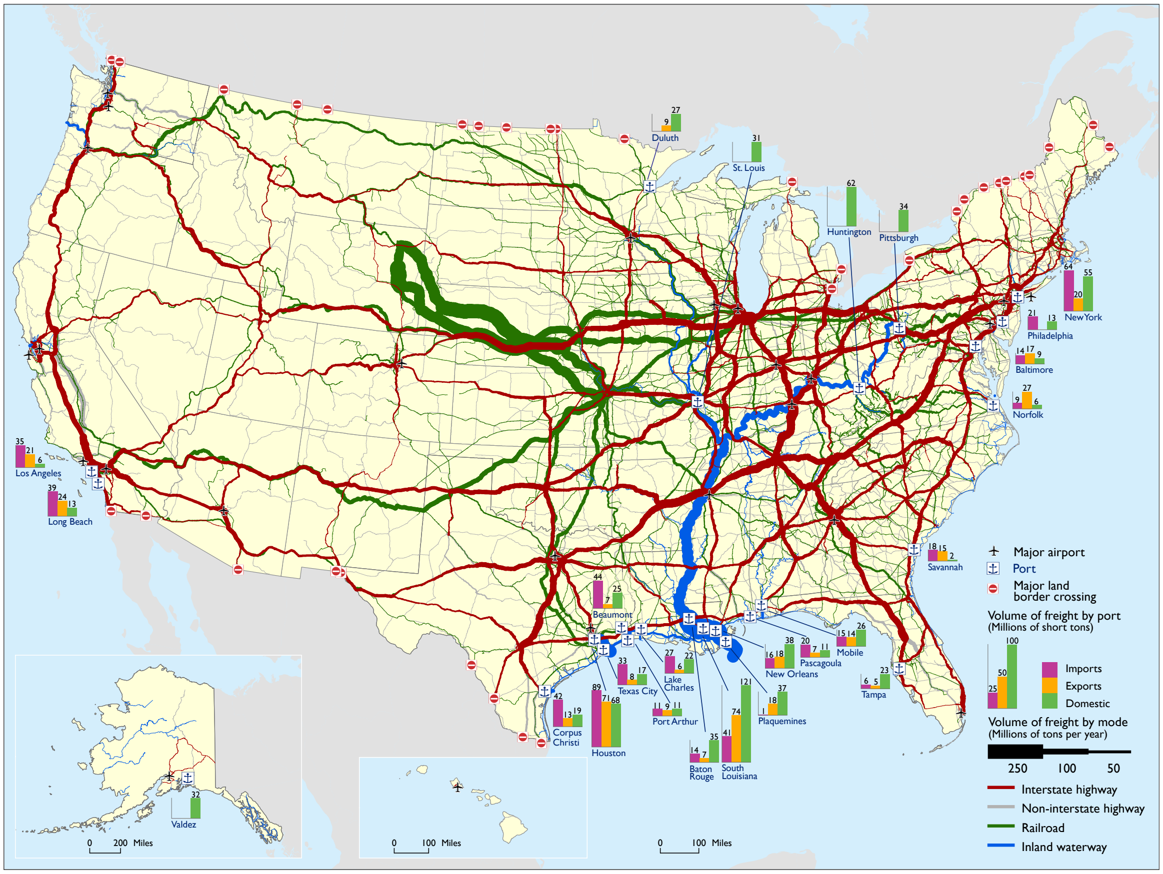
The freight transportation industry moves goods over a network of truck routes, railroads, waterways, airports, and pipelines. The distance a shipment must travel, either by single mode or during any particular leg of a multimodal journey, plays a major part in determining what mode or modes are used.

Overall, trucks carry the highest percentage of the weight and value of goods in the United States, accounting for 60.1 and 60.8 percent, respectively, in 2015. However, figure 3-1 shows that railroads and inland waterways carry large volumes and tonnages of bulk commodities, like coal and petroleum products, over long distances. Rail and water combined accounted for 14.1 percent of the total tonnage and 6.5 percent of the total value of freight moved in the United States in 2015. Air carriers moved high-value, low-weight products. This is underscored by the relatively extreme value-to-weight ratio of air cargo, which is about $108,500 per ton. In comparison, the overall value-to-weight ratio of cargo carried by all modes combined is less than $1,100 per ton. In 2015 pipelines moved nearly 3.3 billion tons of goods valued at about $1.4 trillion ($433 per ton), while rail moved more tonnage of lesser value—1.6 billion tons valued at $617 billion ($384 per ton). [USDOT BTS and FHWA 2016].

Shipments moving by water are typically low-value, bulk products similar to rail.[1] In

[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.

FIGURE 3-1 Freight Flows by Highway, Railroad, and Waterway: 2011



SOURCES: *Highways*: U.S. Department of Transportation, Federal Highway Administration, Freight Analysis Framework, Version 3.5, 2014; *Rail*: Based on Surface Transportation Board, Annual Carload Waybill Sample and rail freight flow assignments done by Oak Ridge National Laboratory, 2013; *Inland Waterways*: U.S. Army Corps of Engineers, Institute or Water Resources, Annual Vessel Operating Activity and Lock Performance Monitoring System data, 2012.

2015 the water transportation industry moved 936 million tons worth $636 billion (nearly $680 per ton), representing 5.2 percent of the tonnage and 3.3 percent of the value of all freight shipments [USDOT BTS and FHWA 2016]. In 2015 approximately 565 million short tons of cargo were moved by vessel along the inland waterways, including the Mississippi River—the Nation's busiest waterway [USACE WCSC 2016a].

In comparison with the rail and water modes, air transport carries high-value products, such as electronics, precision instruments, and pharmaceuticals that require quick delivery. Of all modes, the value of air-freight shipments is projected to increase the fastest from 2015 to 2045, growing by more than 300 percent [USDOT BTS and FHWA 2016]. In 2015 U.S. airlines[2] carried a total of 65,092 million

[2] In all service classes (scheduled and nonscheduled).

international and domestic freight and mail cargo revenue ton-miles, of which 13,190 million were domestic [USDOT BTS 2016c].

Over the last 20 years, the U.S. transportation system has become increasingly interconnected. Although multimodal services accounted for a small share (7.5 percent) of freight tonnage, they moved 18.7 percent of the value of the goods in 2015. FAF forecasts the total value of multimodal shipments will more than double between 2015 and 2045 [USDOT BTS and FHWA 2016].[3]

The growth in intermodal freight movement is driven, in part, by global supply chain requirements. Between 2000 and 2015, the railroad industry reported a 50.5 percent increase in trailer and container traffic [AAR 2016b]. The Association of American Railroads reports that rail intermodal traffic accounted for 13.0 percent of U.S. Class I railroad revenue in 2015. Only coal and chemicals and allied products accounted for a larger share of revenue [AAR 2016a]. With the growth in container trade and improvements in information and logistics technologies, the stage is set for even greater reliance on intermodal transportation to move goods from manufacturers to consumers.

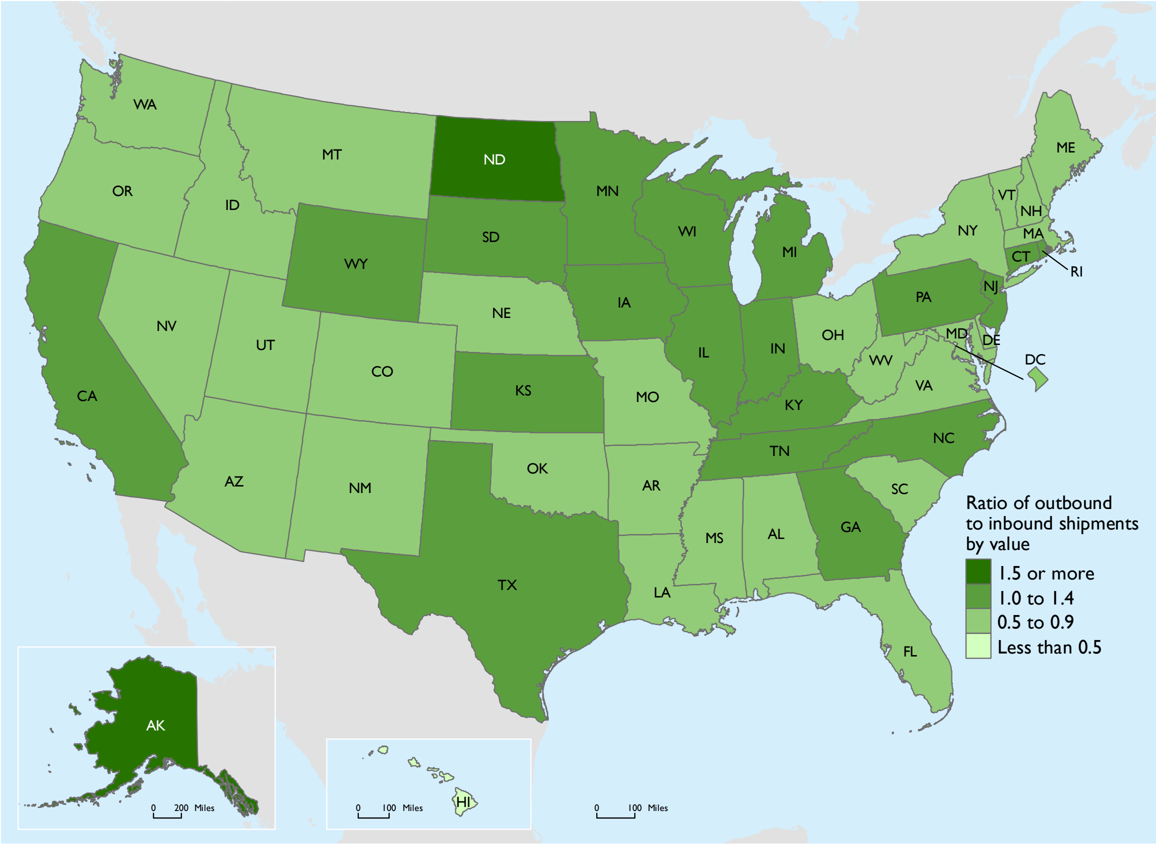
Value and Weight of Domestic Shipments by State

An interconnected freight transportation network contributes to state economic growth by supporting resource development and expanding interstate commerce. Figures 3-2 and 3-3 show the ratios of the value and weight of goods shipped to and from other states. A ratio greater than 1.0 indicates that a state ships more goods 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.

By value, Alaska and North Dakota have the highest ratio of about 2.0, indicating these states export more goods to other states than they import. Both states are major oil producers and exporters while their relatively small populations require fewer imports than other states. According to the FAF, the water mode moved nearly all of Alaska-produced oil to California in 2015, while pipeline and rail were the primary modes for moving oil out of North Dakota. Other major states that export more than they import were California, Connecticut, and Illinois. Electronics was the top outbound domestic shipment category from California, accounting for 20.5 percent of its total exports to other states, while mixed freight was the leading outbound shipment from Connecticut at 20.0 percent. Mixed freight includes items such as grocery and convenience store goods, food for restaurants, office supplies, and hardware and plumbing items. Coal was the top outbound shipment from Illinois, accounting for 9.8 percent of its exports to other states. Hawaii had the lowest ratio of interstate outbound-to-inbound shipments by value at 0.16 because of its geography. Other states that import more than they export by value include Florida and Arizona, partly due to demographics [USDOT BTS and FHWA 2016].

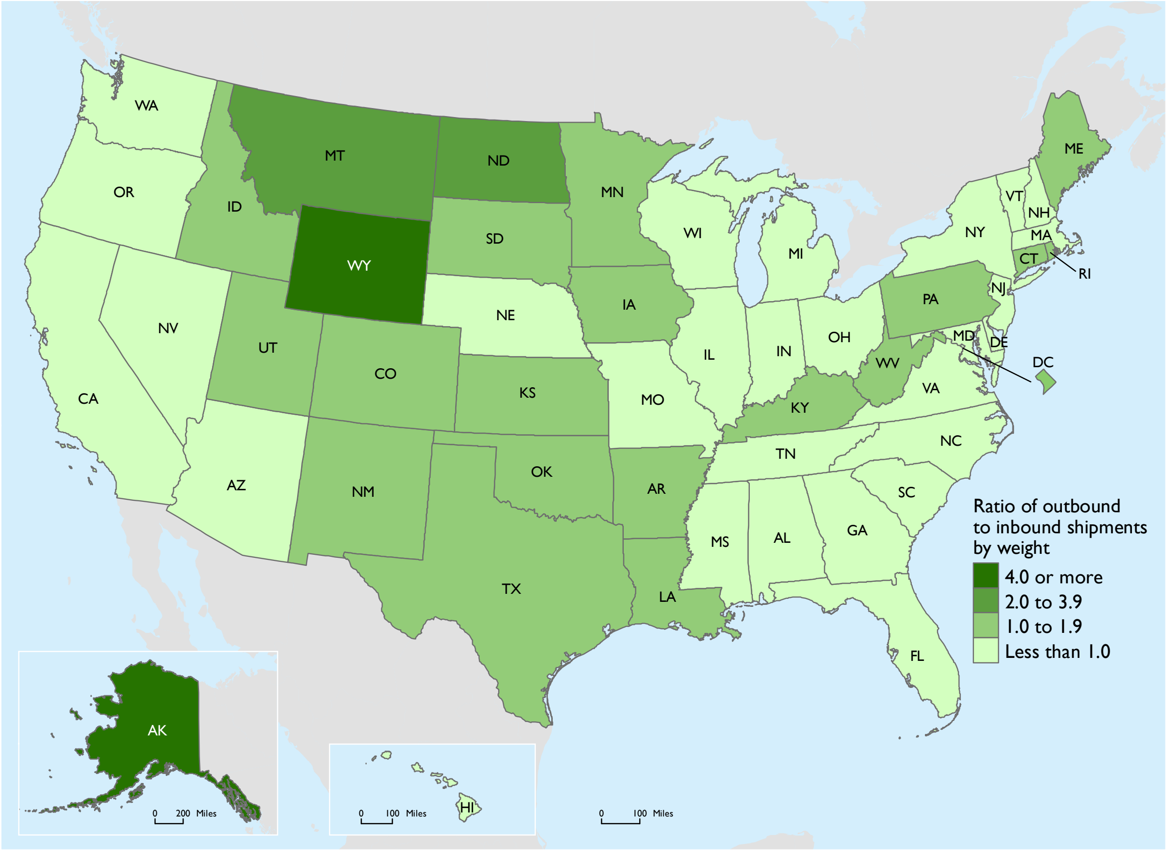
[3] The FAF category for multiple modes and mail includes all multimodal movements and is not limited to traditional intermodal services, such as trailer-on-flatcar and container-on-flatcar rail.

FIGURE 3-2 Ratio of Outbound to Inbound Shipments by Value: 2015



SOURCES: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics, and USDOT, Federal Highway Administration, Freight Analysis Framework, version 4, March 2016.

FIGURE 3-3 Ratio of Outbound to Inbound Shipments by Weight: 2015



SOURCES: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics, and USDOT, Federal Highway Administration, Freight Analysis Framework, version 4, March 2016.

The picture changes when looking at the ratio of outbound to inbound shipments by weight. All of the top five domestic net exporters are major producers of energy commodities: Wyoming, Alaska, Montana, North Dakota, and West Virginia. Wyoming is the largest coal producer, followed by West Virginia, while Montana is the sixth largest coal producer, according to the Energy Information Administration. For domestic markets, rail and barge are used to transport coal over longer distances, primarily to power plants.

For all 50 states (excluding the District of Columbia), an average of 44.3 percent of shipments by value were moved to a destination within state. Trucks accounted for 80.8 percent of intrastate shipments. Hawaii had the highest percentage of intrastate shipments by value (91.9 percent), most of which were transported by truck, followed by Texas (70.9 percent), and Florida (67.6 percent). By value, Nevada had the lowest percentage of intrastate shipments (29.2 percent). Nevada's textile/leather industry moved 88.2 percent of its products to markets outside the state.

Commodities Moved Domestically

Table 3-2 shows the top 10 commodities moved on the U.S. transportation system in 2015. The leading commodities by weight, comprised entirely of bulk products, accounted for 67.5 percent of total tonnage but only 25.6 percent of the Nation's freight value. The top 10 commodities included natural gas, coke,[4] and asphalt; gravel; gasoline; cereal grains; and nonmetal mineral products [USDOT BTS and FHWA 2016].

[4] Coke is a solid fuel usually made by heating coal in the absence of air. It has high carbon content and is used primarily as a fuel in smelting iron ore in a blast furnace.

TABLE 3-2 Top 10 Commodities by Weight and Value: 2015

Weight	Millions of tons	Value	Billions of 2012 dollars
Natural gas, coke, asphalt[1]	2,647	Electronics	1,673
Gravel	1,820	Motorized vehicles	1,467
Gasoline	1,227	Mixed freight	1,458
Cereal grains	1,099	Machinery	1,148
Nonmetal mineral products	1,073	Gasoline	1,129
Fuel oils	1,054	Natural gas, coke, asphalt[1]	938
Coal	1,001	Pharmaceuticals	903
Crude petroleum	903	Fuel Oils	853
Other foodstuffs	704	Miscellaneous manufacturing products	791
Waste/scrap	653	Other foodstuffs	710
Total, top 10	**12,182**	**Total, top 10**	**11,069**
Total, all commodities	**18,056**	**Total, all commodities**	**19,249**

[1]This group includes coal and petroleum products not elsewhere classified such as liquefied natural gas, coke, asphalt, and other products of coal and petroleum refining, excluding gasoline, aviation fuel, and fuel oil.

SOURCE: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics, and USDOT, Federal Highway Administration, Freight Analysis Framework, version 4, March 2016

The story is different when looking at the value of goods shipped. The leading commodities by value are high value-per-ton goods that require more rapid delivery, including electronics, motorized vehicles, mixed freight, machinery, and gasoline. In 2015 the top 10 commodities by value accounted for 57.5 percent of total value but only 36.2 percent of total tonnage [USDOT BTS and FHWA 2016].

Energy Commodities Transportation

The delivery of energy commodities involves various modes, depending on the characteristics of the commodity and the distances from wellhead or mine to processing facilities and then to the final consumer. Increasingly, energy commodity movements are multimodal, utilizing a combination of pipeline, rail, barge, and truck. The transportation of crude oil and refined petroleum products, coal, and ethanol are discussed here.

In recent years, advances in hydraulic fracturing have opened new areas to oil and gas development, creating new demands for the transportation of energy commodities. Box 3-B discusses hydraulic fracturing and its implications for the freight transportation system.

Box 3-B: Hydraulic Fracturing and U.S. Oil and Gas Production

The technique of hydraulic fracturing (also known as fracking) has been widely used to increase domestic oil and gas production in the United States. The process involves injecting a water solution deep into the bedrock formation using a well. Pressure from the water creates cracks in the shale rock formations and creates oil and/or gas flow from the formation [USGS 2016]. The hydraulic fracturing process has existed since around 1949, but only since the 1990s has it gained national attention as various energy companies began utilizing it to produce gas/oil in commercial quantities. In 2015 hydraulic fracturing accounted for more than half of U.S. domestic crude oil production. From 2000 to 2015, the number of hydraulically fractured wells in the United States increased from about 23,000 to around 300,000 [USDOE EIA 2016d].

Hydraulic fracturing has altered patterns of domestic energy transportation by expanding oil and gas production in many areas, including those that do not have pipelines in place to deliver the oil to refineries. According to the Energy Information Administration (EIA), crude oil movement by rail has shown large increases over the past 5 years, with much of the growth stemming from oil being transported from the upper Midwest to the Gulf of Mexico and northeast for processing [USDOE EIA 2016c].

Oil production requires significant transportation inputs, such as the transport of well development equipment and supplies by truck as well as the transport of the crude oil from well fields to refineries via pipelines and/or rail or barge. Well development requires thousands of gallons of water and chemicals resulting in high volumes of truck traffic that far exceed the design and capacity of local roads while potentially creating a safety hazard for local drivers [NPHL 2011]. Each well requires 2,300 drilling-related truck movements [UGPTI 2014]. Once the well goes into production mode, trucks may again be used to transport the oil from the well to a pipeline, barges, or rail cars for transport to a processing facility.

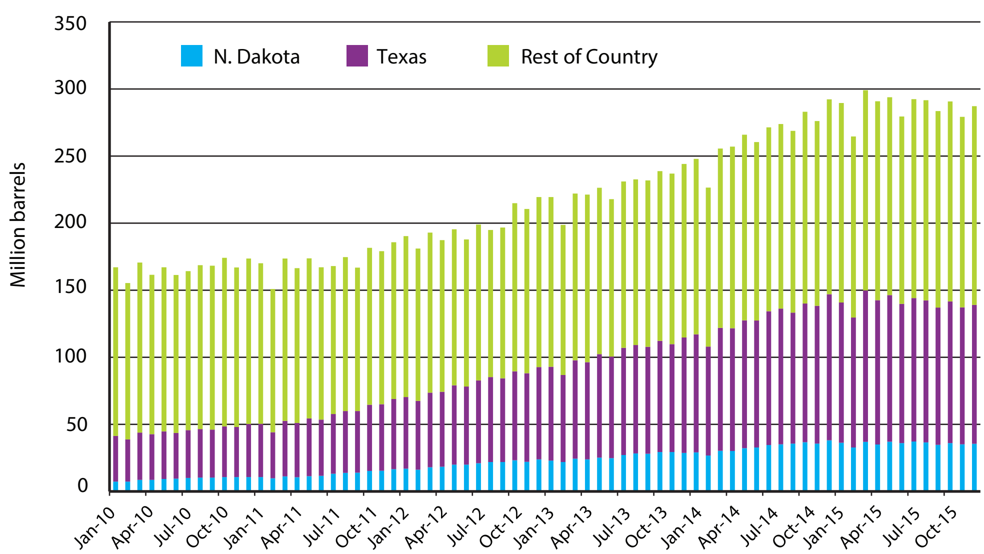
Crude Oil and Petroleum Refined Products

Pipelines are the primary mode for transporting crude oil and petroleum products in the United States. Historically, pipelines delivered crude oil from offshore platforms in the Gulf of Mexico to nearby refineries, but changes in where oil is produced have affected transportation patterns in recent years. For example, expanded production in regions distant from refineries, such as the Bakken formation in North Dakota, has increased the use of rail, barges, and trucks to move oil from the wellhead to refineries. In addition to continuing their historic role of delivering crude oil from the Gulf of Mexico to refineries, pipelines also move domestic and Canadian crude oil to the Gulf of Mexico to be refined and/or exported [USDOE 2015]. U.S. crude oil production increased by 72.2 percent, from nearly 2.0 billion barrels in 2010 to more than 3.4 billion barrels in 2015 (figure 3-4). Texas and North Dakota accounted for 49.1 percent of U.S. crude oil production in 2015.

Expanded oil production also has spurred growth in the waterborne transport of oil. According to the U.S. Army Corps of Engineers, U.S. ports and inland waterways handled more than 7 billion barrels of domestic and international crude oil (48.3 percent) and petroleum products (51.7 percent) in 2014, the latest year for which data are available [USACE NDC 2016]. In comparison, pipelines transported about twice the total volume handled by ports and inland waterways in 2014 [AOPL].

The use of tankers and barges for oil transport on U.S. inland waterways, from port to port along the coasts or on the Great Lakes, also has increased in recent years from about 2.6 percent (15.7 billion barrels) of modal share in 2010 to 3.3 percent (40.0 billion barrels)

FIGURE 3-4 Field Production of Crude Oil: January 2010–December 2015



SOURCE: U.S. Energy Information Administration based on data from the Surface Transportation Board and other information, April 2016.

in 2015, after peaking at 6.8 percent (59.0 billion barrels) in 2013. A significant share of oil transport is intermodal; for example, oil is transported by pipeline or rail to a terminal and then transferred to a barge for delivery to a refinery.

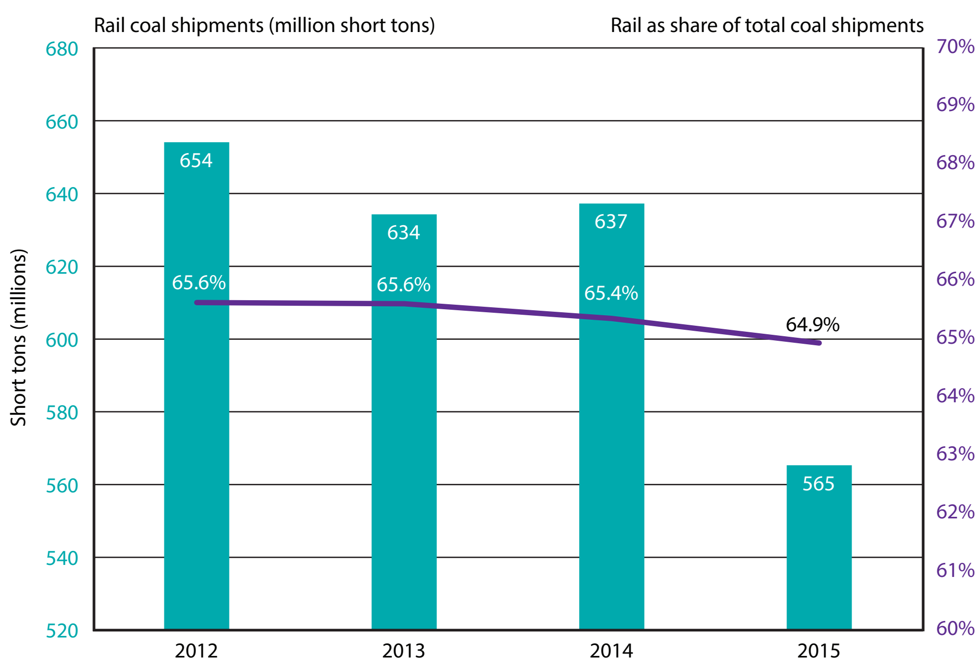
Trucks are used for short-haul drayage of crude oil from the wellhead to gathering pipelines or rail loading terminals for long-distance transport. Because oil production has outpaced the construction of pipeline gathering systems in the Bakken region, trucks deliver about 40 percent of Bakken oil to pipeline and rail terminals, according to DOE [USDOE 2015]. Trucks also are used to move crude oil over short distances to refineries. The demand for truck transport is illustrated by the more than tripling of refinery receipts of crude oil by truck, from 50.6 million barrels in 2000 to nearly 176.7 million barrels in 2015 [USDOE EIA 2015c].

After the crude oil is refined into gasoline, diesel fuel, jet fuel, and heating oil, among other products, these commodities are shipped via pipeline to a bulk storage terminal that serves many companies. Gasoline, for example is loaded on tanker trucks for delivery to various retail gas stations. Jet fuel is pumped directly from the storage terminal to major airports that have receiving facilities on site.

Coal

How coal is transported depends on the distance it must travel. Typically trucks are

FIGURE 3-5 Rail Coal Shipments: 2012–2015



SOURCE: U.S. Energy Information Administration based on data from the Surface Transportation Board and other information, October 2015.

used for short distances, while trains and barges are used for longer hauls. According to FAF, rail moved the greatest share of domestic coal shipments in 2015, accounting for 64.9 percent (565 million short tons) of the total 870.6 million short tons (figure 3-5), which is a 33 percent drop from the 1.3 billion tons moved by rail in 2012. Nearly 70 percent of coal used to generate electricity is delivered to power plants by rail [USDOE EIA 2016e]. Approximately two-fifths of all U.S. coal is produced in Wyoming's Powder River Basin. The vast majority of Wyoming's coal is sent to power plants in 33 states, and almost all of that tonnage is moved by rail [USDOE EIA 2015].

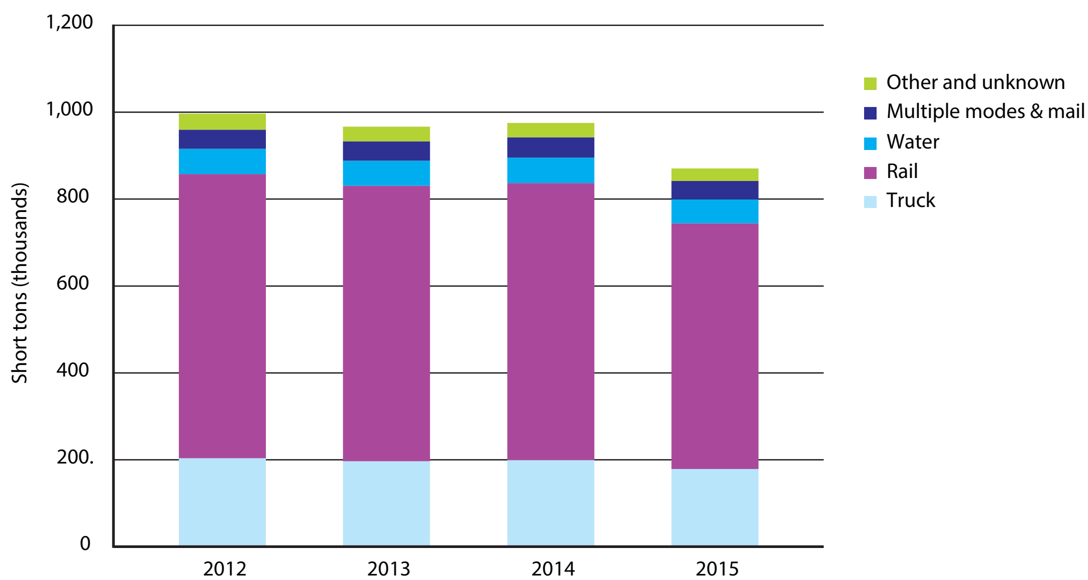
The Association of American Railroads reports that coal represents 36.9 percent of total tonnage moved by rail and 17.2 percent of U.S. Class I railroad gross revenue in 2015 [AAR 2016a]. Many in the railroad industry view coal as its most important single commodity.

Trucks are the second largest mover of domestic coal shipments, hauling 20.5 percent (nearly 179 million short tons) (figure 3-6). Inland waterways are also an important transportation option for coal shipments—292 million tons of coal, lignite, and coke were moved in 2014 [USACE NDC 2015]. Barges typically have the lowest transportation prices per ton, but they are limited by access to navigable waterways and cannot take coal everywhere that it is needed.

Ethanol

U.S. ethanol production has grown steadily from 38.6 million barrels in 2000 to 352.5 million barrels in 2015 [USDOE EIA 2016a]. Ethanol now displaces approximately 10 percent of U.S. gasoline demand by volume.

FIGURE 3-6 Domestic Coal Shipments by Mode: 2012–2015



SOURCE: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics, and USDOT, Federal Highway Administration, Freight Analysis Framework, version 4, March 2016.

Ethanol production is primarily located in the Midwest where most of the corn feedstocks are grown and delivered by trucks from farms or grain storage facilities to ethanol production plants. Typically, rail moves ethanol from production plants to distribution terminals, which accounts for 60–70 percent of ethanol shipments. Nearly 304,000 carloads of ethanol were transported by railroads in 2013 (latest year for which data are available), up from fewer than 40,000 carloads in 2000, according to the American Association of Railroads (AAR). In 2013 ethanol shipments accounted for 1.0 percent of total rail carloads and 1.4 percent of rail ton-miles (AAR 2015]. Most ethanol shipments carried by railroads move in 30,000-gallon tank cars, almost all of which are owned by shippers or leasing companies. The blending of ethanol with gasoline takes place at petroleum product distribution terminals across the country, and the final product is delivered by truck to retail outlets.

Hazardous Materials

As measured by the CFS, nearly 2.6 billion tons of hazardous materials, valued at approximately $2.3 trillion, were moved within the United States in 2012, an increase of 15.6 percent over 2007 tonnage, due in part to expanded coverage [USDOT BTS and USDOC Census 2015]. Trucks moved 59.4 percent of the weight and 62.8 percent of the value of all hazardous materials shipments in 2012. This represents an increase in truck's share of total tonnage by 5.5 percent. Pipelines moved 24.3 percent of hazardous materials tons in 2012, slightly less than its share in 2007; while waterways and rail handled 11.0 and 4.3 percent, respectively, of total hazardous materials shipments by weight (table 3-3).

Hazardous materials were shipped over 307.5 billion ton-miles in 2012, a 4.9 percent decrease from 2007. In comparison to its share of tonnage and value moved, trucks accounted for a smaller share of ton-miles—31.4 percent—because of the relatively short distances these products were transported. Across all modes, hazardous materials shipments were moved an average of 114 miles in 2012, with truck shipments moving about half the average distance (56 miles). Rail accounted for 27.6 percent of hazardous materials ton-miles, with an average distance per shipment of 808 miles in 2012, compared to 578 miles in 2007—a nearly 40 percent increase.

Of the nine classes of hazardous materials, flammable liquids accounted for the largest share by value (86.4 percent) and by tons (85.4 percent), followed by gases, a distant second (table 3-4). Hazardous materials transport poses risks to public safety and the environment. In recent years, several accidents in the United States and Canada involving explosions, fires, and leaks from rail tank cars have heightened concern about public safety in communities through which these cars pass as well as the environmental risks surrounding the transport of these materials. In 2016 BTS established a railroad tank car safety data program to track the number of rail tank cars retrofitted to meet enhanced safety standards. Chapter 8 discusses this and other BTS programs to support transportation safety goals.

TABLE 3-3 Hazardous Materials Shipments by Transportation Mode: 2007 and 2012

Transportation mode	Value ($ billions) 2007	Value ($ billions) 2012	Tons (millions) 2007	Tons (millions) 2012	Ton-miles[1] 2007	Ton-miles[1] 2012	Average distance per shipment (miles) 2007	Average distance per shipment (miles) 2012
All modes, total	**1,448.2**	**2,334.4**	**2,231.1**	**2,580.2**	**323.5**	**307.5**	**96**	**114**
Single modes, total	**1,370.6**	**2,304.7**	**2,111.6**	**2,552.9**	**279.1**	**275.6**	**65**	**68**
Truck[2]	837.1	1,466.0	1,202.8	1,531.4	104.0	96.6	59	56
For-hire	358.8	870.9	495.1	882.3	63.3	62.0	214	150
Private	478.3	595.1	707.7	649.1	40.7	34.5	32	33
Rail	69.2	79.2	129.7	111.0	92.2	84.9	578	808
Water	69.2	217.8	149.8	283.6	37.1	54.9	383	212
Air	1.7	4.4	S	Z	S	Z	1,095	1,120
Pipeline[3]	393.4	537.3	628.9	626.7	S	S	S	S
Multiple modes, total	**71.1**	**29.7**	**111.0**	**27.3**	**42.9**	**31.9**	**834**	**654**
Truck and rail	7.1	13.3	11.7	17.0	10.1	16.6	779	954
Truck and water	23.5	S	36.6	S	12.4	S	1010	1,181
Rail and water	5.2	2.5	5.7	4.6	2.9	1.4	1,506	S
Parcel, U.S. Postal Service, or Courier	7.7	10.3	0.2	0.3	0.2	0.2	836	650
Other multiple modes	27.7	0.0	56.8	0.0	17.3	0.0	233	0
Other modes	**6.5**	**0.0**	**8.5**	**0.0**	**1.5**	**0.0**	**58**	**0**

KEY: S = data are not published because estimate did not meet publication standards. By far, the most common reason for suppressing a cell is a high coefficient of variation (greater than 50 percent).; Z = rounds to zero.

[1] Ton-miles estimates are based on estimated distances traveled along a modeled transportation network.

[2] Truck as a single mode includes shipments that went by private truck only or by for-hire truck only.

[3] Excludes crude petroleum shipments.

NOTE: Value-of-shipment estimates have not been adjusted for price changes. Numbers and percents may not add to totals due to rounding.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and U.S. Department of Commerce, Census Bureau, *2012 Commodity Flow Survey, Hazardous Materials* (Washington, DC: February 2015), table 1b, available at www.bts.gov/publications/commodity_flow_survey/ as of March 2016.

International Trade

The value of total U.S.-international merchandise trade increased from more than $2.4 trillion in 2000 to approximately $3.4 trillion in 2015—a 40.1 percent inflation-adjusted increase [USDOC Census FTD 2016]. Five of the top 10 U.S. trading partners were Asian countries in 2015. Trade with China grew the fastest, from 5.8 percent of the total value of U.S. merchandise trade in 2000 to 16.0 percent in 2015. In 2000 China ranked fourth among U.S. trading partners. Today it is the leading U.S. trade partner, followed by Canada, Mexico, Japan, and Germany, respectively rounding out the top five [USDOC Census ITA].

In 2015 vessels carried $1.6 trillion in imports to and exports from the United States [USDOC Census FTD 2016]. U.S. retailers are increasingly dependent on the U.S. transportation system, especially those that build up their inventories in October in anticipation of holiday sales in November and December. In particular, businesses use liner[5] services to move intermodal shipping

[5] 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.

TABLE 3-4 Hazardous Materials Shipments by Hazard Class: 2007 and 2012

		Value ($ billions)		Tons (millions)		Ton-miles[1]		Average distance per shipment (miles)	
Hazard class	Description	2007	2012	2007	2012	2007	2012	2007	2012
Class 1	Explosives	11.8	18.4	3.0	4.0	0.9	1.0	738	840
Class 2	Gases	131.8	125.1	250.5	164.8	55.3	33.2	51	57
Class 3	Flammable liquids	1,170.5	2,016.7	1,752.8	2,203.5	181.6	204.6	91	93
Class 4	Flammable solids	4.1	5.4	20.4	11.3	5.5	5.8	309	565
Class 5	Oxidizers and organic peroxides	6.7	7.6	15.0	12.0	7.0	5.5	361	437
Class 6	Toxic (poison)	21.2	15.2	11.3	7.6	5.7	3.6	467	513
Class 7	Radioactive materials	20.6	12.3	0.5	S	Z	0.4	S	34
Class 8	Corrosive materials	51.5	75.9	114.4	125.3	44.4	37.8	208	264
Class 9	Miscellaneous dangerous goods	30.1	58.0	63.2	51.0	23.0	16.1	484	530
Total		**1,448.2**	**2,334.4**	**2,231.1**	**2,580.2**	**323.5**	**307.5**	**96**	**114**

KEY: S = data are not published because estimate did not meet publication standards. By far, the most common reason for suppressing a cell is a high coefficient of variation (greater than 50 percent).; Z = rounds to zero.

[1] Ton-miles estimates are based on estimated distances traveled along a modeled transportation network.

NOTE: Value-of-shipments estimates have not been adjusted for price changes. Numbers and percents may not add to totals due to rounding.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and U.S. Department of Commerce, Census Bureau, 2012 Commodity Flow Survey, Hazardous Materials (Washington, DC: February 2015), table 2b, available at www.bts.gov/publications/commodity_flow_survey/ as of March 2016.

containers through the global transportation system. Container ports provide a link between the global and domestic freight network, utilizing intermodal barge, truck, and rail connections to transport containers to their final destinations [CHAMBERS 2012].

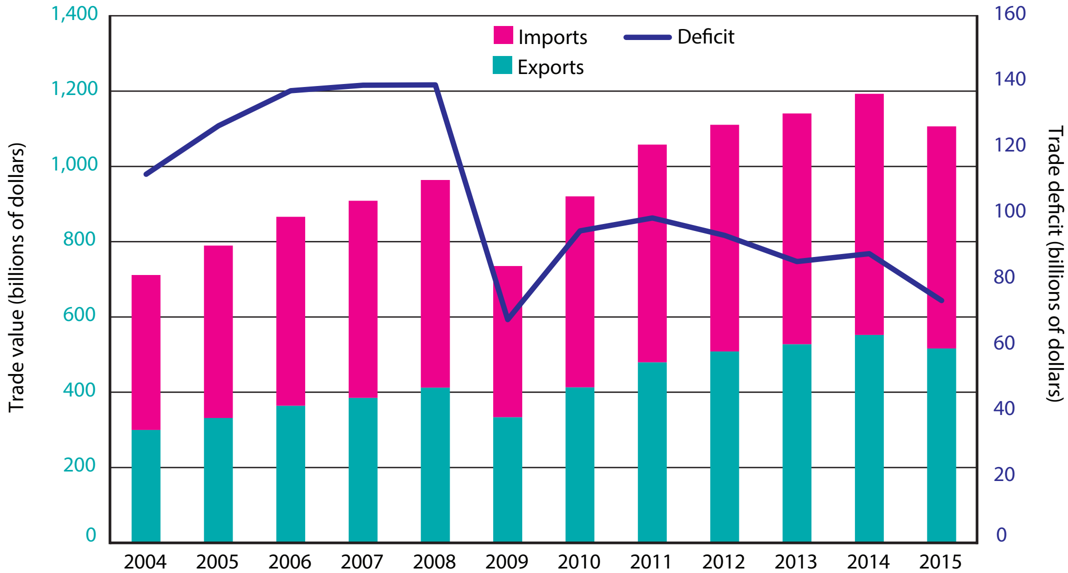
U.S. Freight Trade with Canada and Mexico

The U.S. North American Free Trade Agreement (NAFTA) partners—Canada and Mexico—accounted for 29.6 percent ($1.0 trillion in inflation-adjusted dollars) of the value of U.S.-international merchandise trade in 2015. Over the 2000 to 2015 period, combined trade (adjusted for inflation) with Canada and Mexico increased 26.7 percent[6] [USDOC Census FTD 2016]. However, from 2014 to 2015, the value of cross-border freight declined by 7.2 percent, largely due to a drop in crude oil and petroleum product prices. The value of petroleum-related commodity shipments declined by almost 40 percent year-over-year, while the value of other freight dropped 0.9 percent [USDOT BTS 2016b].

In 2015 U.S. imports from Canada and Mexico exceeded exports in terms of total merchandise trade value. Imports totaled nearly $5.9 billion

[6] The percent increase was calculated by adjusting the 2000 trade data using the CPI Inflation Calculator.

FIGURE 3-7 Value of U.S. Exports/Imports: 2004–2015



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, North American Transborder Freight Data.

TABLE 3-5 Value and Tonnage of U.S. Merchandise Trade with Canada and Mexico: 2000, 2010, 2014 and 2015

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

	2000		2010		2014		2015	
Mode	**Value**	**Weight**	**Value**	**Weight**	**Value**	**Weight**	**Value**	**Weight**
Truck[1]	429	NA	560	176	715	206	712	199
Rail[1]	94	NA	131	114	178	150	165	142
Air	45	<1	45	<1	44	<1	43	<1
Water	33	194	81	210	104	212	73	219
Pipeline[1]	24	NA	65	107	94	160	57	180
Other[1]	29	NA	37	8	58	40	56	38
TOTAL[1]	**653**	**NA**	**920**	**614**	**1,193**	**767**	**1,107**	**778**

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. The weight of U.S. exports by land modes of transportation is not available because this data is not required to be reported on the paper Shipper's Export Declarations (SEDs) documents that are required by the U.S. Census Bureau. BTS uses value to weight ratio of U.S. imports at two-digit commodity code to calculate the export weights where available.

SOURCES: *Truck, Rail, Pipeline, and Other*: U.S. Department of Transportation, Bureau of Transportation Statistics, North American Transborder Freight Data, available at www.bts.gov/transborder as of March 2016; *Air and Water*: U.S. Department of Commerce, Census Bureau, Foreign Trade Division, *FT920 - U.S. Merchandise Trade: Selected Highlights* (Washington, DC: annual issues).

in 2015, an increase of 28.8 percent since 2005. While the value of imports outpaced exports over that period, the value of U.S. exports to Canada and Mexico also continued to grow, increasing by 55.8 percent since 2005 (figure 3-7) [USDOT BTS 2016b].

Trucks carried 25.6 percent of the tonnage and 64.3 percent of the value of U.S. merchandise trade with Canada and Mexico, while rail carried 18.3 percent of the tonnage and 14.9 percent of the value in 2015 (table 3-5). Vehicles and parts (other than railway vehicles and parts) was the top commodity category transported between the United States and Canada. The truck and rail modes transported 60.0 and 37.5 percent, respectively. Mineral fuels and oil were the next highest commodity category, transported primarily by the pipeline and water modes [USDOT BTS 2016b].

Michigan, which accounts for 13.0 percent of the U.S.-Canada border mileage, was the leading state for trade with Canada, amounting to $69.1 billion or 12.0 percent of total trade with Canada in 2015. Michigan has border crossing/entry ports between Detroit, Port Huron, and Sault Ste. Marie and southern Ontario; both Michigan and Ontario have a high concentration of automakers [USDOT BTS 2016b].

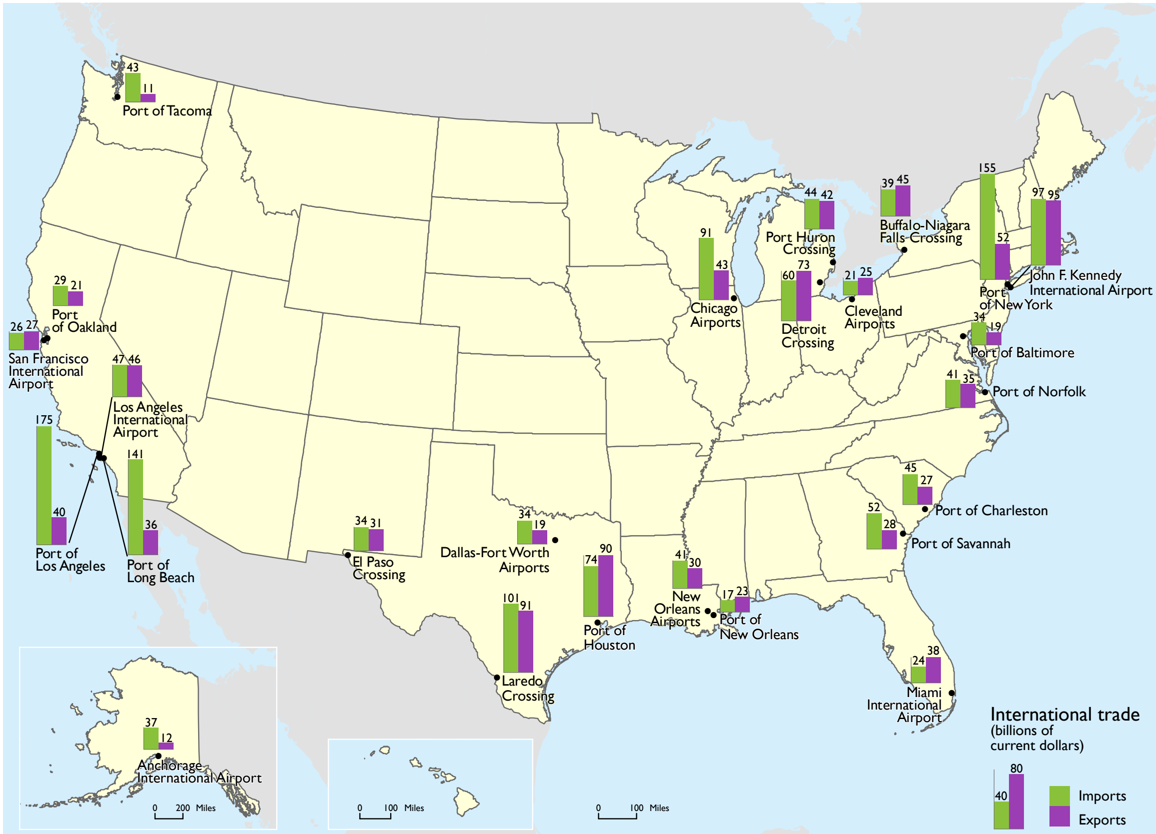
Texas, which accounts for 64.2 percent of the U.S.-Mexico border mileage and is home to 11 border crossing/entry ports, led all other states in surface freight with Mexico [USDOT BTS 2016a]. (In total, there are 87 ports-of-entry along the U.S.-Canada border and 25 on the U.S.-Mexico border.) In 2015 Texas trade with Mexico amounted to nearly $178.0 billion, or 33.5 percent of total U.S. trade with Mexico. Electrical machinery, equipment, and parts was the top commodity category transported between the United States and Mexico, followed by vehicles and vehicle parts (other than railway vehicles and parts). Truck is the primary mode for transporting electrical machinery while rail moves the bulk of vehicles [USDOT BTS 2016b].

Freight Transportation Gateways

A large volume of U.S.-international merchandise trade passes through a relatively small number of freight gateways—the entry and exit points for trade between the United States and other countries (figure 3-8). According to the Census Bureau, there were 480 ports of entry, including airports, border crossings, and seaports that could handle international cargo [USDOC Census FTD 2016], while the latest available data show that in 2014 the top 25 gateways in terms of value handled the greatest share of U.S. international merchandise trade—$2.5 trillion in current dollars or 63.0 percent of the more than $3.9 trillion (in current dollars) in total U.S.-international merchandise trade in that year. Eighteen of the top 25 gateways handled more imports than exports in 2014, compared to 17 in 2013.

Water is the leading transportation mode for U.S.-international trade both in terms of weight and value. Ships moved more than 71.1 percent of trade weight and 41.8 percent of trade value in 2015 (figure 3-9). The Port of South Louisiana was the top water gateway by weight in 2014 (the latest year for which data are available), handling 267.4 million short tons, followed by the Port of Houston, moving

FIGURE 3-8 Top 25 U.S. Foreign Trade Freight Gateways by Value of Shipments: 2014



NOTES: *All data*: Trade levels reflect the mode of transportation as a shipment enters or exits at a border port. Flows through individual ports are based on reported data collected from U.S. trade documents. Trade does not include low-value shipments. (In general, these are imports valued at less than $1,250 and exports that are valued at less than $2,500). Numbers may not add to totals 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 Bureau of Census 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.

SOURCE: *Air*: U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, USA Trade Online, April 2016. *Land*: U.S. Department of Transportation, Bureau of Transportation Statistics, North American Transborder Freight Data, available at http://www.bts.gov/programs/international/transborder/ as of April 2016. *Water*: U.S. Army Corps of Engineers, Navigation Data Center, special tabulation, October 2015.

FIGURE 3-9a U.S. International Merchandise Trade Value by Transportation Mode: 2015

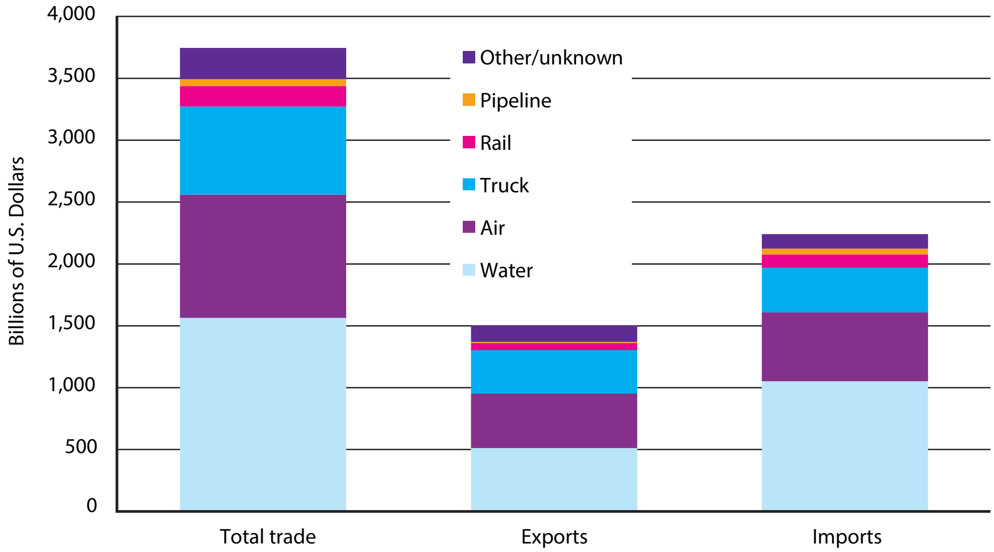
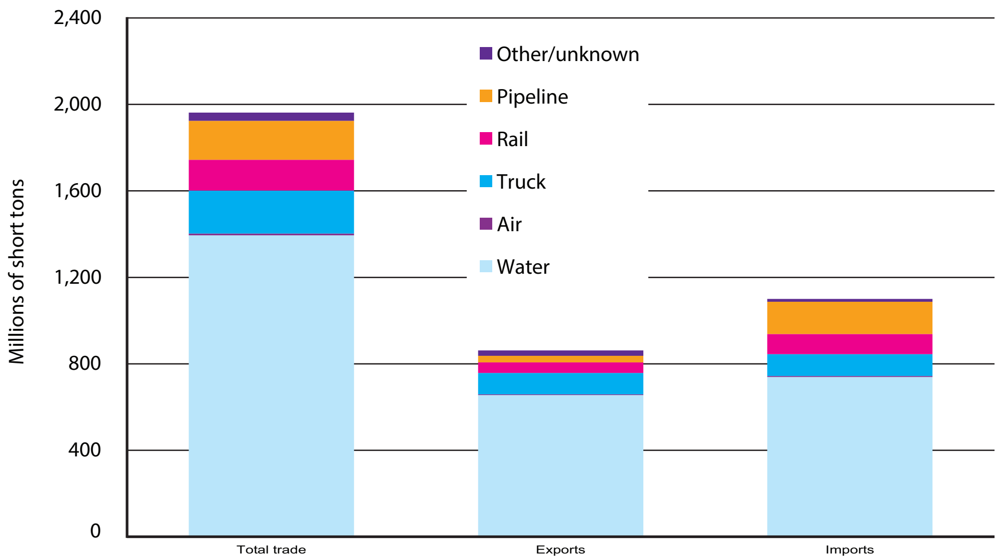


FIGURE 3-9b U.S. International Merchandise Trade Weight by Transportation Mode: 2015



NOTES: 1 short ton = 2,000 pounds. The U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics estimated 2015 weight data for truck, rail, pipeline, and other and unknown modes using value-to-weight ratios derived from imported commodities. Totals for 2015 differ slightly from the Freight Analysis Framework (FAF) due to variations in coverage and FAF conversion of values to constant dollars. Numbers may not add to totals due to rounding.

SOURCES: *Total, water and air data*: U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, *FT920 - U.S. Merchandise Trade: Selected Highlights* (Washington, DC: February 2016). *Truck, rail, pipeline, and other and unknown data:* U.S. Department of Transportation, Bureau of Transporation Statistics, North American Transborder Freight Data, available at www.bts.gov/transborder as of March 2016.

234.3 million short tons (USACE WCSC 2016b]. A considerable portion of this tonnage included crude oil and petrochemicals. By value, the Port of Los Angeles was the leading water gateway, handling more than $215.0 billion in cargo, mostly imports, while on the Atlantic coast the Port of New York and New Jersey ranked second with $206.5 billion in trade [USDOT BTS 2016d].

Air handles less than 1.0 percent of trade weight but 26.6 percent of trade value, due to its focus on high-value, time-sensitive, and perishable commodities. In 2014 John F. Kennedy International airport was the top U.S.-international air gateway by value, handling $191.8 billion in exports and imports, followed by Chicago area airports ($134.0 billion) and Los Angeles International ($92.4 billion) [USDOT BTS 2016d]. 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 11.4 million, 7.9 million, and 5.8 million short tons of cargo, respectively, in 2014 [USDOT FAA].

Trucks, which haul a large share of imports and exports between U.S. international gateways and inland locations, carried 19.0 percent of the value of total U.S.-international trade (figure 3-9a) and 10.1 percent of the tonnage in 2015 (figure 3-9b). Laredo, TX, is the top land-border crossing, handling $192.1 billion in trade between the U.S. and Mexico while Detroit, MI, ranked second with $133.0 billion [USDOT BTS 2016d].

Trade growth with Canada and Mexico and the tapping of natural resources, such as oil from the Bakken formation, generates increased north-south traffic flows on a domestic transportation infrastructure that was initially developed along east-west corridors during the westward development of the Nation.

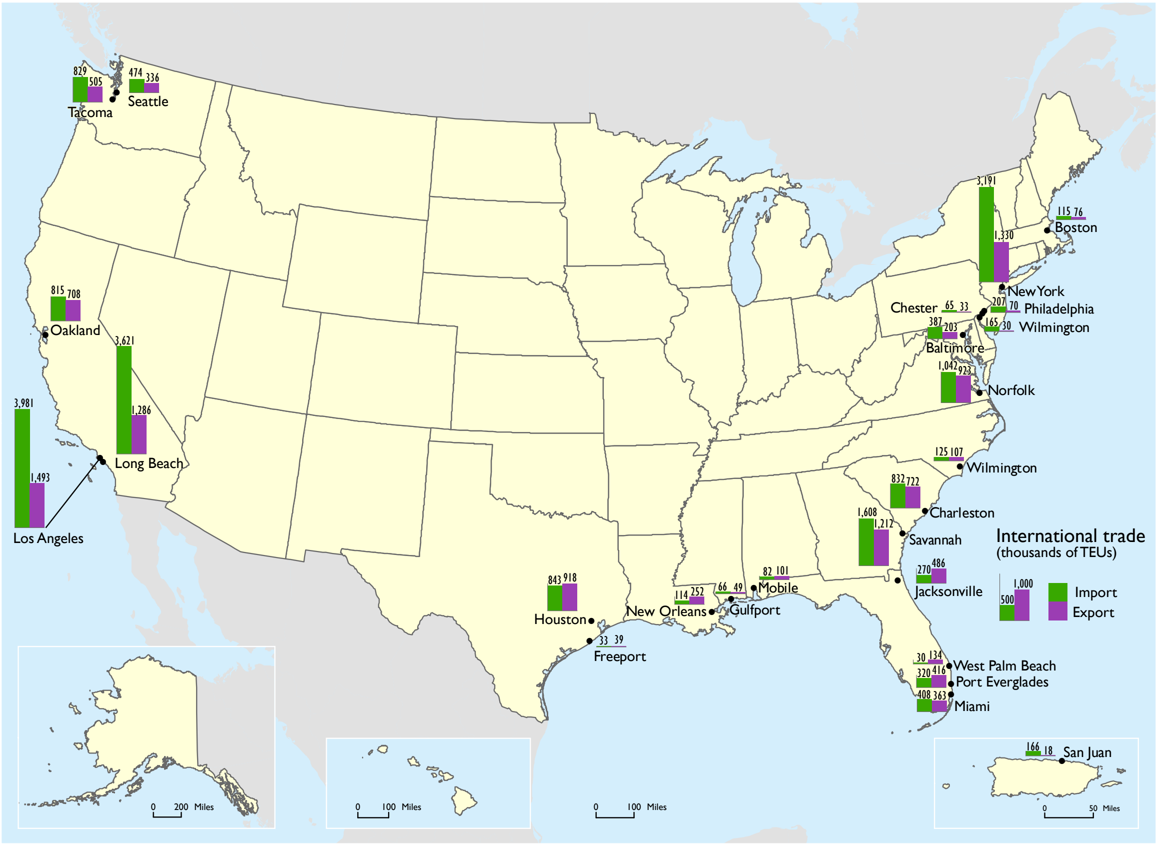
Water Trade

As a result of the growth in international trade, the number of container vessels calling at U.S. ports has increased. Between 2013 and 2015, vessel calls at U.S. seaports increased by 11.0 percent, from 74,000 in 2013 to 82,000 in 2015. The average displacement of container vessels continued to increase, from 44,601 deadweight tons (dwt) in 2005 to 57,458 dwt in 2015, a 28 percent increase. In 2015 tankers accounted for 40.4 percent of the vessel calls, followed by containerships with 22.8 percent of the more than 82,000 vessel calls [USDOT MARAD 2016a].

In 2015 U.S. seaports handled approximately 32.0 million TEU of containerized cargo, which is 12.0 percent more than reported in 2010 [USDOT MARAD 2016b]. 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 3-10, the geographic distribution of container ports is more concentrated along the Pacific and Atlantic coasts, while large volumes of bulk commodities are transported through Gulf coast ports (figure 3-1).

The major increase in trade with China has resulted in a large share of trade moving through Pacific coast ports (figure 3-11). The trend toward larger containerships, which is expected to continue, has led to a concentration

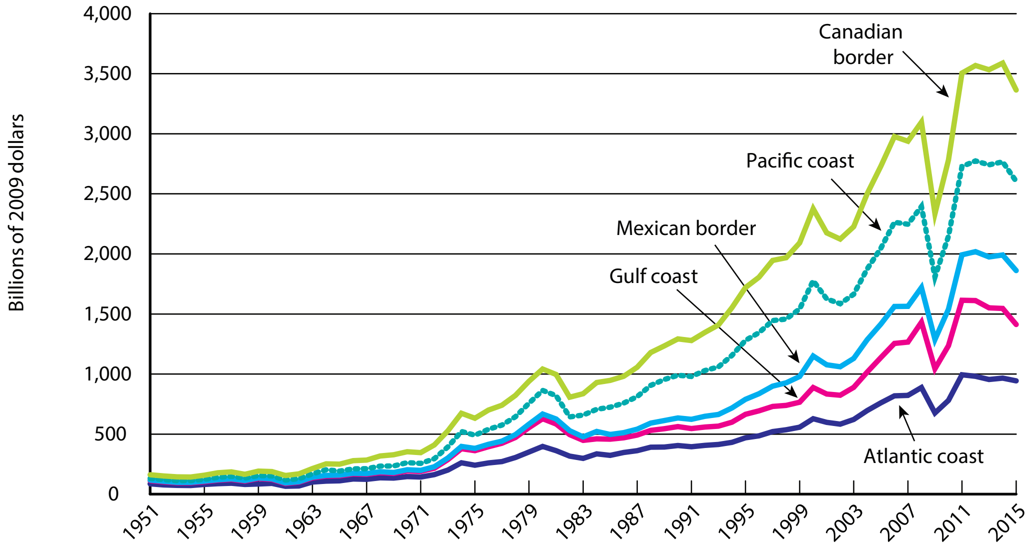
FIGURE 3-10 Top 25 Water Ports by Containerized Cargo: 2015



NOTE: The statistics include both government and non-government shipments by vessel into and out of U.S. foreign trade zones, the 50 states, the District of Columbia, and Puerto Rico.

SOURCE: U.S. Department of Transportation, Maritime Administration, *U.S. Waterborne Container Trade by U.S. Custom Ports*, available at www.marad.dot.gov/resources/data-statistics/ as of April 2016.

FIGURE 3-11 Value of U.S. International Merchandise Trade by Coasts and Borders: 1951–2015



NOTES: The value of coal shipments through Mobile, AL; Charleston, SC; and Norfolk, VA are considered proprietary information and are consolidated. The total value of coal exports for the above three cities are included under the Atlantic Coast Customs District.

SOURCES: *1951-1970*: U.S. Department of Commerce, Census Bureau, *Historical Statistics of the United States, Colonial Times to 1970, Bicentennial Edition* (Washington, DC: 1975); *1971-1999:* U.S. Department of Commerce, Census Bureau, *Statistical Abstract of the United States* (Washington, DC: annual issues); *2000-2015*: U.S. Department of Commerce, Census Bureau, Foreign Trade Division, *FT920 - U.S. Merchandise Trade: Selected Highlights* (Washington, DC: annual issues). *Implicit GDP Deflator*: U.S. Department of Commerce, Bureau of Economic Analysis, *Current-Dollar and Real Gross Domestic Product*, available at www.bea.gov as of April 2016.

Box 3-C: Panama Canal Expansion

In 2015 nearly 14,000 ships transited the Panama Canal, between the Atlantic and Pacific Oceans, carrying 340 million long tons[1] of cargo, 70.2 percent of which was either going to or coming from the United States [PCA 2015]. Figure 3-12 shows major U.S. ports that handle trade moving through the Panama Canal.

Figure 3-12

To meet increasing demand and help to maintain the Canal's competitiveness in international maritime trade, the Panama Canal Authority undertook the expansion of the Canal that included the construction of a third set of locks that are bigger than the original ones and the widening and deepening of the Gatun Lake and access channels. These changes increased the maximum size of ships that can transit the Canal from 5,000 TEU up to 13,000 TEU, effectively doubling the Canal's throughput capacity. The newly expanded Canal, which opened for business on June 26, 2016, has already affected U.S. port and landside infrastructure development and will likely affect shipping routes and U.S. international trade as well as a host of other maritime system considerations. According to the U.S. Army Corps of Engineers, post-Panamax vessels[2] will represent 62 percent of total container ship capacity by 2030 [USACE 2012].

The expansion also may provide a boost to U.S. agricultural, energy, and other commodity exports from Atlantic coast and Gulf coast ports to Asian markets. Grains, container cargo, petroleum/petroleum products, ores/metals, and coal/coke were the top U.S. commodities shipped via the Panama Canal in 2015 [PCA 2015]. According to a Maritime Administration study, the expanded Canal will reduce the cost to export U.S. grains and energy commodities to Asian markets via new and larger bulk vessels, liquefied natural gas carriers, and liquid petroleum and bulk chemical tankers. This, in turn, could generate more barge and rail traffic from the Midwest where these commodities are produced to Atlantic and Gulf coast ports [USDOT MARAD 2013].

of liner service at ports with ample overhead clearance and water draft, intermodal connections such as double stack rail, and room to grow. The newly expanded Panama Canal allows larger vessels, carrying up to 13,000 TEU, to transit between the Atlantic and Pacific Oceans. Box 3-C discusses the effects the Panama Canal expansion may have on U.S. ports and trade patterns.

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CHAPTER 4

Transportation System Performance

Highlights

- The average annual delay per commuter rose from 37 hours in 2000 to 42 hours in 2014, a 13.5 percent increase, and the combined hours of delay experienced by all commuters across the Nation in 2014 reached 6.9 billion hours—about a third higher than the 2000 total.
- Urban highway congestion cost the economy $160 billion in 2014, of which 17.5 percent, or $28 billion, was due to the effects of congestion on truck movements. Highway traffic congestion levels have increased over the past 30 years in all urban areas, from the largest to the smallest.
- On average in 2014, travelers in major metropolitan areas had to allow at least 150 percent more travel time during peak periods to arrive on time 95 percent of the time.
- Chicago, Austin, Atlanta, and Houston continued to be the most congested truck bottlenecks on freight-heavy highways.
- Amtrak's on-time performance increased from 70 percent in 2005 to a record high 83 percent in 2012, but declined to 71 percent in 2015. On-time improvement was more prominent on long distance routes.
- About 18 percent of domestic scheduled airline flights (or 1.1 million flights) arrived at the gate at least 15 minutes late in 2015. Almost 11 percent (634 thousand) arrived at the gate more than 2 hours late.
- The Transportation Security Administration screened more than 708 million airline passengers in 2015 and confiscated 2,653 firearms, 83 percent of which were loaded. Nationwide less than 2 percent of passengers waited in line for more than 20 minutes.
- Barge tows on the inland waterways experienced an average delay of 2.4 hours navigating a lock in 2015, the largest delay on record and more than double the delay in 2000.
- At inland waterway locks in 2015, scheduled maintenance and unexpected stoppages due to weather and operational issues resulted in almost 132,000 hours of lock shutdowns to traffic, almost 75 percent higher than the level in 2000.

As used here, system performance refers to how efficiently and reliably people and freight carriers can travel to destinations on the transportation network. This chapter focuses on measures that can be used to determine whether certain aspects of system performance are improving or declining over time.[1] The performance measures discussed are accessibility, congestion, reliability, resiliency, and security. Other aspects of system performance, such as safety, energy usage, and environmental impacts, are discussed separately in other chapters. The chapter concludes with a discussion of the economic benefits of improved system performance.

System performance measures often are viewed from the perspectives of both the user and the operator. Users are interested in characteristics, such as travel cost, travel time, and the reliability of successfully completing a trip within a certain time, each of which directly affects their ability to accomplish a trip purpose. Owners and operators are concerned with the level of service provided to users and the ability to respond to service disruptions so as to promote reliable and safe mobility and accessibility.

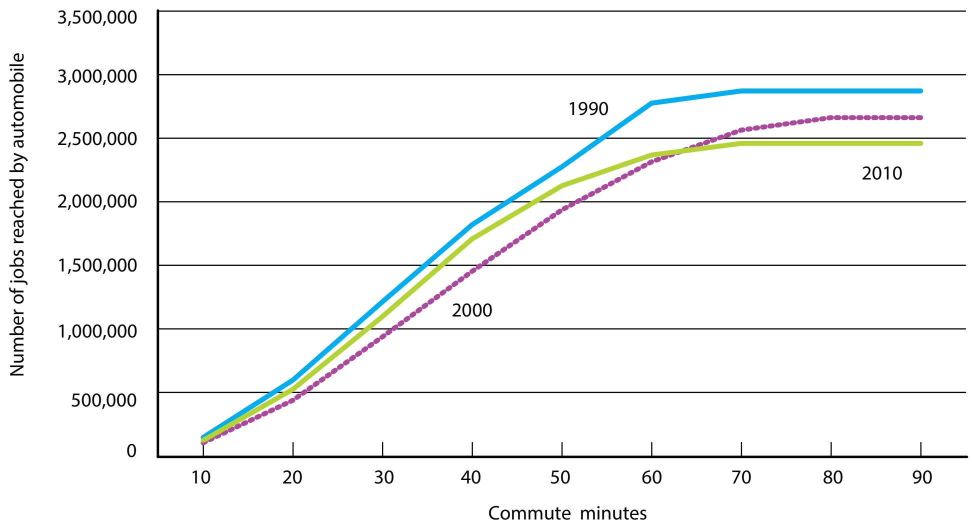
System Accessibility

System accessibility is defined as the ability of travelers and freight shippers to reach key destinations, such as hospitals, job sites, schools, factories, airports, ports, and community centers. In evaluating system performance, it is important to know how accessibility has changed over time. The measure most often used is the number of destinations reachable within a given travel time, in particular the number of jobs that are accessible. The Center for Transportation Studies, at the University of Minnesota, has developed a method for comparing morning peak-period accessibility to jobs by automobile across 51 U.S. metropolitan areas for 1990, 2000, and 2010 [UMN CTS 2013]. Figure 4-1 shows how accessibility to jobs has changed from 1990 to 2010. In 1990, for example, 2 million jobs across 51 metropolitan areas were accessible in an average travel time of 44 minutes by automobile. A decade later, in 2000, the average travel time increased to 52 minutes. But by 2010 that average travel time dropped to 47 minutes as travel speeds increased (to about where they were in 1990) [UMN CTS 2013]. The crossing of the 2000 and 2010 lines in figure 4-1 most likely reflects the impact of the December 2007 through June 2009 recession and the subsequent slow recovery, that is, not as many jobs were available for access.

A second University of Minnesota study [UMN CTS 2014] extends the analysis to consider transit accessibility to jobs. This more limited effort considers only morning peak-period transit schedules in 46 of the 50 largest (by population) U.S. metropolitan areas in January 2014. The 10 metro areas with the greatest accessibility to jobs by transit were (in rank order) New York, San Francisco, Los Angeles, Washington, Chicago, Boston,

[1] The Moving Ahead for Progress in the 21st Century Act (MAP-21) requires the U.S. Department of Transportation to establish performance measures and standards for several program/policy areas. MAP-21 also requires statewide and metropolitan transportation planning agencies to establish and use performance-based approaches for transportation decision-making. The Fixing America's Surface Transportation (FAST) Act, enacted in December 2015, continues these initiatives.

FIGURE 4-1 Number of Jobs Accessible by Commute Time: 1990, 2000, and 2010



SOURCE: D. Levinson. 2013. *Access Across America*, Center for Transportation Studies, University of Minnesota, Access Across America. CTS 13-20. Figure 3.1. Available at http://www.cts.umn.edu/Research/featured/access/ as of June 2015.

Philadelphia, Seattle, Denver, and San Jose. New York dominates this list by a wide margin. Due to its development density and extensive transit resources, it has 210,000 jobs accessible by transit within 30 minutes of total travel time and 1.2 million jobs accessible within 60 minutes. In contrast, for the ninth ranked city, Denver, where the jobs and population are more dispersed and transit service includes a rapidly expanding light rail system and an extensive bus network, the comparable accessibility figures are 20,000 jobs available within 30 minutes and 176,000 jobs available within 60 minutes. A more robust analysis would include other time periods, including tracking how transit accessibility changes over time, and other travel modes.

Congestion

The ability of travelers to reach a destination in a cost-effective, safe, and reliable manner is an important aspect of the Nation's transportation system. The characteristics of making such trips, including travel time, costs, and access to facilities/services, are used to indicate the level of mobility afforded to users.

Road congestion in urban areas is one of the major causes for travel time delay. The Texas Transportation Institute has monitored congestion levels on the U.S. road network for decades and has reported in an annual *Urban Mobility Report* [2] on the number of hours of congestion experienced by network users and the associated economic costs [TAMU TTI 2015]. Recent editions of the report provide data for 498 urban areas in the United States.

Table 4-1 shows the estimates for annual hours of delay, the number of gallons of wasted fuel

[2] In 2015 the report title was changed to *Urban Mobility Scorecard.*

TABLE 4-1 Annual Congestion Delay and Costs: 2000, & 2005–2014
498 urban areas

Year	Travel Time Index	Delay per commuter (hours)	Total delay (billion hours)	Fuel wasted (billion gallons)	Total cost (billions of 2014 U.S. dollars)
2000	1.19	37.0	5.20	2.1	114
2005	1.21	41.0	6.3	2.7	143
2006	1.21	42.0	6.4	2.80	149
2007	1.21	42.0	6.6	2.8	154
2008	1.21	42.0	6.60	2.4	152
2009	1.2	40.0	6.30	2.4	147
2010	1.2	40.0	6.40	2.5	149
2011	1.21	41.0	6.60	2.5	152
2012	1.21	41.0	6.70	3	154
2013	1.21	42.0	6.80	3.1	156
2014	1.22	42.0	6.90	3.1	160

NOTE: Includes 15 very large urban areas (population over 3 million), 32 large urban areas (population over 1 million but less than 3 million), 33 medium urban areas (population over 500,000 but less than 1 million), 21 small urban areas (population less than 500,000), and 397 other urban areas.

SOURCE: Texas A&M University, Texas Transportation Institute, *2015 Urban Mobility Scorecard*, available at http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/mobility-scorecard-2015-wappx.pdf as of August 2015.

due to delay, the dollar value of delay and wasted fuel, and a measure called the Travel Time Index (TTI).[3] For example, a TTI value of 1.21 indicates that a trip taking 30 minutes without congestion will take an average of 21 percent longer, or just over 36 minutes (1.21 × 30), during the peak travel period.

Road congestion, in terms of amount and cost, has steadily increased since 2000. The exception was the economic recession from the end of 2007 to the middle of 2009, which had a dampening effect. Congestion in the Nation's urban areas in 2014 had an economic cost of $160 billion compared to $114 billion in 2000 (2014 dollars). The average yearly delay per commuter rose from 37 hours in 2000 to 42 hours in 2014, a 13.5 percent increase, and the total national hours of delay in 2014 reached 6.9 billion hours—about a third higher than the 2000 total. The effects of congestion on truck movements accounted for $28 billion (17.5 percent) of the total congestion cost [TAMU TTI 2015]. In addition, the average commuter:

- wasted 19 gallons of fuel in 2014 (a week's worth of fuel for the average U.S. driver), up from 8 gallons in 1982;
- experienced an average yearly delay of 42 hours in 2014; and
- planned for approximately 2.41 times (freeway only) as much travel time as would be needed in non-congested

[3] The ratio of the travel time during the peak period to the time required to make the same trip at free-flow speeds.

conditions to arrive at their destination on time 9 times out of 10 [TAMU TTI 2015].

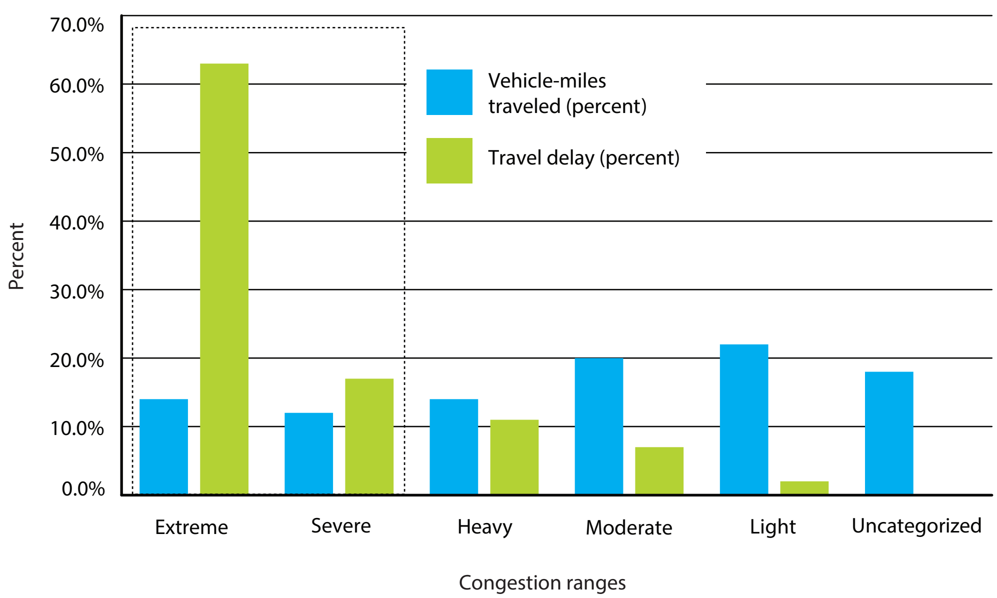
The worst congestion levels (defined as "extreme, severe, or heavy") affected only one in nine trips in 1982, whereas this proportion increased to more than one in three trips in 2014. In addition, the most congested sections of road (labeled extreme and severe) handled only 26.0 percent of all urban road travel, but accounted for 80 percent of peak period delays as shown in figure 4-2. It is important to note that congestion levels have increased over the past 30 years in all urban areas, from the largest to the smallest. Congestion is worse in the afternoon, but it can occur at any time throughout the day. Between 2011 and 2014, notable progress was made in reducing congestion during the afternoon peak hours of 4 and 5 pm (figure 4-3).

The Federal Highway Administration (FHWA) uses vehicle probe data[4] to compile the *Urban Congestion Trends* report, which tracks 3 congestion measures in the 52 largest urban areas in the United States. While not as comprehensive as the *Urban Mobility Report*, which covers 498 urban areas and all of the congestion indicators reported above, the smaller scope of *Urban Congestion Trends* allows for more frequent updates. The latest edition of this report shows that congestion remained unchanged or marginally improved in 2015 [USDOT FHWA 2016]. The average duration of daily congestion[5] decreased from 5

[4] Vehicle probe data are based on real-time vehicle positions, typically obtained from the vehicle's GPS receiver or the operator's mobile phone.

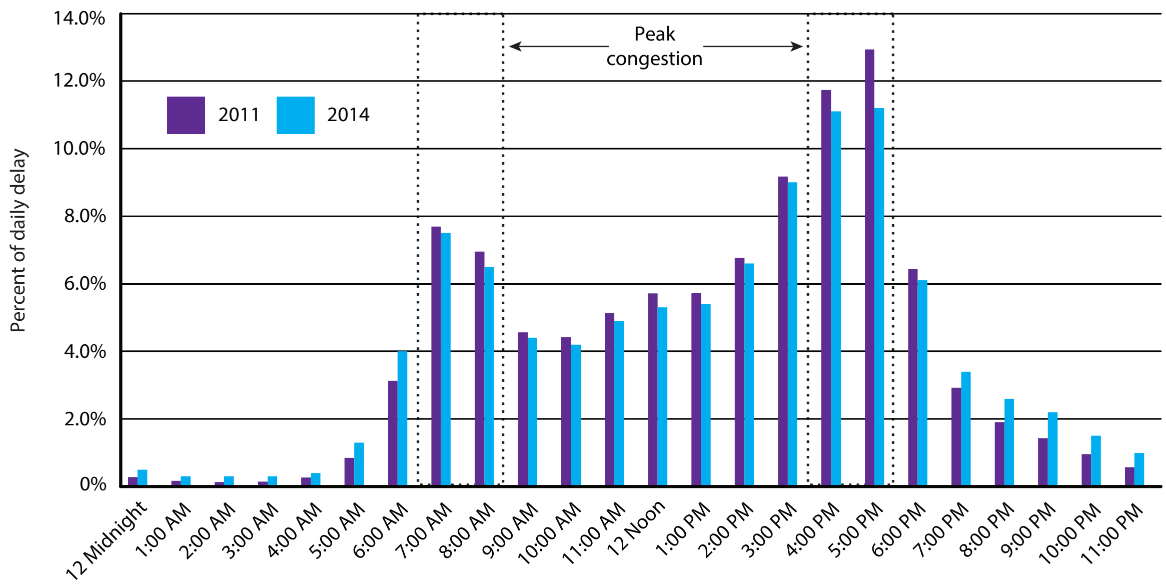
[5] Hours of congestion is defined as the amount of time when highways operate at less than 90 percent of free-flow speeds.

FIGURE 4-2 Vehicle Travel and Travel Delays in Congestion Ranges: 2014



SOURCE: Texas A&M University, Texas Transportation Institute, 2015 *Urban Mobility Scorecard*, available at http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/mobilicorecard-2015-wappx.pdf as of May 2016.

FIGURE 4-3 Percent of Congestion by Time of Day: 2011 and 2014



SOURCE: Texas A&M University, Texas Transportation Institute, *2015 Urban Mobility Report* (August 2015: full report with exhibits), Exhibit 5. Available at http://tti.tamu.edu/ as of May 2016.

hours and 3 minutes in 2014 to 4 hours and 40 minutes in 2015, while the Travel Time Index (TTI) increased slightly, from 1.33 to 1.34.

Congestion and delays are not limited to roadways. The average length of commercial airline flight delays has been over 50 minutes in every year since 2004 and reached 59 minutes in 2015, even though the number of arriving domestic flights operated by the large U.S. airlines decreased by 18.4 percent over that period (table 4-2). More than 634,000 flights arrived at the gate more than 2 hours behind schedule in 2015. Mainline carrier's average aircraft size (seats per aircraft mile) increased in 2015 by 3.5 seats, from 145.6 to 149.1, which is the highest level since 1994. This trend is forecasted to continue through 2035, especially with the retirement of older, smaller narrow-body aircraft (i.e., MD-80's, 737-300/400/500, and 757's). Airlines are retiring these less efficient aircraft and shifting to wide-body and larger narrow-body aircraft [USDOT FAA 2016], which often require more separation in the air and on the ground. Larger aircraft (a.k.a. "heavy") typically require a safety margin or separation of 4 to 8 nautical miles from the following aircraft. This is because of wake turbulence, which is a violent or unsteady movement of air that forms behind an aircraft, especially during takeoff and landing. Operational factors and weather conditions may require additional separation, which may contribute to congestion and delays.

Flight delays are caused by a variety of reasons, ranging from extreme weather to disruptions in airline carrier operations (figure 4-4). The combined effects of non-extreme

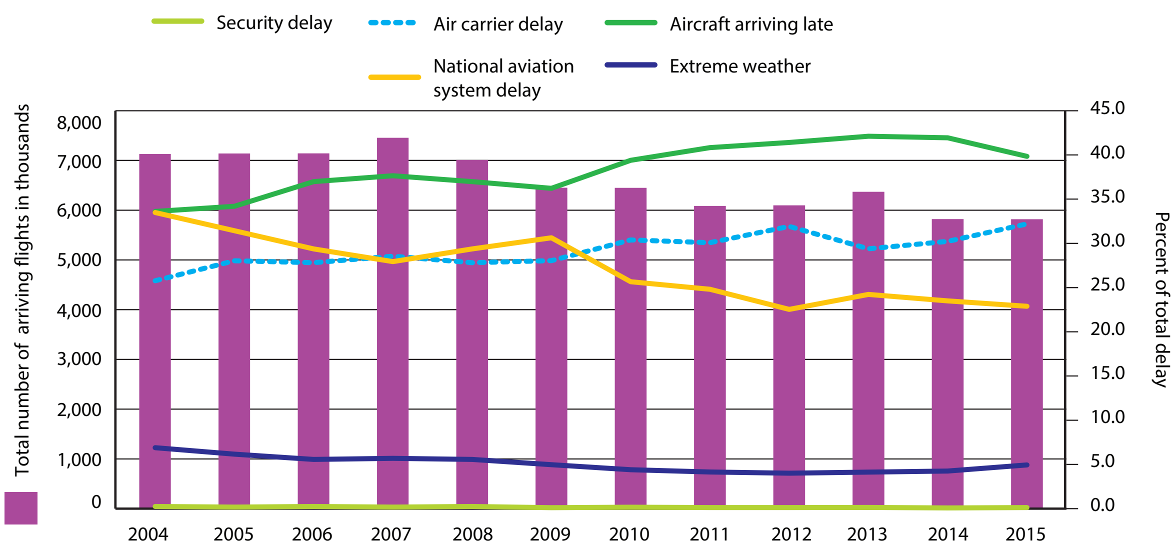
TABLE 4-2 Percentage of All Delayed Flights by Length of Time Delayed: 2004–2015

	Total number of arriving flights	Percentage of arriving flights, delayed	Average length of delay (minutes)	15-29 minutes	30-59 minutes	60-89 minutes	90-119 minutes	More than 120 minutes
2004	7,129,270	19.9	51	42.3	31.3	12.3	6.1	7.8
2005	7,140,596	20.5	52	41.8	31.1	12.4	6.2	8.1
2006	7,141,922	22.6	54	40.3	31.2	12.8	6.5	8.9
2007	7,455,458	24.1	56	39.1	31.0	13.1	6.9	9.7
2008	7,009,726	21.7	57	39.1	30.5	13.0	6.9	10.2
2009	6,450,285	18.8	54	40.7	30.7	12.7	6.6	9.0
2010	6,450,117	18.2	54	41.2	30.7	12.5	6.5	8.9
2011	6,085,281	18.2	56	40.4	30.1	12.8	6.8	9.7
2012	6,096,762	16.6	56	40.6	30.1	12.6	6.7	9.8
2013	6,369,482	19.9	56	39.7	30.4	12.7	6.8	10.1
2014	5,819,811	21.3	57	39.2	31.3	12.8	6.6	9.9
2015	5,819,079	18.3	59	38.8	30.6	12.8	6.9	10.9

NOTES: For the monthly number of carriers reporting, please refer to the *Air Travel Consumer Reports* available at http://airconsumer.dot.gov/reports/index.htm. A flight is considered delayed when it arrived *at the gate* 15 or more minutes later than scheduled. Arriving flights consists of scheduled operations less canceled and diverted flights. Average *length of delay* is calculated for delayed flights only. Percents may not add to 100 due to rounding.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transtats Database, *Airline On-Time Performance*, available at http://www.transtats.bts.gov/ as of May 2016.

FIGURE 4-4 Percent of Congestion by Time of Day: 2011 and 2014



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.). **Extreme Weather Delays**-significant meteorological conditions (actual or forecasted) that, in the judgment of the carrier, delays or prevents the operation of a flight. **National Aviation System Delay**-delays and cancellations attributable to the national aviation system refer to a broad set of conditions non-extreme weather conditions, airport operations, heavy traffic volume, air traffic control, etc. **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. **Late Arriving Aircraft Delay**-previous flight with same aircraft arrived late which caused the present flight to depart late.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transtats Database, *Airline On-Time Performance*, available at http://www.transtats.bts.gov/ as of May 2016.

weather conditions, airport operations, heavy traffic volume, and air traffic control contributed to 22.9 percent of delays in 2015, a 10.6 percentage point improvement from 2004. Flight delays can ripple through the U.S. aviation system as late arriving flights, for whatever reason, delay subsequent flights—the cause of 39.8 percent of delays for scheduled flights in 2015.

Congestion is especially a problem for time-sensitive freight shipments. Various performance indicators are used to monitor time-related system performance. The USDOT's FHWA, in cooperation with the American Transportation Research Institute (ATRI), is working to quantify the impact of traffic congestion on truck-based freight at 250 specific locations across the United States. Similar to the TTI, the primary measure is the ratio of uncongested speed to congested speed at key freight locations (often interstate-to-interstate interchanges). For example, a 21.3 mph peak period average speed and a 41.2 mph non-peak period average speed in Chicago yields a ratio of 1.94. Some of the most congested truck bottlenecks on freight-heavy highways in 2013 could be found in Chicago, IL (1.94), Austin, TX (1.93), Atlanta, GA (1.61), and Houston, TX (1.46) [USDOT BTS 2015].

On the inland water network, the U.S. Army Corps of Engineers (Corps) is responsible for 239 lock chambers and monitoring the movements of barges and other commercial vessels. In 2015 barge tows experienced an average delay of 2.4 hours navigating a lock (table 4-3), the largest delay on record and more than double the delay in 2000 [USACE 2016]. Furthermore, the percent of vessels that experienced any delays increased from 35 to 48 percent. The increase in delay is most likely due to the aging of the locks in the inland water system. On older systems, the majority of tows must be split into two parts and locked through their smaller (e.g., 600-foot) lock chambers, which were not designed to handle today's longer (e.g., 1,200-foot) tows. The average age of locks under jurisdiction of the Corps is over 63 years,[6] and it is expected that delays will likely increase without the needed rehabilitation and reconstruction of key locks.

System Reliability

Reliability is defined as the level to which one can make trips with some certainty that the actual trip will occur within an expected range of travel times. More reliability means less uncertainty associated with trips due to events such as crashes, vehicle breakdowns, and similar incidents; work zones; unannounced road work; weather; and special events that can often lead to widely varying travel times from one day to the next for the same trip.

The Planning Time Index (PTI)[7] is used to estimate the extra time that one should plan for a trip to assure on-time arrival with 95 percent confidence. For example, a PTI of 1.5 means that for a traveler to arrive on time 19 out of 20 times, the traveler should allow 50 percent more time. This means 30 extra minutes

[6] A recent study [TRB 2015] shows that, when adjusted for the dates of major rehabilitation projects, the effective average age of locks is about 10 years less, but that still puts the average age at over 50 years.

[7] 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.

TABLE 4-3 Lock Characteristics and Delays on Rivers with 5,000 or More Lockages: 2000, 2010, and 2015

	Total lockages (2015)	Average age of locks (2015)	Percent commercial vessels (2015)	Average delay in minutes			Percent of vessels delayed		
				2000	2010	2015	2000	2010	2015
All Waterways	**595,089**	**60**	**59**	**64**	**80**	**143**	**35**	**36**	**48**
Ohio River	104,487	53	88	52	97	140	31	34	45
Mississippi River	99,339	74	46	90	81	109	20	19	42
Gulf Intracoastal Waterway	38,811	53	98	58	65	164	78	84	91
Illinois Waterway	24,941	81	88	127	53	143	41	29	65
Monongahela River	22,784	71	76	12	11	25	16	18	27
Tennessee River	22,370	69	47	209	122	432	24	24	43
Tennessee Tombigbee Waterway	19,403	33	64	9	3	19	38	10	16
Arkansas River	18,351	47	84	11	13	12	35	23	25
Chicago River	11,006	78	33	5	5	17	1	1	79
Caloosahatchee River	9,509	56	11	5	2	2	26	16	8
Allegheny River	8,898	85	12	8	4	13	7	3	9
Kanawha River	8,260	64	81	52	20	72	34	23	37
Columbia River	7,088	48	90	32	30	24	85	90	77
St. Mary's River	5,417	80	88	27	16	29	26	19	41
Cumberland River	5,236	55	53	16	18	65	13	12	23
Calcasieu River	5,104	47	1	10	14	18	37	45	33

NOTES: A lockage is the movement through the lock by a vessel or other matter. Commercial vessels include all vessels operated for purposes of profit and include freight and passenger vessels.

SOURCE: United States Army Corps of Engineers, Navigation Data Center, *Lock Use, Performance, and Characteristics*, (Alexandria, VA: annual issues). Available at www.navigationdatacenter.us/ as of May 2016.

should be budgeted for a trip that in free flow conditions would typically take 60 minutes to arrive on-time. The extra time allowed, in this example 30 minutes, is called the buffer index, which is often used to assess system reliability. Figure 4-5a shows that the Travel Time Index (TTI) has been trending upward with 2015 levels mostly above 2013 and 2014, indicating that (as noted above) urban traffic congestion has been increasing . Based on PTI data collected from 52 cities between 2013 and 2015, travelers would have to plan at least 150 percent more travel time to arrive "on-time" for 19 out of 20 trips (figure 4-5b). Through the first half of 2015 that minimum rose to at least 180 percent more travel time, indicating less reliability due to higher traffic congestion. Figure 4-5c shows the potential impact of weather on travel as the congested hours were generally higher in winter than in summer months. It also shows that average congested hours per day in 2015 fell slightly below their 2014 levels. So while congestion levels were higher, for some unknown reason they didn't last quite as long.

For non-highway modes, different measures can be used to assess system reliability. For passenger transportation, for example, on-time performance is often an indicator of service reliability. Amtrak experienced a significant

FIGURE 4-5a Travel Time Index (TTI): July 2013–June 2015

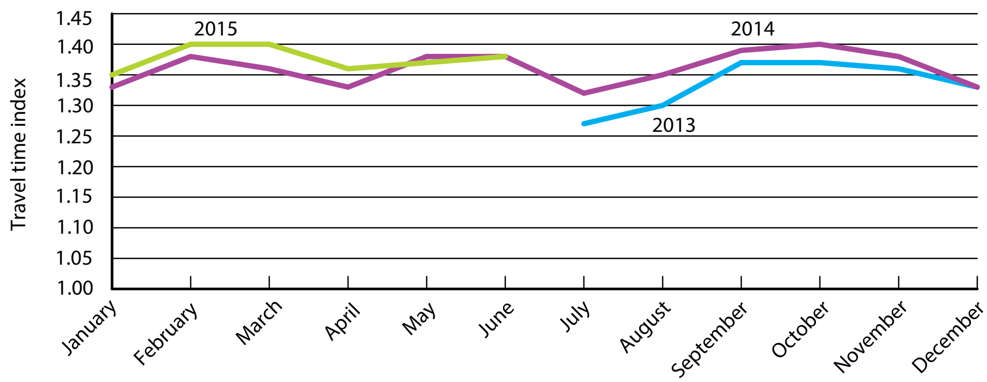


FIGURE 4-5b Planning Time Index (PTI): July 2013–June 2015

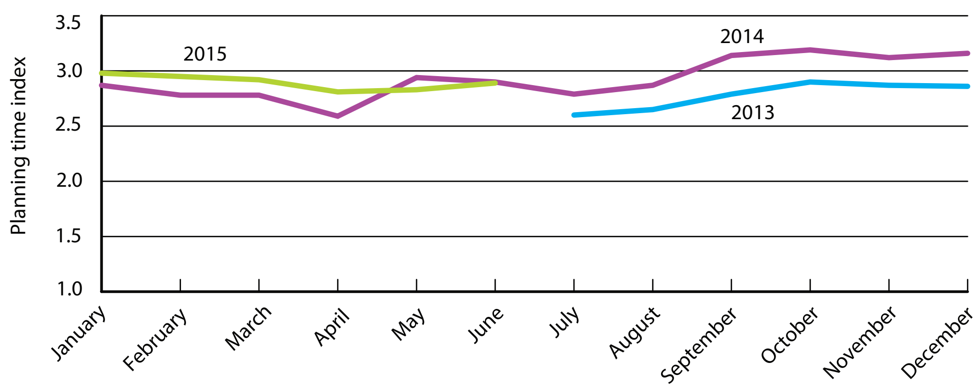
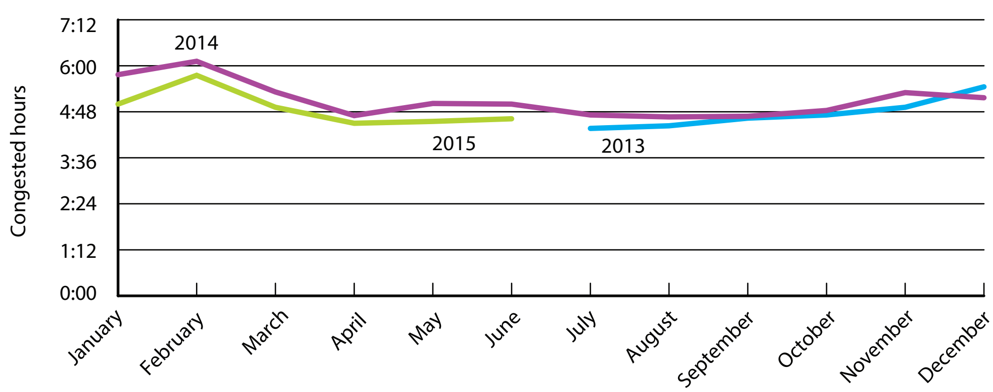


FIGURE 4-5c Congested Hours: July 2013–June 2015



NOTES: The reports utilize vehicle probe-based travel time data from FHWA's National Performance Management Research Data Set (NPMRDS). The reports are currently using data from 52 urban areas in the U.S. *Congested Hours* are computed as the average number of hours during specified time periods in which road sections are congested — speeds less than 90 percent of free-flow speed (e.g., 54 mph if free-flow speed is 60 mph). This measure is reported for weekdays (6:00 a.m. to 10:00 p.m.). Averages are weighted across road sections and urban areas by VMT using volumes from FHWA's HPMS. *Travel Time Index* is the ratio of the peak-period travel time as compared to the free-flow travel time. This measure is computed for the AM peak period (6:00 a.m. to 9:00 a.m.) and PM peak period (4:00 p.m. to 7:00 p.m.) on weekdays. Averages across urban areas, road sections, and time periods are weighted by VMT using volume estimates derived from FHWA's HPMS. *Planning Time Index* is the ratio of the 95th percentile travel time as compared to the free-flow travel time. The measure is computed during the AM and PM peak periods as defined in the TTI, and averages across urban areas, road sections, and time periods are weighted by VMT using volume estimates derived from FHWA's HPMS.

improvement in on-time performance with a record 83.0 percent on-time performance in 2012, but which declined to 71 percent in 2015 (table 4-4). Greater improvement in on-time performance is seen for trips over 400 miles in length, where on-time performance jumped from 42.1 percent in 2005 to 68.1 percent in 2015. The vast majority of passenger train services outside the Northeast Corridor are provided over tracks owned by and shared with the Class I freight railroads. As a result, Amtrak's on-time performance is largely dependent on the condition and performance of the host railroads, with the important exception of Amtrak-owned tracks in the Northeast Corridor.

U.S. airlines reported that over 18 percent of domestic scheduled flights, or more than one million flights, arrived at the gate at least 15 minutes late in 2015. The average length of delay for late arriving flights was almost an hour. Almost 11 percent, or 636,000 flights,

TABLE 4-4 Amtrak On-Time Performance Trends and Hours of Delay by Cause: 2000, 2005, and 2010–2015

	2000	2005	2010	2011	2012	2013	2014	2015
On-time performance, total percent (weighted)	78.2	69.8	79.7	78.1	83.0	82.3	72.4	71.2
Short distance (<400 miles), percent	82.0	73.6	80.3	79.8	84.5	86.1	75.7	74.2
Long distance (>=400 miles), percent	55.0	42.1	74.7	63.6	70.7	58.0	69.1	68.1
Hours of delay by cause, total	**70,396**	**95,259**	**79,976**	**86,021**	**79,235**	**77,719**	**98,779**	**100,847**
Amtrak[a]	23,337	25,549	23,404	26,121	21,384	17,467	24,603	24,191
Host railroad[b]	43,881	64,097	44,090	48,707	46,564	48,733	63,191	63,632
Other[c]	3,176	5,613	12,482	11,192	11,286	11,520	10,984	13,025

[a] Includes all delays that occur when operating on Amtrak owned tracks and all delays for equipment or engine failure, passenger handling, holding for connections, train servicing, and mail/baggage handling when on tracks of a host railroad.

[b] Includes all operating delays not attributable to Amtrak when operating on tracks of a host railroad, such as track and signal related delays, power failures, freight and commuter train interference, routing delays, etc.

[c] Includes delays not attributable to Amtrak or other host railroads, such as customs and immigration, law enforcement action, weather, or waiting for scheduled departure time.

NOTES: Host railroad is a freight or commuter railroad over which Amtrak trains operate for all or part of their trip. Numbers may not add to totals due to rounding. All percentages are based on Amtrak's fiscal year (October 1–September 30). Amtrak trains are considered on time if arrival at the endpoint is within the minutes of scheduled arrival time as shown on the following chart. Trip length is based on the total distance traveled by that train from origin to destination:

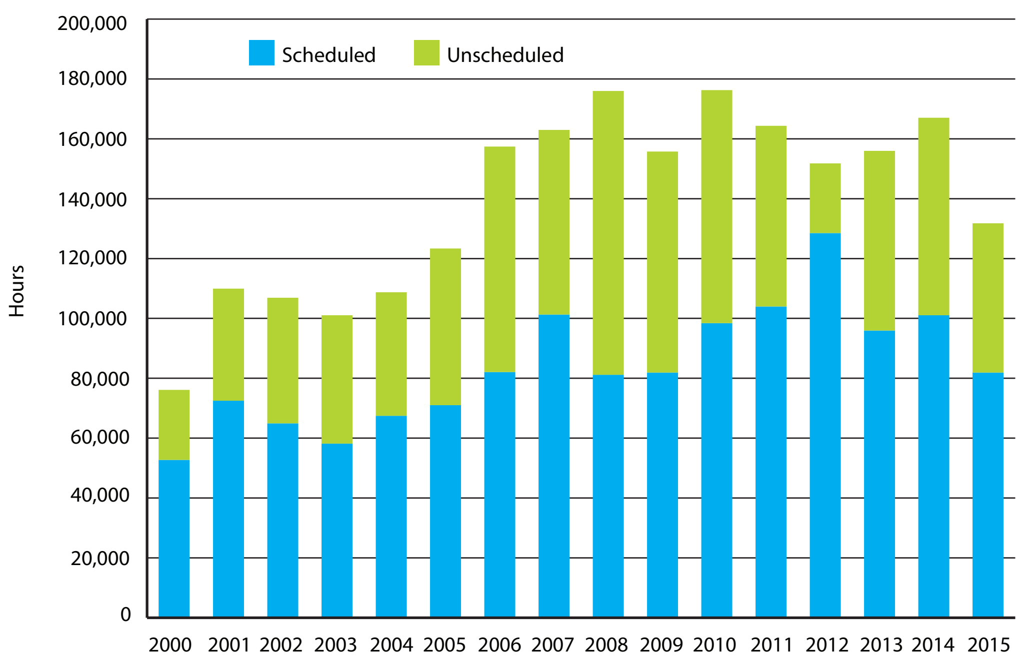
Trip length (miles)	Minutes late at endpoint
0–250	10 or less
251–350	15 or less
351–450	20 or less
451–550	25 or less
> 551	30 or less

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics. *National Transportation Statistics*, Table 1-73. Available at http://www.bts.gov/ as of May 2016.

arrived at the gate more than 2 hours late (table 4-2). Late arrivals peaked at 24.1 percent in 2007, and since then have been in the range of about 18 to 20 percent.

For the U.S. Army Corps of Engineers inland waterway locks, system reliability can be measured as the percent of time a lock is unavailable for use (defined as the cumulative periods over a year during which a lock facility was unable to pass traffic). Locks could be unavailable for a number of reasons, ranging from scheduled maintenance, unexpected stoppages due to operational issues, and weather conditions such as flooding and ice. For example, high water levels and flows shut down 22 locks and stopped cargo movements along the Upper Mississippi River and its confluences in late April 2013 [USACE 2013]. As shown in figure 4-6, the total number of hours of unavailability in 2015 was almost 132,000, nearly 75 percent higher than the level in 2000. Lock unavailability due to scheduled operations, such as maintenance, ranged from 46 to 85 percent over the period shown and averaged 61 percent. Scheduled downtime was 62 percent of total down time in 2015. Unscheduled lock chamber downtime peaked during the 2006 to 2010 timeframe, over which it averaged about 77,000 hours per year. Over the past 4 years unscheduled lost time dropped to more typical levels, averaging about 52,000 hours per year.

FIGURE 4-6 Total Number of Hours of Lock Closures: 2000–2015



SOURCE: U.S. Army Corps of Engineers, Navigation Data Center, *Lock Performance Monitoring System. Locks by Waterway, Locks Unavailability, Calendar Years 1993-2015* (May 22, 2015). Available at http://www.navigationdatacenter.us/ as of May 2016.

System Resiliency

Many parts of the Nation's transportation system are vulnerable to both natural and man-made disruptions. Because of this vulnerability, transportation firms and agencies have become interested in providing a system that is resilient to disruptive impacts. 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].

System Disruptions from Extreme Weather

The United States has experienced extreme weather events throughout its history. However, 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. For example, the U.S. Department of Commerce (USDOC), National Oceanic and Atmospheric Administration (NOAA) estimated that the United States experienced 188 weather/climate disasters (or about 5 per year on average) since 1980, including 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 trillion cumulative cost to the Nation [USDOC NOAA NCEI 2016]. Part of the physical recovery costs and overall economic impact were due to the damage and disruption to the transportation system. The year 2005 was the most costly since 1980, with over $200 billion in damages and 2,002 deaths due to extreme weather. In 2015 there were ten such events causing 155 deaths and estimated damages of $22.4 billion.

Hurricane Sandy and the January–February 2015 New England blizzards are two recent examples of extreme weather events that disrupted the transportation system. Hurricane Sandy caused extensive damage in October 2012 along the New Jersey, New York, and Connecticut coasts and record flooding in lower Manhattan. Roads and bridges were damaged throughout the region, and road and rail tunnels were flooded. The region's major airports were closed, and transit service was not restored in many areas until several months after the storm [Kaufman, Qing, Levenson and Hanson 2012].

Between January 24th and February 25th, 2015, severe winter weather produced blizzard-like conditions and record setting snowfalls throughout the New England region. Boston and Worcester, MA, were hit particularly hard, each recording over 94 inches of snow over the 30-day period. The transportation system in the region was severely disrupted. Over those 30 days the Massachusetts Department of Transportation implemented 171 lane or road closures of significant duration. Massachusetts Bay Transportation Authority commuter rail, heavy rail, and light rail services ran between 50 and 80 percent of normal levels over much of the period, and ferry service was similarly reduced. Boston Logan International Airport experienced 4,576 flight cancellations, impacting approximately 230,000 passengers. AMTRAK canceled all Northeast corridor service between New York and Boston on January 27th, and canceled two or more trains on 10 additional days [MEMA 2015].

A snow event of even broader impact occurred in the eastern United States in January of 2016. Box 4-A provides some illustrative information about that storm and its impacts.

There are economic and other costs associated with such major disruptions, including those resulting from cleanup and infrastructure repair, foregone commercial opportunities (e.g., lost business sales due to closures), and loss in productivity. For example, the economic impact to New Jersey and New York resulting from Hurricane Sandy was estimated at $67 billion [USDOC NOAA 2016], although some studies have suggested that the impact was less given the economic rebound associated with the recovery from the hurricane [Rutgers University 2013]. This cost included the estimated expenditures to replace the roads, bridges, and transit facilities damaged by the storm. IHS Global Insight estimates that each day of snow-related shut down in Massachusetts results in direct and indirect economic impacts exceeding $250 million[8] [IHS 2015].

Although the impacted regions suffered huge losses during their respective storms, one of the key lessons from each event was the importance of transportation system resilience. Major transportation facilities—roads, bridges, transit systems, ports, and airports—were in operation within weeks of the severe weather. 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 [MTA 2012]. The existence of redundant paths in the transportation network provided travel options for both person and freight trips seeking to avoid travel blockages. In all three cases the transportation agencies were able to quickly put the transportation system back into operation, thus minimizing the economic impact to state and regional economies.

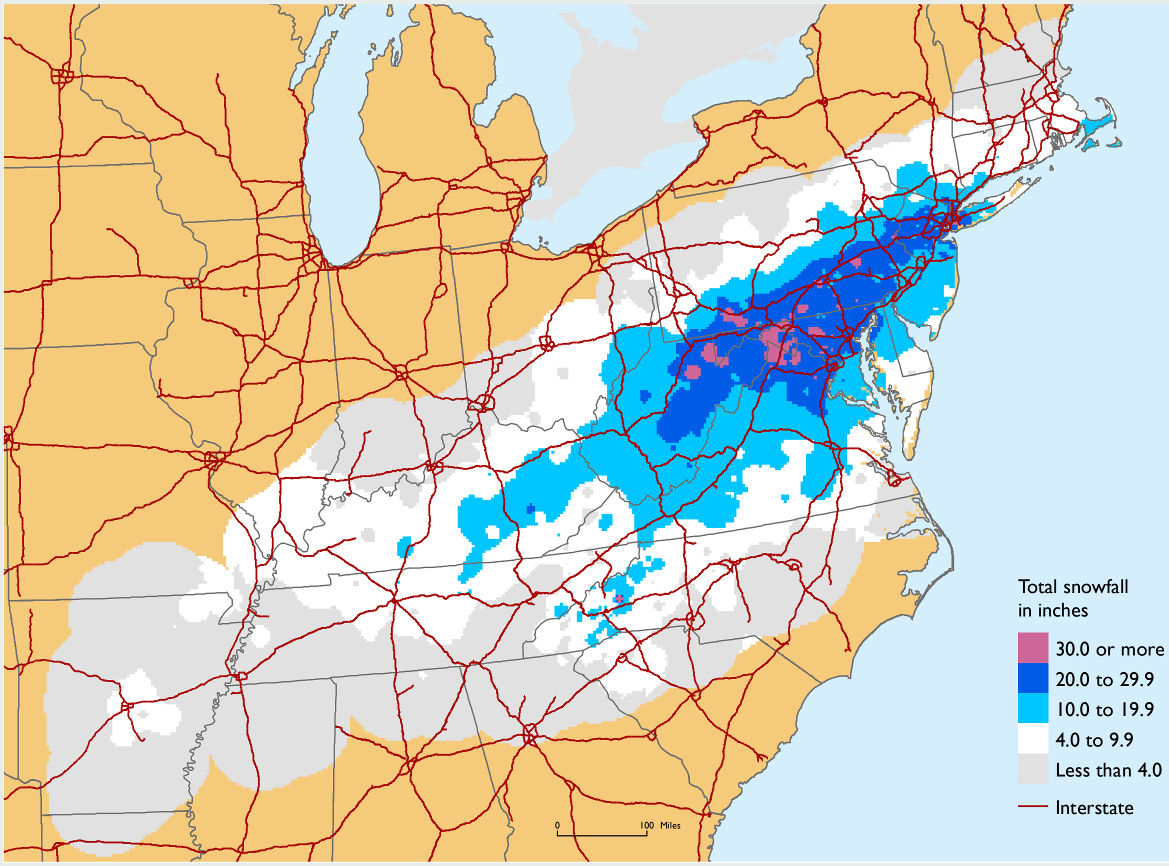
Security Concerns

The Transportation Security Administration (TSA), of the U.S. Department of Homeland Security, screens people as they pass through security checkpoints at 450 airports with Federal screening, and at other passenger checkpoints. In 2015 TSA officers screened more than 708 million passengers (more than 1.9 million per day), 1.6 billion carry-on bags, 432 million checked bags, and 12.9 million airport employees. Despite news headlines that report long lines when they do occur, nationwide less than 2 percent of passengers (14.1 million) waited in line for more than 20 minutes.

These TSA inspections prevented a wide array of prohibited items from being brought onto passenger aircraft, notably 2,653 firearms, 83 percent of which were loaded (see box 4-B). Other prohibited items discovered in checked and carry-on bags included many thousands of knives, swords, and other sharp blades; ammunition; gunpowder, black powder, flashbang grenades, and fireworks; and inert and replica explosive devices. Federal air

[8] IHS estimates for other, more populous states are: New York, $700 million; Illinois, $400 million; Pennsylvania, $370 million; Ohio, $300 million; and New Jersey, $290 million.

Box 4-A Impacts of January 22–23, 2016 Blizzard on Eastern U.S. Interstate System



SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, April 2016.

marshals flew more than a billion miles to help keep the skies secure for travel [USDHS TSA 2016].

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 2015 the waters of Southeast Asia experienced 254 piracy events, an increase of 54 over those reported for 2014. The Gulf of Guinea, in West Africa, had 96 events, about the same number as in 2014. The Horn of Africa waters, which have been of major concern since 2009, had no events in 2015 and only two attempted boardings in 2014 [USN ONI 2016].

Economic Benefits of Improved System Performance

Maintaining and improving the performance of the transportation system provides benefits to people and economy at all levels. Performance can improve either through investments that

Box 4-B Firearms Discovered at TSA Checkpoints, 2015

expand capacity, such as adding a transit station, or enhance performance on the existing system through investments, such as improving intersection signal timing and adding a high-occupancy lane. Improving system performance improves the economy by reducing congestion, linking markets, and increasing shipment and personal travel time reliability. It is also important to maintain the existing infrastructure to ensure continued economic growth.

Comprehensive estimates of economic benefits associated with improved system performance are extremely limited. The *Urban Mobility Scorecard* [TAMU TTI 2015] includes an estimate of the cost to system users of about $160 billion in delay and fuel wasted in congestion costs in 2014. The 2012 *Urban Mobility Report* [TAMU TTI 2013] also estimated the beneficial effects of public transportation and roadway operational improvements to reduce these costs. For public transportation, the analysis examined what would happen if transit services were eliminated in the 498 urban areas that were part of the study. The additional system cost (or the cost avoided given transit service) is thus considered the benefit of transit investment. For 2011 the savings included 865 million hours of delay and 450 million gallons of fuel, resulting in an estimated $20.8 billion (2011 dollars) in cost savings. For road operational improvements, the report estimated 364 million hours of delay eliminated and 194 million gallons of fuel saved, resulting in an estimated $8.5 billion in cost savings.

The Federal Highway Administration and Federal Transit Administration examined transportation investment benefits versus the costs in its 2013 *Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance Report* (C&P) [FHWA 2013]. The C&P finds that the annual capital investment level needed to maintain the conditions and performance of highways and bridges at 2010 levels through the year 2030 is projected to range from $65.3 billion to $86.3 billion per year, depending on the growth rate of vehicle-miles traveled. Moving existing transit assets to a state of good repair would require an annualized investment of $18.5 billion through the year 2030. These investment levels hold the potential to maintain the transportation related economic development on its current upward trend, while investing at lower levels could hamper economic growth.

Based on a 2005 survey in Portland, Oregon, the White House Council of Economic Advisors [NECPCE 2014] reported the economic costs associated with poor transportation system performance. Higher business costs were found to cause Portland businesses to hold more inventories or rely on additional distribution centers:

- Portland General Electric estimated that it spend approximately $500,000 a year for maintenance crew travel time.
- Nike spends an additional $4 million per week to carry an extra 7-to-14 days of inventory in case of shipping delays.
- One day of delay requires American President Line's eastbound trans-Pacific services to increase its use of containers and chassis by 1,300, which adds $4 million in costs per year.

- A week-long disruption to container movements through the Ports of Los Angeles and Long Beach could cost the national economy between $65 and $150 million per day.

The economic benefits of transportation investments can stem from meeting needed capacity expansions. For the trucking industry alone, the Federal Highway Administration calculated that highway bottlenecks cause more than 243 million hours of delay each year, at a cost of $7.8 billion annually [FHWA 2007]. A recent FHWA report [LAWRENCE 2015] provides a compendium of case studies of benefit cost analysis of operational improvements, such as coordinated arterial traffic signal timing, transit signal priority, ramp metering at freeway on-ramps, high occupancy toll lanes, work zone traffic management, and travel demand management. Some of the case studies provide actual estimated economic benefits of the improvements. For example, implementing adaptive signal control in Greeley and Woodland Park, CO, was estimated to generate annual benefits of $2.2 million, and providing a freeway service patrol program in Florida had an estimated benefic cost ratio of 6.7.

The American Recovery and Reinvestment Act (Recovery Act) of 2009 allocated an additional $48 billion into improving transportation infrastructure and operations. A 2012 report by the Treasury [TREASURY] summarizes the historical and recent literature linking transportation investments to economic growth, from the linking of the national rail network to the creation of the interstate highway system and into the 22nd century with high speed rail and connected vehicle technologies. While studies differ in the magnitude of the economic return on investment, they all find positive economic returns to transportation investments. Fernald [AER 1999] found that previous investments in infrastructure led to substantial productivity gains and highlighted the potential for further increases in productivity through additional, well-targeted investments.

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CHAPTER 5

Transportation Economics

Highlights

- The demand for transportation increased by 4.2 percent from 2013 to 2014, marking the highest annual growth since the end of the December 2007 to June 2009 economic recession. The demand for transportation in 2014 exceeded 2007 for the first time since the end of the 2007 to 2009 recession.
- Freight traffic, as measured by the freight TSI, has a strong relationship to the economy, with the freight TSI tending to lead accelerations and decelerations in the economy.
- Employment in for-hire transportation and transportation-related industries has continued to rise since declining during the 2007 to 2009 recession, reaching 13.1 million in 2014, but has yet to rise above the pre-recession level of 13.5 million in 2007.
- Total national expenditures on transportation accounted for roughly $1,184 billion of all personal expenditures, making it the fourth largest expenditure category after healthcare, housing, and food.
- Total government transportation revenues continue to fall short of government transportation expenditures. In 2012 government transportation revenues covered 56.3 percent of expenditures. The gap between transportation revenues and expenditures has declined since 2009, when revenues covered 51.0 percent of expenditures.
- The total costs faced by producers of transportation services have increased. Businesses purchasing transportation services also have faced price increases, with the price for rail transportation services growing (58.2 percent) more rapidly than any other transportation mode except pipeline, which grew 124.3 percent between 2014 and 2015.

Transportation Economics

Transportation plays a vital role in the American economy. It makes economic activity possible and serves 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, etc.) and employing workers in transportation occupations in both the transportation industry 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. The full scope of transportation's role in the economy is available in BTS's new *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 transportation's contribution to gross domestic product (GDP). GDP is an economic measure of all goods and services produced and consumed in the country. The transportation component of GDP can be measured in terms of investments made and transportation goods and services consumed (collectively known as the demand for transportation) or in terms of the transportation services produced.

In 2014 the demand for transportation ($1,422.1 billion) included personal consumption, such as vehicle and motor fuel purchases ($978.3 billion), private domestic investment in transportation structures and equipment ($282.7 billion), government purchases of transportation goods and services ($273.0 billion), and net exports (exports minus imports) related to transportation goods and services (-$111.9 billion) (as measured in chained 2009 dollars) (table 5-1). Personal consumption of transportation is the largest component at 68.8 percent, followed by private domestic investment in transportation structures and equipment at 19.9 percent, government purchases at 19.2 percent, and net exports related to transportation goods and services at -7.9 percent. Altogether, the demand for transportation accounted for 8.9 percent of U.S. GDP.

The demand for transportation increased by 4.2 percent from 2013 to 2014, marking the highest annual growth since the end of the December 2007 to June 2009 economic recession. Gross private domestic investment in transportation equipment and structures, which grew 11.5 percent from 2013 to 2014, contributed significantly to the overall increase in the demand for transportation. The demand for transportation in 2014 exceeded 2007 for the first time since the end of the 2007 to 2009 recession (table 5-1).

TABLE 5-1 U.S. Gross Domestic Product (GDP) Attributed to Transportation-Related Final Demand: 2000, 2007–2014
Billions of chained 2009 dollars

	2000	2007	2008	2009	2010	2011	2012	2013	2014
Gross Domestic Product	**$12,559.7**	**$14,873.7**	**$14,830.4**	**$14,418.7**	**$14,783.8**	**$15,020.6**	**$15,354.6**	**$15,583.3**	**$15,961.7**
Total transportation-related final demand	**$1,336.2**	**$1,389.7**	**$1,296.9**	**$1,208.5**	**$1,239.5**	**$1,287.6**	**$1,323.1**	**$1,365.1**	**$1,422.1**
Total transportation in GDP (percent)	10.6%	9.3%	8.7%	8.4%	8.4%	8.6%	8.6%	8.8%	8.9%
Year-to-year growth in transportation-related final demand	NA	NA	-6.7%	-6.8%	2.6%	3.9%	2.8%	3.2%	4.2%
Personal consumption of transportation, total	**$945.0**	**$1,005.0**	**$924.5**	**$867.0**	**$870.4**	**$882.6**	**$910.8**	**$940.8**	**$978.3**
Motor vehicles and parts	$346.4	$392.8	$340.8	$317.1	$323.4	$333.8	$359.1	$375.8	$396.7
Motor vehicle fuels, lubricants, and fluids	$265.8	$273.2	$262.4	$260.2	$259.9	$254.7	$252.5	$256.3	$257.7
Transportation services	$332.8	$339.0	$321.3	$289.7	$287.1	$294.1	$299.2	$308.7	$323.9
Gross private domestic investment, total	**$212.9**	**$213.0**	**$166.9**	**$79.7**	**$146.7**	**$192.3**	**$229.3**	**$253.5**	**$282.7**
Transportation structures	$8.8	$9.4	$10.0	$9.1	$9.8	$9.3	$10.4	$10.4	$10.9
Transportation equipment	$204.1	$203.6	$156.9	$70.6	$136.9	$183.0	$218.9	$243.1	$271.8
Exports (+), total	**$217.0**	**$269.5**	**$268.7**	**$218.7**	**$247.5**	**$273.3**	**$295.8**	**$312.3**	**$323.5**
Imports (-), total	**$321.7**	**$386.5**	**$350.6**	**$254.0**	**$323.0**	**$349.6**	**$389.9**	**$410.6**	**$435.4**
Net exports of transportation-related goods and services	-$104.7	-$117.0	-$81.9	-$35.3	-$75.5	-$76.3	-$94.1	-$98.3	-$111.9
Government transportation-related purchases, total	**$283.0**	**$288.7**	**$287.4**	**$297.1**	**$297.9**	**$289.0**	**$277.1**	**$269.1**	**$273.0**
Federal purchases	$25.3	$32.6	$35.3	$35.9	$37.8	$38.6	$38.9	$36.2	$36.1
State and local purchases	$245.5	$235.5	$232.5	$238.7	$236.0	$228.1	$221.4	$219.5	$224.3
Defense-related purchases	$12.2	$20.6	$19.6	$22.5	$24.1	$22.3	$16.8	$13.4	$12.6

NOTES: Total transportation-related final demand is the sum of total Personal consumption of transportation, total Gross private domestic investment, Net exports of transportation-related goods and services and total Government transportation-related purchases. Net exports is exports minus Imports of civilian aircraft, engines, and parts; automotive vehicles, engines, and parts; and transport. Federal purchases and State and local purchases are the sum of consumption expenditures and gross investment. Defense-related purchases are the sum of transportation of material and travel. The Bureau Economic Analysis has changed the reference year for chained dollar estimates from 1999 onward as part of the comprehensive revision of the national income and product accounts in 2014.

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, and 5.5.6, available at http://www.bea.gov/National/nipaweb/SelectTable.asp?Selected=N as of May 2016.

Transportation's Role in Production

The contribution of transportation to the economy can also be found by examining transportation's role in production. The transportation services used to move wheat from farms to mills, flour from mills to bakers, and bread from bakers to grocery stores, exemplify how transportation enables the production and sale of nearly everything made and consumed in the United States. The U.S. Bureau of Economic Analysis (BEA) produces the U.S. Input-Output (I-O) accounts, which show the inputs each industry uses to produce output, the type of output produced by each industry, and the types of products purchased by final consumers.

With regards to transportation, the I-O accounts show the industries using transportation services provided by transportation firms on a fee basis, called for-hire transportation, and the contribution of for-hire transportation firms to the economy. In 2015 for-hire transportation (including warehousing) contributed $527.7 billion (2.9 percent) to U.S. GDP (current dollars) [USDOC BEA 2016a]. 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 deliver finished products to wholesale and retail outlets.

In addition to using for-hire transportation services, many nontransportation industries also undertake transportation activities for their own purposes (called in-house transportation), which the I-O accounts do not explicitly show. BTS developed the Transportation Satellite Accounts (TSAs) to clearly show in-house transportation operations and thereby estimate the full contribution of transportation to the economy (box 5-A). The TSAs also show the contribution of transportation carried out by households through the use of an automobile.

In 2014, the latest year for which comprehensive data are available, transportation's total estimated contribution to the economy was $1,001.9 billion. For-hire transportation contributed $504.8 billion (2.9 percent) to the U.S. GDP of $17.7 trillion. Transportation services (air, rail, truck, and water) provided by nontransportation industries for their own use (in-house transportation) contributed an additional $187.2 billion (1.1 percent). Total household transportation (i.e., the depreciation cost associated with households owning motor vehicles) contributed

Box 5-A Transportation Satellite Accounts (TSAs)

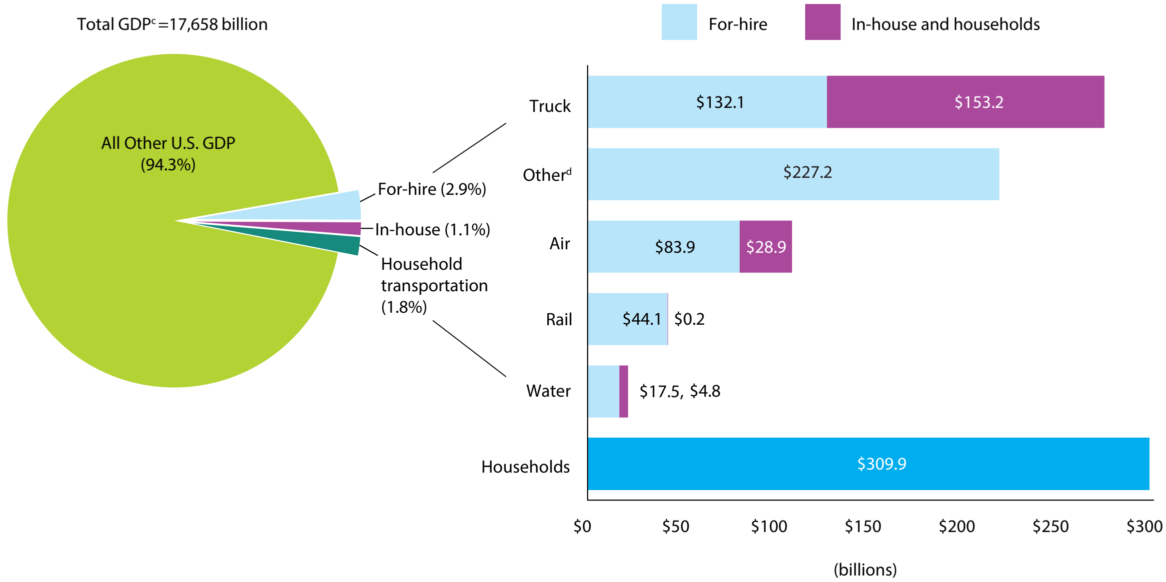
Satellite industry accounts expand on and supplement the national income and product accounts and input-output (I-0) accounts by focusing on a particular aspect of economic activity. The Transportation Satellite Accounts (TSAs) capture the full role of transportation in the economy by expanding on the U.S. I-O accounts. The I-O accounts capture the role of for-hire transportation. For-hire transportation consists of the air, rail, truck, passenger and ground transportation, pipeline, and other support services (e.g., air traffic control) provided by transportation firms, such as railroads, transit agencies, common carrier trucking companies, and pipelines to industries and the public on a fee-basis. For-hire transportation includes ticketed air passenger travel.

The TSAs reorganize the I-O accounts to show transportation activities carried out by households through the use of an automobile and transportation activities carried out by nontransportation industries for their own purposes, known as in-house transportation. In-house transportation consists of air, rail, water, and truck services provided by businesses for their own use. Business in-house transportation includes privately owned and operated vehicles of all body types, used primarily on public rights of way, and the supportive services to store, maintain, and operate those vehicles. A baker's delivery truck is an example of business in-house transportation.

The TSAs use the same structure as the I-O accounts and quantify transportation's role and impact on the economy from four perspectives:

- the value of transportation services each transportation industry *makes* (e.g., trucking services made by the for-hire trucking industry),
- the amount of transportation *used* by each industry in the economy and the contribution of each industry to the economy,
- the amount of transportation *required* to produce one dollar of each product, and
- the inputs *required* to produce one dollar of transportation [USDOT BTS 2016b].

FIGURE 5-1 Contribution of For-Hire[a] and In-House[b] Transportation to U.S. Gross Domestic Product: 2014 (nominal dollars)



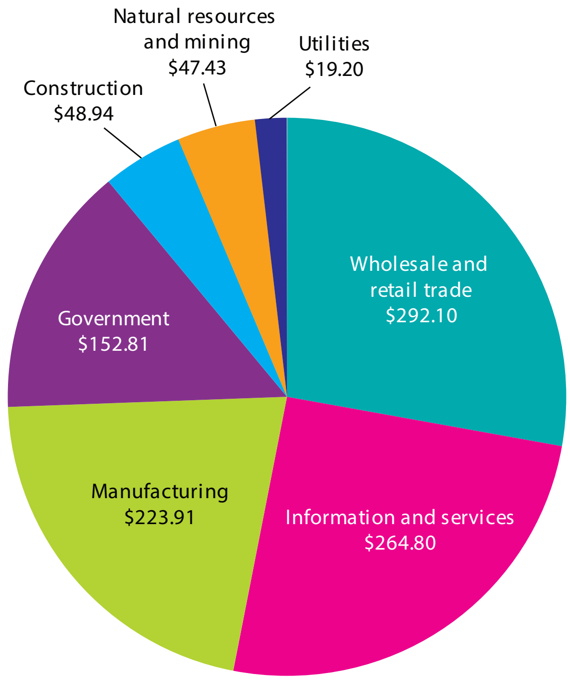
NOTES: [a] For-hire transportation consists of the services provided by transportation firms to industries and the public on a fee-basis. [b] In-house transportation consists of the services provided by non-transportation industries, including households, for their use. Business in-house transportation includes privately owned and operated vehicles of all body types, used primarily on public rights of way, and the supportive services to store, maintain, and operate those vehicles. Household transportation covers transportation provided by households for their own use through the use of an automobile. [c] Gross domestic product (GDP) increased from value reported by the Bureau of Economic Analysis in I-O use table by total output from the household production of transportation services. [d] 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.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at www.bts.gov, as of March 2016.

$309.9 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 $285.2 billion. In-house truck transportation operations contributed $153.2 billion, while for-hire truck transportation services contributed $132.1 billion (figure 5-1). The size of trucking's contribution reflects the use of trucks by for-hire transportation and nontransportation industries for their own purposes.

Transportation indirectly contributes to the economy by enabling the production of goods and services. *Industry Snapshots: Uses of Transportation* summarizes the transportation services and related resources used by the six major nontransportation sectors to produce their goods and services [USDOT BTS 2016c]. Some sectors use more transportation than others. In 2014 the wholesale and retail trade sector used the largest amount of transportation services at $292.1 billion, followed by the information and services sector at $264.8 billion, the manufacturing sector at $225.7 billion, and the government sector at $153.1 billion (figure 5-2).

FIGURE 5-2 Use of Transportation by Industry: 2014 (current dollars, billions)



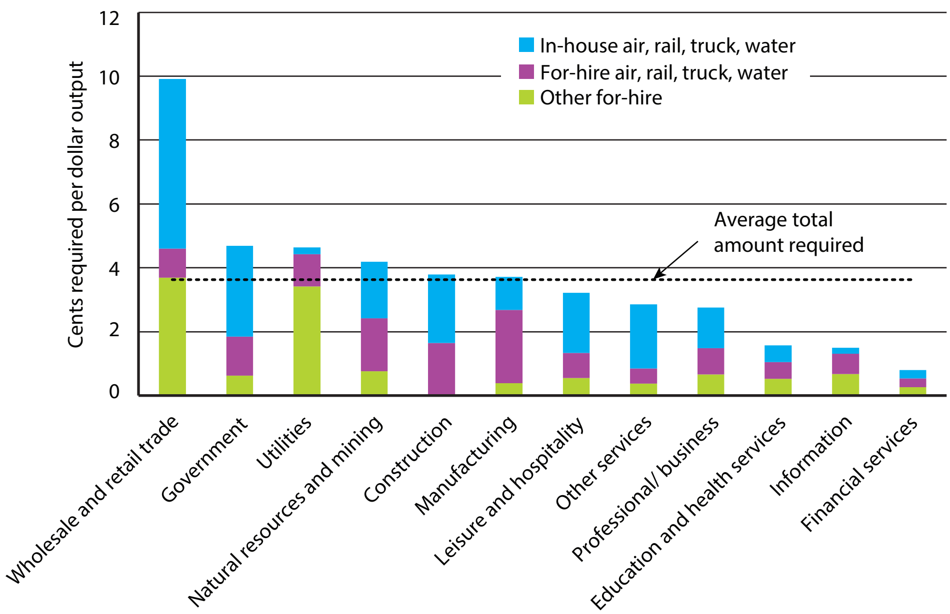
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at http://www.bts.gov as of March 2016.

Looking at the amount of transportation required to produce one dollar of output shows how much a sector depends on transportation. In 2014 the wholesale and retail trade sector required more transportation services to produce one dollar of output than any other sector. In 2014 the wholesale and retail trade sector required 9.9 cents of transportation services to produce one dollar of output—5.3 cents of in-house truck transportation operations and 4.6 cents of for-hire transportation services in 2014 (figure 5-3).

Transportation and Economic Cycles

Transportation activities have a strong relationship to the economy. The Bureau of Transportation Statistics (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 (see box 5-B). BTS research shows that changes in the TSI occur before changes in the economy, making the TSI useful for predicting economic trends

FIGURE 5-3 Transportation Required Per Dollar of Output by Sector: 2014



NOTES: In-house transportation consists of transportation services (air, rail, truck, and water) provided by nontransportation industries for their own use. For-hire transportation consists of the services provided by transportation firms to industries and the public on a fee-basis. Airlines, railroads, transit agencies, common carrier trucking companies, and pipelines are examples of for-hire transportation industries.
"Other" for-hire transportation includes: Transit and passenger ground transportation (including State and local government passenger transit); Pipeline; Sightseeing transportation and transportation support; Courier and messenger services (excluding U.S. Postal Service); Warehousing and storage; and Other transportation and support activities.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at http://www.bts.gov as of March 2016.

Box 5-B Transportation Services Index (TSI)

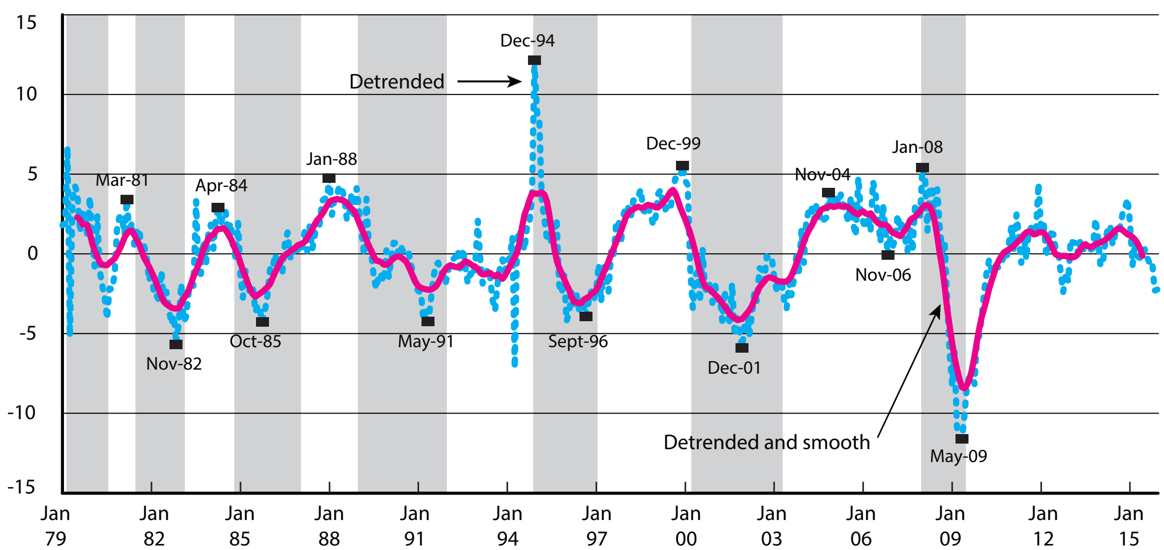
The Transportation Services Index (TSI), produced by the U.S. Department of Transportation, Bureau of Transportation Statistics (BTS), measures the movement of freight and passengers. BTS produces three indexes – a freight index, a passenger index, and a total or combined index. The indexes combine monthly data from multiple for-hire transportation modes. Each index shows the month-to-month change in for-hire transportation services. Monthly data on each mode of transportation is seasonally adjusted and then combined into the three indexes. The freight index is a weighted average of data for trucking, freight rail, waterborne, pipeline, and air freight. The passenger index is a weighted average of data for passenger aviation, transit, and passenger rail. The combined index is a weighted average of all these modes. These indexes serve both as multimodal monthly measures of the state of transportation and as indicators of the U.S. economic future.

[USDOT BTS 2014]. This relationship is particularly strong for freight traffic.

Figure 5-4 illustrates the relationship between the freight TSI and the national economy from 1970 to 2015. The dashed blue line shows the freight TSI detrended to remove long-term changes. The red line shows the freight TSI detrended and smoothed to eliminate month-to-month volatility. The gray bars represent economic slowdowns, or periods when economic growth slows below normal rates and unemployment rises as a result. The marked peaks and troughs show that the freight TSI usually peaks before a growth slowdown begins and hits a trough before a growth slowdown ends. The most recent trough occurred in May 2009—one month prior to the end of the January 2008 to June 2009 economic slowdown. The freight TSI rose rapidly after May 2009 but then slowed through 2015. Overall, the freight TSI grew 27.2 percent from May 2009 to December 2015.

Figure 5-5 shows the changes in freight movement by the transportation modes included in the freight TSI. Rail intermodal grew the fastest, rising 47.1 percent from June 2009 (the end of the economic recession) to February 2016 (the latest available month). Competitive pricing, track upgrades, and investment in rail intermodal terminals and other infrastructure contributed to the rapid growth of rail intermodal traffic [AAR 2016a]. Trucking grew the second fastest at 35.3 percent. All other modes likewise grew from June 2009 through February 2016 except rail

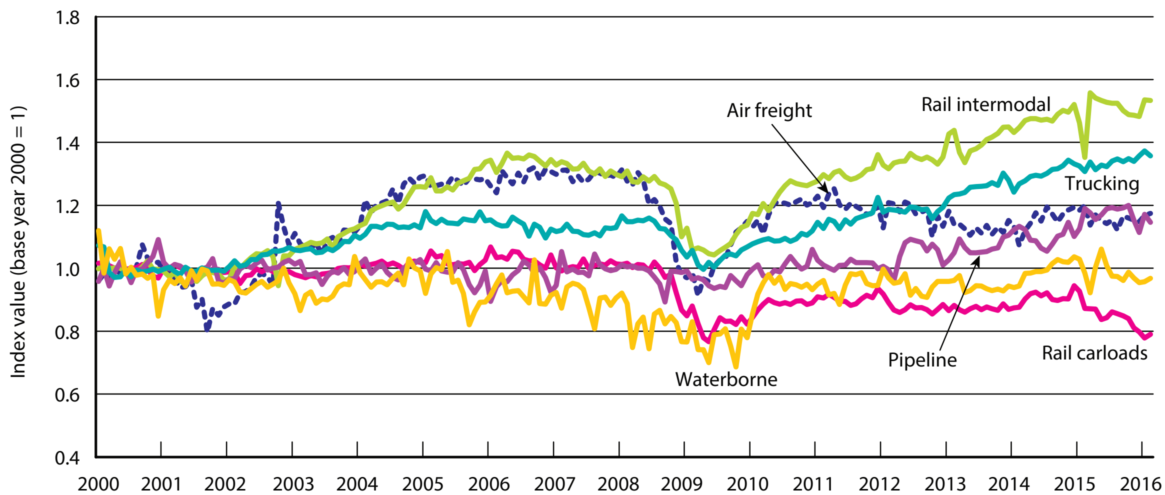
FIGURE 5-4 Freight Transportation Services Index (TSI) and the Economic Growth Cycle: January 1979–December 2015



NOTES: Shaded areas indicate decelerations in the economy (growth cycles). Detrending and smoothing refer to a statistical procedure that makes it easier to observe changes in upturns and downturns of the data. Detrending removes the long term growth trend and smoothing eliminates month to month volatility.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Services Index, available at www.bts.gov as of May 2016.

FIGURE 5-5 Freight Transportation Services Index (TSI) Modal Data: January 2000–December 2015



NOTES: Data are seasonally adjusted and indexed.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, seasonally adjusted transportation data, available at www.bts.gov as of May 2016.

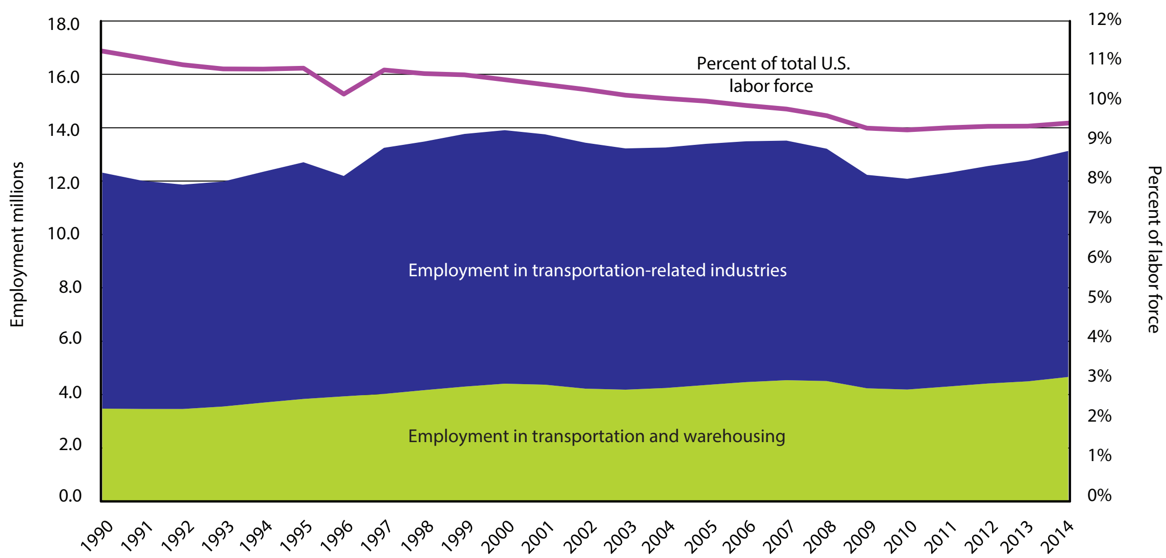
carloads, which declined 1.8 percent. Data from *Railroads and Coal* suggests that the weakness in rail carload shipments is due to a weakness in coal shipments. Total coal shipped by Class I railroads peaked in 2008 at 878.6 million tons, dropped to 787.6 in 2009, and continued to fall to 638.1 million tons in 2015 [AAR 2010, 2015, and 2016b].

Transportation-Related Employment and Wages

The transportation and warehousing sector and related industries employ over 13.1 million people in a variety of roles, from driving buses to manufacturing cars to building and maintaining ports and railroads. Figure 5-6 shows the number and percentage of workers employed by for-hire transportation and transportation-related industries in the United States from 1990 to 2014. In 1990 12.3 million workers were employed in for-hire transportation and transportation-related industries. Employment rose to a high of 13.9 million workers in 2000, but declined to 13.2 million in 2003 due to the March to November 2001 economic recession and to the aftermath of September 11, 2001. Employment declined further to a low of 12.1 million in 2010 due to the 2007 to 2009 recession. Employment has steadily risen, reaching 13.1 million in 2014, but remains below the 2007 level of 13.5 million. The percentage of American workers employed in for-hire transportation and transportation-related industries, however, has continued its decline—from 11.3 percent in 1990 to 9.4 percent in 2014. [USDOT BTS 2016d]

The for-hire transportation sector (transportation service providers and warehousing) is a major source of employment

FIGURE 5-6 Employment in Transportation and Transportation-Related Industries in the United States: 1990–2014



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 3-23, available at www.bts.gov as of July 2016.

in the United States, employing 4.7 million in 2014 (figure 5-6). The sector's labor force declined during the 2007 to 2009 recession and continued to fall through 2010 before rising above the 2007 level in 2014 [USDOT BTS 2016d]. Additional persons work as independent contractors for private transportation providers, such as drivers for independent, on-demand ride-services (e.g., Uber and Lyft) but are not counted in the totals (see box 5-C).

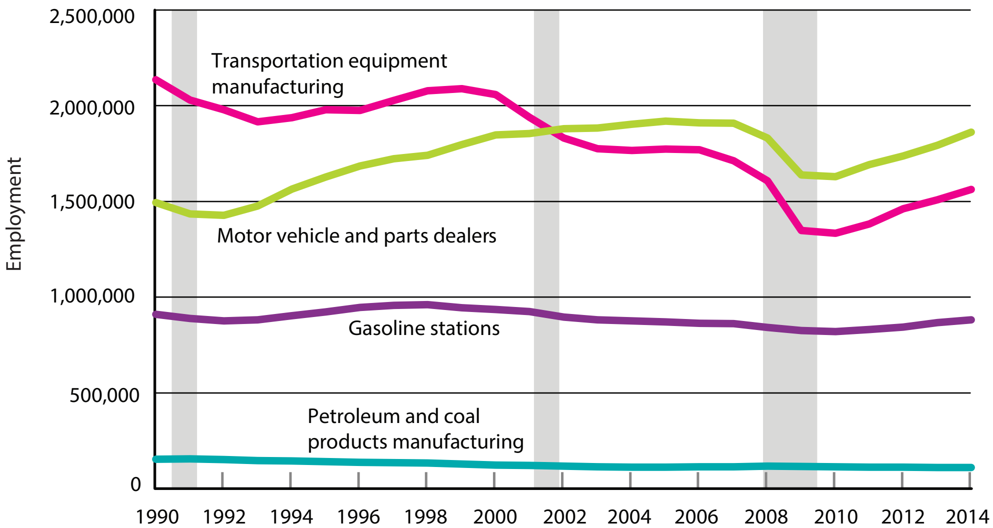
Transportation also leads to employment in related industries that provide the goods and services needed to produce transportation. These transportation industries include motor vehicle and parts dealers, transportation equipment manufacturing, gasoline stations, and petroleum and coal products manufacturing. A notable shift in transportation-related employment occurred between 1990 and 2014. From 1990 through 2001, transportation equipment manufacturing was the largest transportation-related industry. However, as employment in transportation equipment manufacturing experienced a prolonged decline, motor vehicle and parts dealers became the largest transportation-related industry in 2002. Employment in motor vehicle and parts dealers grew by 24.6 percent from 1990 to 2014 (figure 5-7).

Workers with transportation occupations overall earned, at $30,090, a lower median wage than workers of all occupations ($36,200) in 2015 [USDOL BLS 2016b]. Annual wages earned by transportation and transportation-related workers vary widely across transportation

Box 5-C Independent, On-Demand Ride Services

The launch and spread of independent, on-demand ride-services, such as Uber and Lyft, has created new employment opportunities in transportation. Persons who provide ride services are considered independent contractors. Independent contractors are not counted in official U.S. job counts of transportation workers. In 2005 the Bureau of Labor Statistics (BLS) estimated 403,000 independent contractors in the transportation and material moving occupations as compared to 7.8 million workers with traditional arrangements [USDOL BLS2005]. BLS plans to include the Contingent Worker Supplement in the 2017 Current Population Survey to capture on-demand services employment.

FIGURE 5-7 Employment in Selected Transportation-Related Industries: 1990–2014



NOTE: Shaded areas indicate U.S recessions, as defined by the National Bureau of Economic Research.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 3-23, available at www.bts.gov as of July 2016.

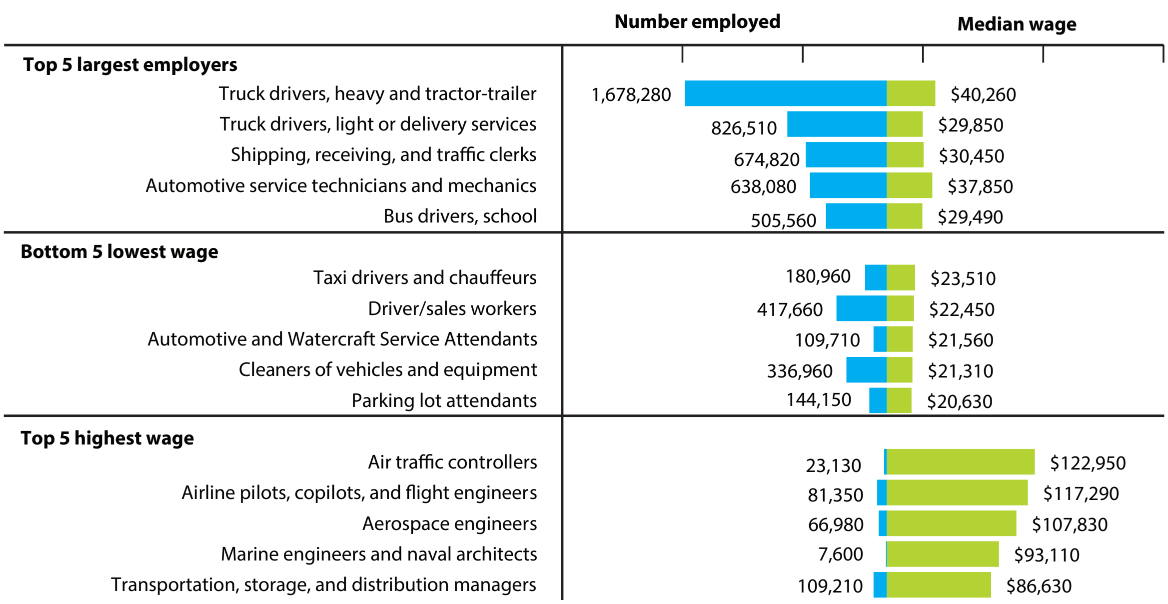
occupations. For example, in 2015 air traffic controllers, airline pilots, and aerospace engineers had an annual median wage of more than $100,000 while the largest transportation-related occupation, heavy and tractor-trailer truck drivers, had an annual median wage of $40,260. The top-five highest wage transportation-related occupations collectively employ fewer workers (288,270), while the lowest-five wage occupations employ 4.1 times more workers (1.2 million) (figure 5-8).

Transportation Productivity

The size of the transportation workforce depends on the demand for transportation and on firms' utilization of the workforce. Technological improvements, more efficient use of workers, and other factors allow firms to provide transportation services that use fewer employees.

Labor productivity measures the production of goods and services per hour of labor.

FIGURE 5-8 Employment and Wages in Selected Transportation and Transportation-Related Occupations: May 2015



KEY: SOC = Standard Occupational Classification

NOTE: Transportation and transportation-related occupations from U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 3-24, available at www.bts.gov

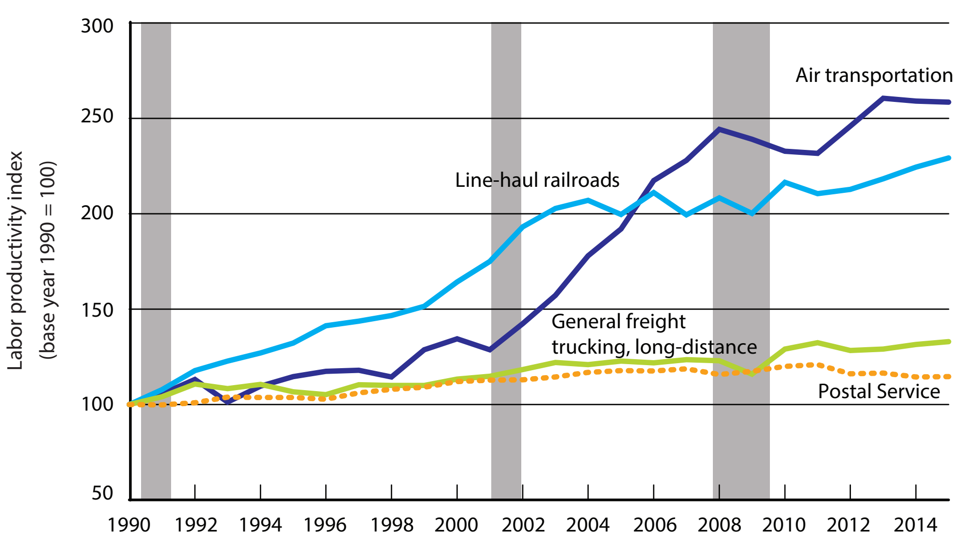
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Occupational Employment and Wages, available at http://www.bls.gov/oes as of May 2016.

From 1990 to 2015, air transportation's labor productivity increased 158.4 percent—the largest increase among transportation modes that collect labor productivity data—making air transportation the most productive mode in 2015. Labor productivity for rail increased by 129.3 percent during the same period. Smaller increases occurred in freight trucking (32.9 percent) and the U.S. Postal Service (14.6 percent) [USDOL BLS 2016c] (figure 5-9). Increases in labor productivity are the result of multiple factors, including a more efficient mix of labor and capital through technology growth, reductions in the workforce or wages following the recession, and changes in regulations among other potential market forces impacting the alignment between labor and output.

The impact of productivity on transportation companies can be seen through changes in the price charged per unit of output. For passenger transportation, the unit of output is passenger-miles, and average revenue per passenger-mile is the measure of what travelers pay. For freight transportation, the unit of output is ton-miles, and average freight revenue per ton-mile is the measure of what freight shippers pay. For modes where users do not typically pay per use, like driving, complete data are difficult to obtain. Increases in productivity often reduce business costs, which allow transportation companies to offer lower prices.

Figure 5-10 shows nominal changes in revenue per passenger-mile from 1990 to 2015 relative to the index for all consumer expenditures (the Consumer Price Index) 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 166.1 percent

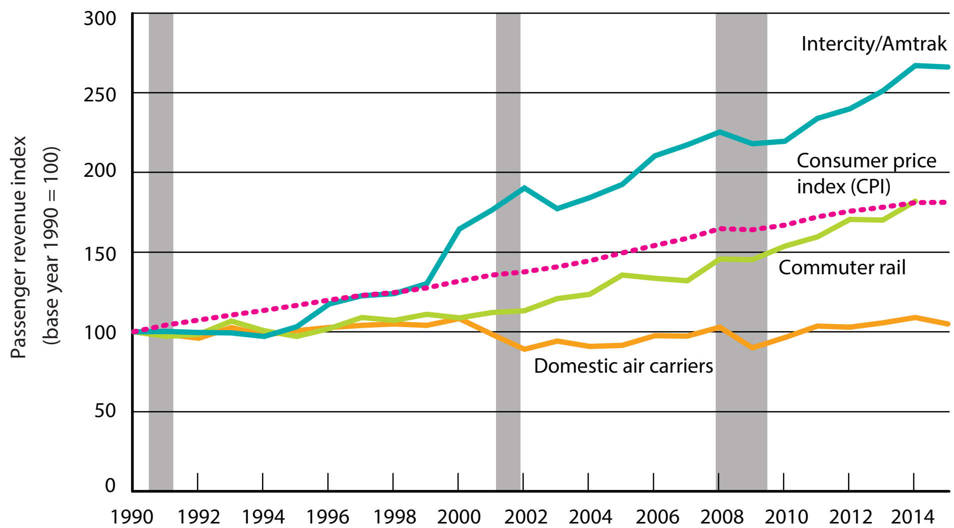
FIGURE 5-9 Labor Productivity Indices for Selected Transportation Industries: 1990–2015



NOTE: 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, Industry Productivity and Costs, available at *http://www.bls.gov/lpc/* as of May 2016

FIGURE 5-10 Revenue Per Unit of Output for Passenger Transportation Modes: 1990–2015



NOTE: Shaded areas indicate U.S recessions, as defined by the National Bureau of Economic Research.

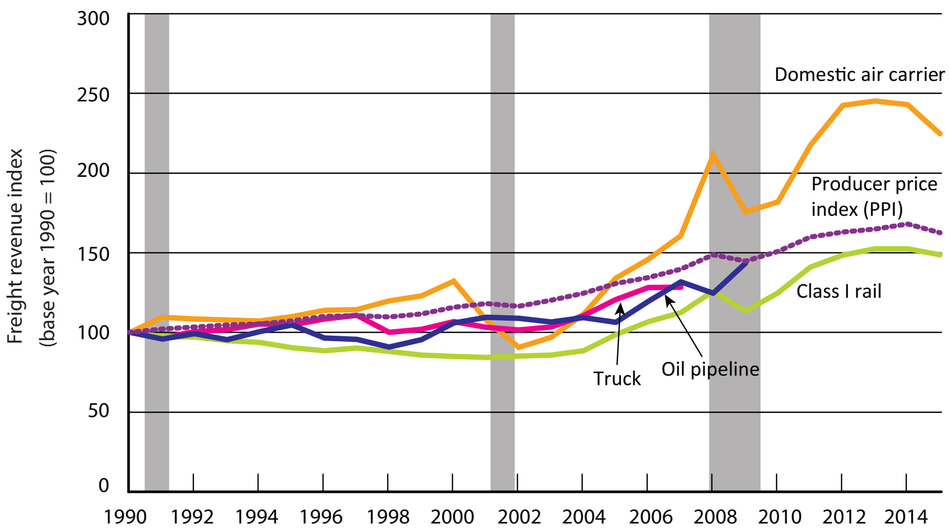
SOURCES: Air carrier, domestic, scheduled service (passenger): U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, *TranStats Database, T1: U.S. Air Carrier Traffic and Capacity Summary by Service Class*, available at http://www.transtats.bts.gov/DL_SelectFields.asp?Table_ID=264&DB_Short_Name=Air%20Carrier%20Summary as of Aug. 31, 2015 and *Air Carrier Financial Reports, Schedule P-1.2*, available at http://www.transtats.bts.gov/databases.asp?Mode_ID=1&Mode_Desc=Aviation&Subject_ID2=0 as of Aug. 31, 2015.
Commuter rail: 1990-2001: American Public Transportation Association, 2011 Public Transportation Fact Book (Washington, DC: 2011), tables 2 and 42 (passenger fares / passenger miles). 2002-13: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, *Data Tables 19 and 26* (Washington, D.C.: Annual reports), available at http://www.ntdprogram.gov/ntdprogram/data.htm as of Aug. 31, 2015.
Intercity/Amtrak: 1990-2002: National Passenger Rail Corporation (Amtrak), *Amtrak Annual Report*, Statistical Appendix (Washington, DC: Annual Issues) (transportation revenues / passenger-miles). 2003-13: Association of American Railroads, *Railroad Facts* (Washington, DC: Annual Issues), p. 77 and similar pages in previous editions (passenger revenue/revenue passenger miles). 2014-15: Amtrak, Monthly Performance Review for September 2015 (November 13, 2015), Tables A.2-2, A4-2, available at https://www.amtrak.com/ccurl/322/821/Amtrak-Monthly-Performance-Report-September-2015-Preliminary-Unaudited.pdf as of May 31, 2016.
Consumer Price Index: U.S. Department of Labor, Bureau of Labor Statistics, *Consumer Price Index-Urban*, U.S. All Items Indexes, available at http://www.bls.gov/cpi/ as of Aug. 31, 2015.

between 1990 and 2015, while commuter rail increased 81.9 percent between 1990 and 2014 (the latest year for which data are available). Domestic air carrier revenue per passenger-mile remained almost unchanged, increasing 4.9 percent.

The increases in revenue per passenger-mile are partly due to an increase in the overall price of goods and services. The CPI, which measures overall changes in prices, increased by 81.3 percent from 1990 to 2015, indicating that Amtrak/intercity rail was the only industry with real increasing revenue per passenger-mile during the period. Commuter rail only marginally surpassed the growth in the CPI (81.1 percent) between 1990 and 2014.

Figure 5-11 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 124.6 percent from

FIGURE 5-11 Revenue Per Unit of Output for Freight Transportation Modes: 1990–2015



NOTES: Shaded areas indicate U.S recessions, as defined by the National Bureau of Economic Research. Total finished goods. Converted to 1990 base year index by the Bureau of Transportation Statistics.

SOURCES: Air carrier, domestic, scheduled service (freight): U.S. Department of Transportation, Bureau of Transportation Statistics, *TranStats Database, T-1, Schedule P-11, and Schedule P-12 data*, available at http://www.transtats.bts.gov/ as of Sep. 1, 2015, special tabulation.
Truck: 1990-2003: Eno Transportation Foundation, Inc., Transportation in America (Washington, DC: 2007), p. 46.
2004-07: U.S. Department of Commerce, U.S. Census Bureau, *2009 Transportation Annual Survey* (Washington, DC: January 2011), table 2.1, available at http://www.census.gov/services/ as of Aug. 9, 2011, special tabulation.
Class I rail: Association of American Railroads, *Railroad Facts* (Washington, DC: Annual Issues), p. 34 and similar pages in previous editions.
Producer Price Index: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index-Commodities (finished goods), available at http://www.bls.gov/ppi/ as of Sept. 1, 2015.

1990 to 2015. Class I railroads[1] experienced a smaller increase in revenue per ton-mile of 48.7 percent in the same period. Domestic air freight was the only mode with a revenue increase greater than the overall increase in the prices received by transportation service providers for their services.[2] Domestic air freight, therefore, was the only mode to experience real growth in revenue per ton-mile from 1990 to 2015.

[1]As of 2014, Class I railroads are defined as line-haul freight railroads with annual operating revenues of $475.75 million or more.

[2] As measured by the producer price index (PPI).

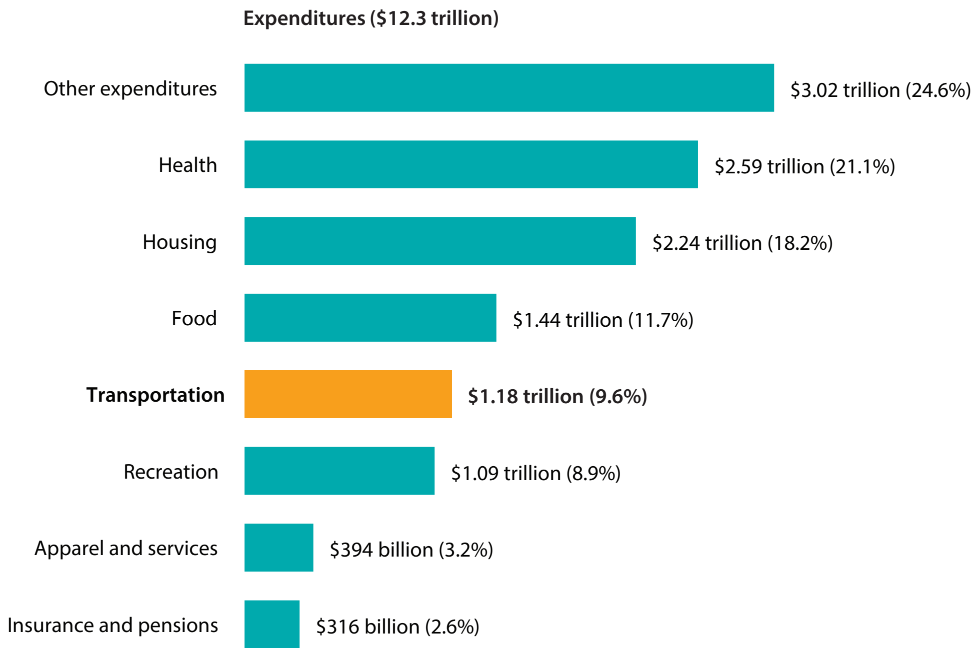
Transportation Expenditures and Revenues

Household Spending

In 2015 total national expenditures on transportation by and on behalf of U.S. residents amounted to $1,184 billion, making it the fourth largest expenditure category after healthcare, housing, and food (figure 5-12). Ninety-two percent of personal transportation expenditures went to the purchase, operation, and upkeep of personal vehicles [USDOC BEA 2016b].

Between 2000 and 2015, transportation expenditures increased 41.2 percent, from

FIGURE 5-12 Total National Household Expenditures (major expenditure categories): 2015



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 2.5.5, 2.4.5U, available at http://www.bea.gov/iTable/index_nipa.cfm as of May 2016.

$838 billion to $1,184 billion. The growth in total expenditures outpaced the growth in transportation expenditures, increasing 80.7 percent, from $6.79 trillion to $12.27 trillion over the same period. Expenditure growth for healthcare (133.5 percent), housing (84.1 percent), and food (78.1 percent) outpaced expenditure growth for transportation. As a result, the percentage of total expenditures for transportation declined from 12.3 percent in 2000 to 9.6 percent in 2015. [USDOC BEA 2016b]

Public and Private Sector Expenditures and Revenue

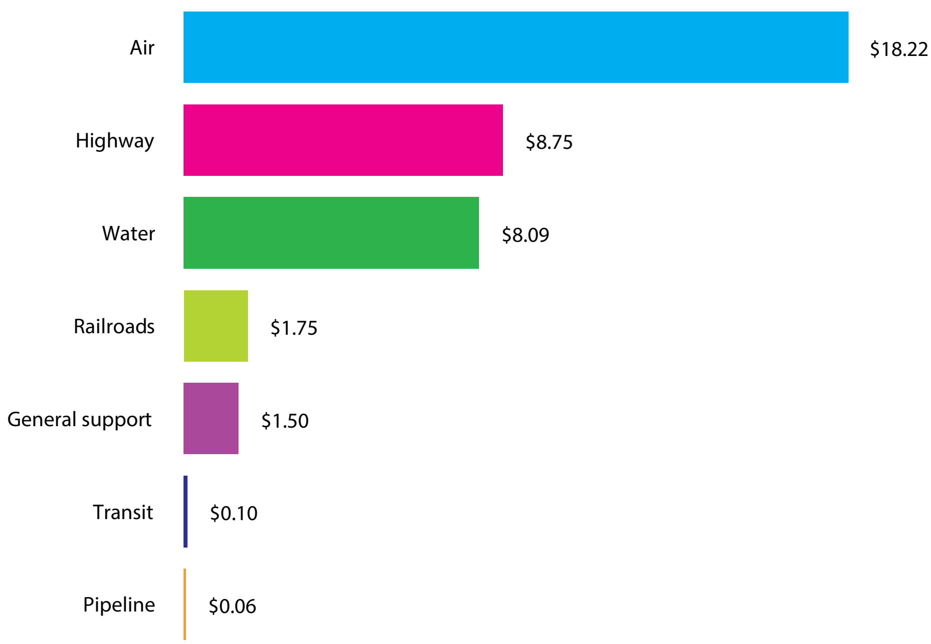
Expenditures

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 2012 the Federal Government spent $38.5 billion on transportation (excluding federal grants to states), and state and local governments spent $281.4 billion (including expenditures paid with federal grants). In real[3] 2009 dollars, transportation expenditures at all levels of government have increased since 1995. From 1995 to 2012, real state and local expenditures (including expenditures paid for with federal funds) increased more, at 36.8 percent, than federal expenditures, at 17.3 percent. In 2009 the Federal Government enacted the *American Recovery and Reinvestment Act of 2009* (Pub. L. 111–5), which authorized $48.1 billion in transportation stimulus spending. As a result, transportation government expenditures for 2009 rose significantly. [USDOT BTS 2016a]

Most federal spending (excluding federal grants to states) is for aviation ($18.2 billion in 2012, or 47.4 percent) and highways ($8.7 billion, or 22.7 percent) (figure 5-13). In real 2009 dollars, aviation spending peaked in 2002, when governments increased spending on airport security in response to September 11, 2001 and has since decreased by 40.3 percent. Federal highway spending peaked in 2010 with the post-recession stimulus spending, then declined. [USDOT BTS 2016a]

[3] Real dollars are chained dollar estimates, which remove the effects of inflation. Values are converted to chained dollars using the chain-type price index of government transportation consumption and gross investment from the Bureau of Economic Analysis' National Income and Product Accounts Tables.

FIGURE 5-13 Federal Transportation Expenditures by Mode: 2012 (billions)



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

SOURCE: US Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics 2014, Table 17-A, available at www.bts.gov as of July 2016.

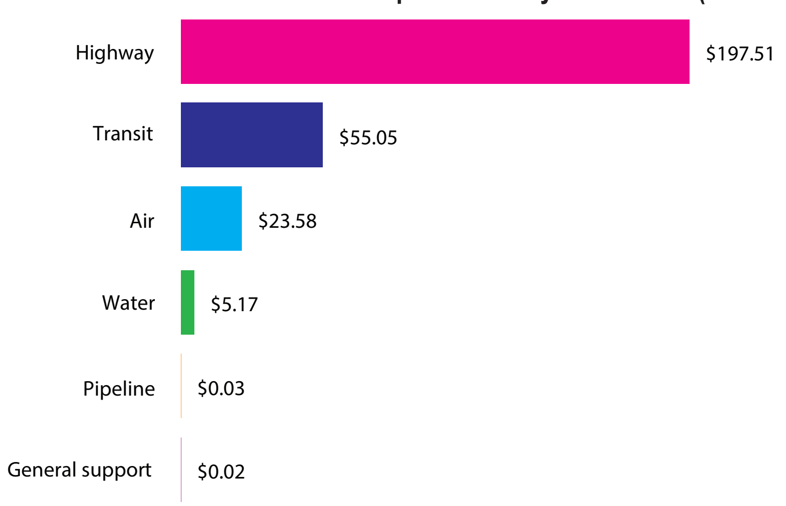
Most state and local spending (including expenditures paid for with federal grants) on transportation went to highways ($197.5 billion in 2012, or 70.2 percent) and transit ($55.1 billion, or 19.6 percent) (figure 5-14). In real 2009 dollars, both highway and transit expenditures have increased from 1995 to 2012—highways by 34.0 percent and transit by 36.5 percent. Highway and transit spending peaked in 2009 as a result of transportation stimulus spending. [USDOT BTS 2016a]

In 2015 private and public spending on transportation construction totaled $134.3 billion (figure 5-15). The public sector is the major funding source for transportation infrastructure construction, especially for streets and highways. In 2015 the value of government-funded (public) construction underway accounted for 90.2 percent ($121.2 billion) of total spending on transportation construction, and private transportation construction accounted for the remaining 9.8 percent ($13.1 billion). Approximately three-quarters of government-funded investment was for highways ($89.5 billion); the remainder supported the construction of air, land, and water transportation facilities ($31.7 billion). Investment has been growing since 2002, despite a slight decline in 2011 associated with the terminus of *American Recovery and Reinvestment Act of 2009* (Pub. L. 111–5) stimulus spending on transportation. [USDOC CENSUS 2016]

Revenue

Government transportation revenue comes from user taxes and fees, such as gasoline taxes and tolls, air ticket taxes and fees, and general revenues as well as income from investing transportation funds and receipts from fines and penalties. In 2012 government revenue collected and dedicated to transportation programs totaled $350.4 billion. A portion of this revenue ($180.2 billion, or

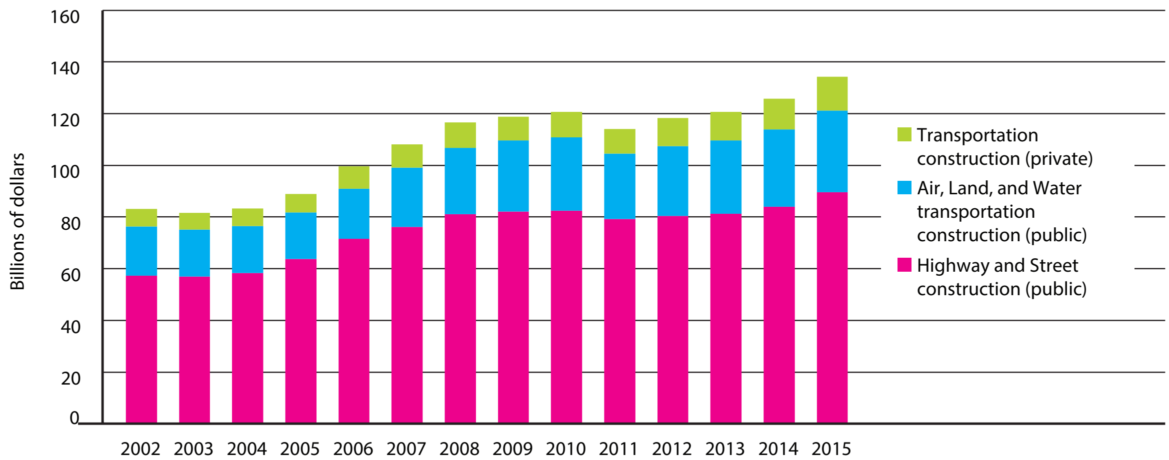
FIGURE 5-14 State and Local Expenditures by Mode: 2012 (billions)



NOTE: State and local expenditure includes outlays from all sources of funds including funds from federal grants.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics 2014, Table 17-A, available at www.bts.gov as of July 2016.

FIGURE 5-15 Value of Transportation Infrastructure Construction Put in Place (current dollars): 2002–2015



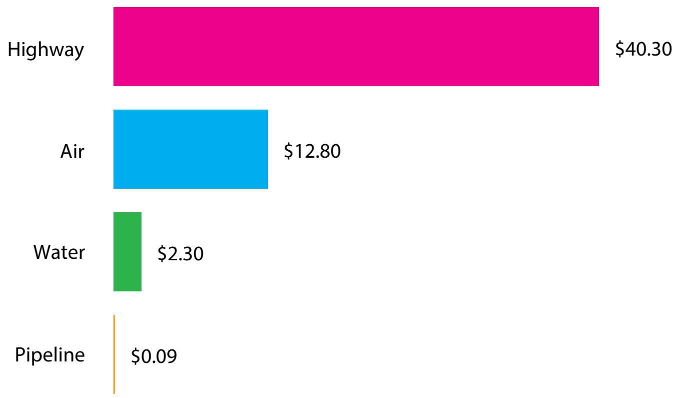
SOURCE: U.S. Department of Commerce, Census Bureau, Value of Construction Put in Place, Not Seasonally Adjusted (2002-2014), available at http://www.census.gov/ as of May 2016.

51.4 percent) comes from taxes and charges levied on transportation-related activities, while $170.3 billion (48.6 percent) comes from non-transportation-related activities but supports transportation programs (e.g., state or local sales or property taxes used to finance transportation projects). In addition to the $350.4 billion, governments collected $21.4 billion in revenue from transportation-related activities but diverted this revenue to nontransportation programs (e.g., revenue from motor fuel taxes directed to the general fund for other uses). In real 2009 dollars, total revenue collected by the government and dedicated to transportation programs increased by 43.3 percent from 1995 to 2012. [USDOT BTS 2016a]

The Federal Government collected $112.9 billion of the $350.4 billion (32.2 percent). Of this revenue, the Federal Government collected $55.5 billion from transportation-related activities, most of which came from highway and air transportation activity. Highway and air transportation, which have trust funds supported by dedicated taxes, accounted for 95.6 percent of federal transportation revenue in 2012. The Federal Government collected and dedicated $40.3 billion (72.6 percent) in highway revenues and $12.8 billion (23.1 percent) in aviation revenues to transportation programs (figure 5-16). In real 2009 dollars, highway trust fund revenues decreased by 8.7 percent from 1995 to 2012 [USDOT BTS 2016a]. 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, causing real revenues to decline. Revenues also declined because vehicle gas mileage improved over the last two decades and because vehicle miles traveled declined during the 2007 to 2009 recession.

State and local governments collected $237.6 billion of the $350.4 billion (67.8 percent). Of

FIGURE 5-16 Federal Own-Source Revenue by Mode: 2012 (billions)



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 2014, Table 10-A, available at www.bts.gov as of July 2016.

this revenue, the state and local governments collected $124.7 billion from transportation-related activities, most of which is from highway revenue sources ($84.8 billion, or 68.0 percent of transportation revenue in 2012), which include fuel taxes, motor vehicle taxes, and tolls. Aviation-related revenue ($18.3 billion, or 14.7 percent) comes from landing fees, terminal area rentals, and several other sources (figure 5-17).

Revenue collected from transportation-related activity and dedicated to transportation programs continues to fall short of government transportation expenditures. In 2012 transportation revenues covered 56.3 percent of expenditures. The gap between transportation revenues and expenditures has declined since 2009 when revenues covered 51.0 percent of expenditures [USDOT BTS 2016a]. When revenues do not cover expenditures, general tax receipts (e.g., from sales and property taxes), trust fund balances, and borrowing are needed to cover shortages.

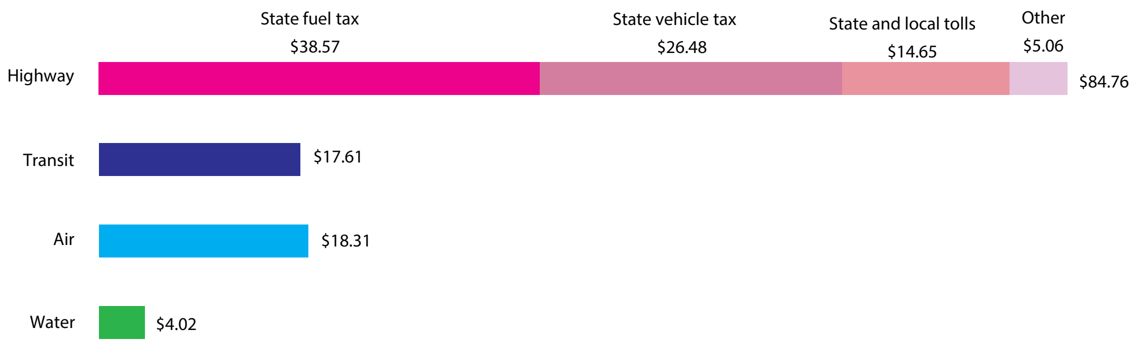
Cost of Transportation

The movement of goods and people requires the use of resources—labor, equipment, fuel, and infrastructure. The use of these resources is the cost of transportation. Producers and users of transportation services pay for the resources. Users of transportation services include businesses, the government, and households. Businesses pay for transportation to acquire inputs for the goods they make and to deliver final products to consumers. Households purchase resources, such as motor vehicles and motor vehicle fuel, for travel by automobile.

Costs Faced by Producers of Transportation Services

There are two types of transportation services provided: freight transportation services provided to producers of goods and service (e.g., trucking and air freight) and passenger transportation services provided to both producers and household consumers. The

FIGURE 5-17 State and Local Own Source Revenue by Mode: 2012 (billions)



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 2014, Table 9-A and 10-A, available at www.bts.gov as of July 2016.

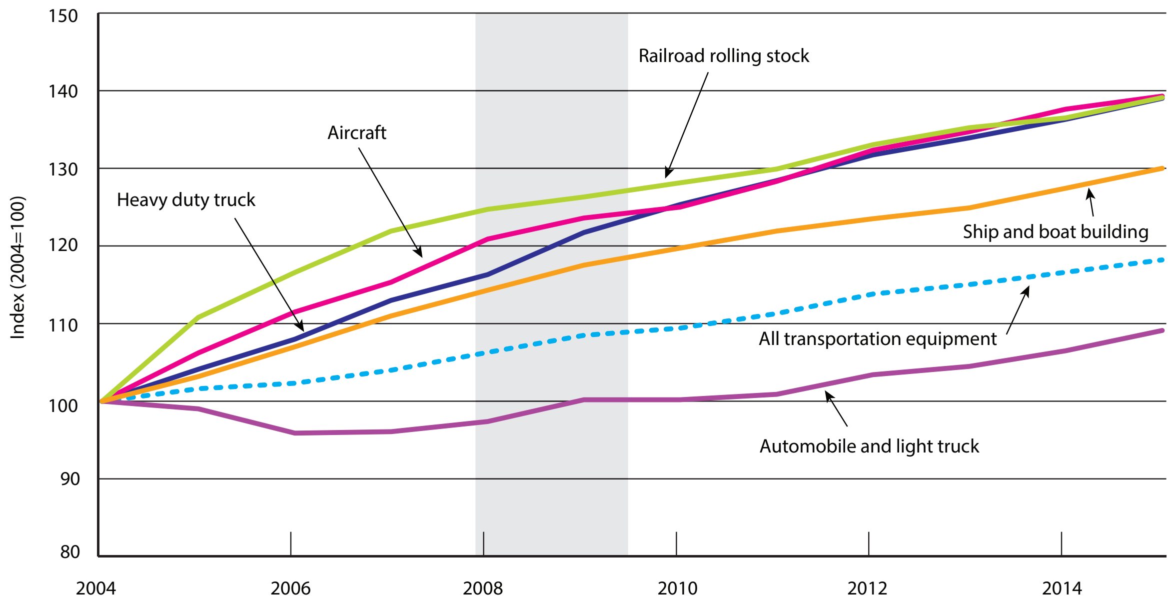
major inputs to produce transportation services include transportation equipment, fuel, labor, and other materials and supplies as well as the depreciation of items like airplanes, trucks, railroad locomotives and freight cars, trucking terminals, railroad track, and other infrastructure. The price of these inputs impacts the price of freight and passenger transportation services.

The costs faced by producers of transportation services for transportation equipment continuously increased between 2004 and 2015, except for automobiles and light duty motor vehicles (figure 5-18).[4] The costs faced when purchasing automobiles and light duty vehicles contrastingly declined between 2004 and 2008, leveled off from 2009 to 2010, and then increased between 2011 and 2015. The costs faced for railroad, aircraft, heavy duty truck, and ship and boat manufacturing showed greater growth than that for all transportation equipment combined. This increase in equipment prices potentially impacts the profitability and purchase decisions of transportation sectors, the transportation costs for transportation users, and/or prices in other sectors that use transportation services, such as wholesale, retail, and warehousing and storage industries.

Transportation fuel prices also impact the price of freight and passenger transportation and the demand for transportation. An increase in fuel prices, for instance, may reduce the demand for transportation modes reliant on that fuel and shift demand to transportation modes that use less costly fuels. Average annual fuel prices for all classes of transportation fuels, except aviation gasoline and railroad diesel fuel, peaked in 2012 and have since declined. The

[4] The Bureau of Labor Statistic's Producer Price Index (PPI) for transportation equipment (which includes indexes for automobile and light motor vehicles, aircraft, railroad rolling stock, heavy duty trucks, ships and boats, and all transportation equipment) reflects changes in transportation equipment prices faced by transportation service providers. The actual prices transportation service providers pay may differ from the prices sellers receive for the transportation equipment they sell because of government subsidies, sales and excise taxes, and distribution costs.

FIGURE 5-18 Average Change in Prices Faced by Transportation Providers in Purchasing Transportation Equipment: 2004–2015



NOTES: Annual averages. Rebased to 2004. 2015 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.

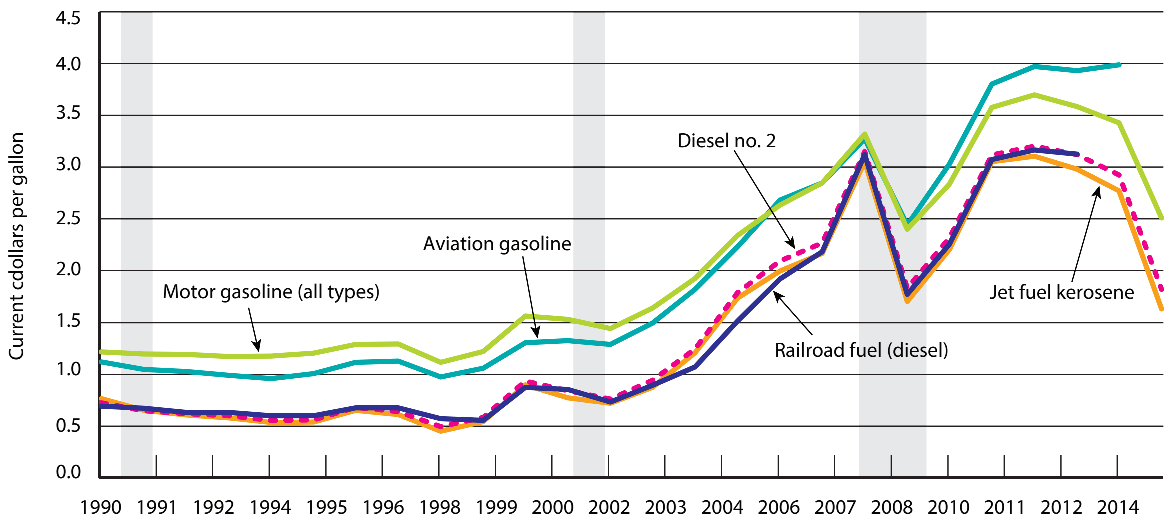
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index Industry Data, available at http://www.bls.gov as of May 2016.

average annual fuel price for gasoline peaked at $3.70 in 2012 and declined 32.1 percent to $2.51 in 2015 (figure 5-19). The most recent data for aviation gasoline and railroad diesel fuel show little change in price since 2012 (the most recent year for which data are available).

Costs Faced by Purchasers of Transportation Services

The prices that transportation companies charge for transportation impact freight shippers' and travelers' transportation decisions. Despite periods of modest decline, businesses purchasing transportation services saw an overall increase in the relative prices for air, rail, truck, water, and pipeline transportation services between 2004 and 2015. During that time, the costs faced by businesses to purchase rail services grew by 58.2 percent; more rapidly than that for any other transportation mode, except pipeline which grew 124.3 percent. The costs faced to purchase truck, water, and air transportation services also increased, with trucking services growing at a slightly slower rate (28.3 percent) than water (37.9 percent) and air (36.4 percent) transportation services. Transportation service prices declined during the 2007 to 2009 recession after which they climbed steadily through 2014. The average price of air, rail, and truck transportation services declined between 2014 and 2015, while water transportation service prices rose (figure 5-20).

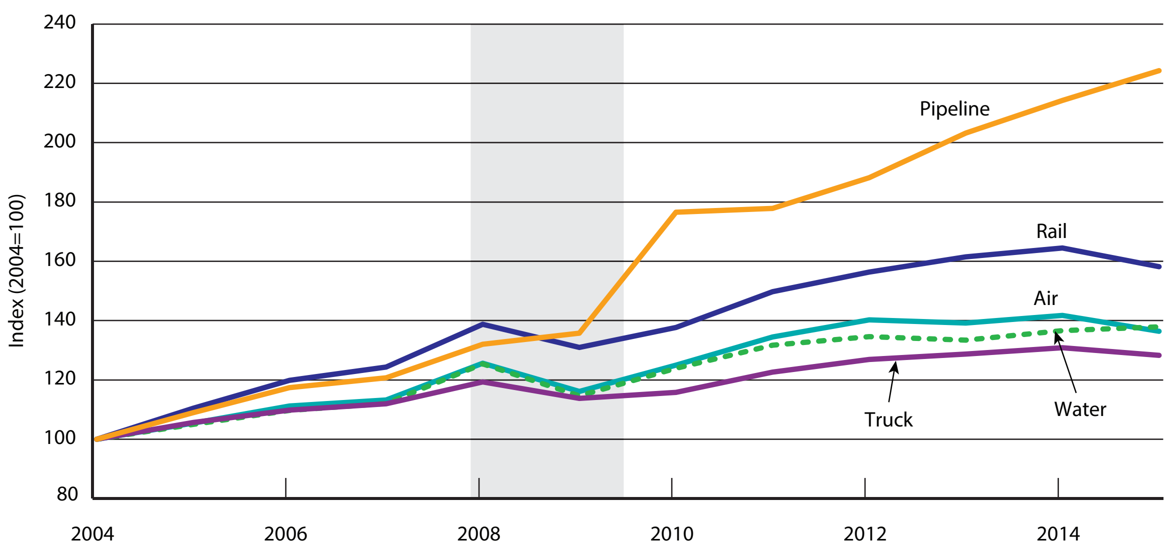
FIGURE 5-19 Sales Price of Transportation Fuel to End-Users (dollars/gallon): 1990–2015



NOTES: Railroad fuel data through 2013. Aviation gasoline through 2014. 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 May 2016.
Railroad fuel: Association of American Railroads, *Railroad Facts* (Washington, DC: Annual Issues), p. 61.

FIGURE 5-20 Average Changes to Transportation Prices Faced by Businesses Purchasing Transportation Services: 2004–2015



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

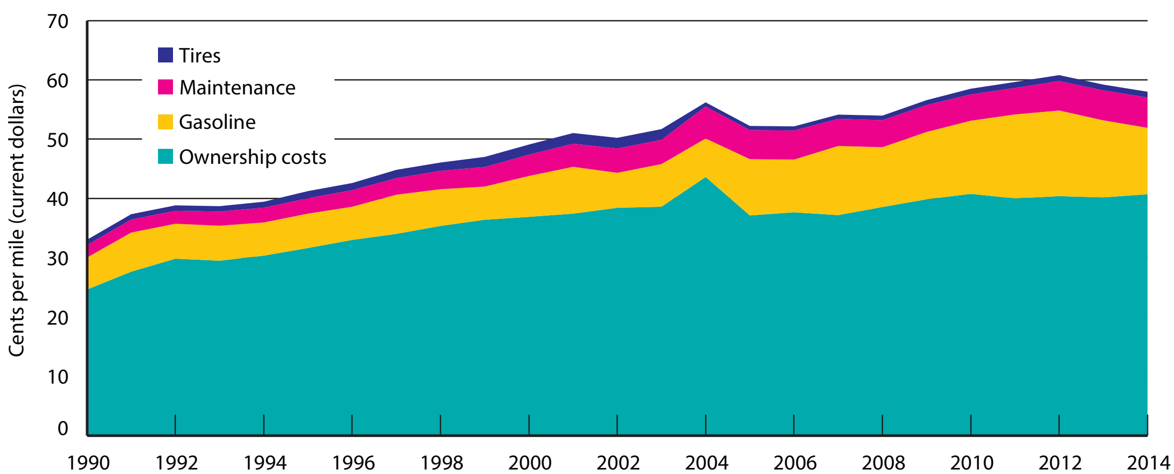
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index Industry Data, available at http://www.bls.gov as of May 2016.

Costs Faced by Households

The costs households face for transportation services (e.g., air travel) and transportation inputs (e.g., motor vehicle fuel) impact households' spending decisions. Most passenger travel in the United States is by personal motor vehicle. The cost of owning and operating personal motor vehicles impacts household travel behavior—what mode households choose, how often they travel, and how far.

The cost of owning and operating a personal motor vehicle includes insurance, license, registration, taxes, depreciation, and finance charges (ownership costs) as well as gasoline, tires, and maintenance (operating costs). Ownership costs accounted for nearly three-fourths of the total annual cost of owning and operating a personal motor vehicle on a cents per mile basis in 2014. Ownership costs in 2014, however, accounted for a smaller share of the total annual cost than in 1990, while operating costs accounted for a larger share. Looking at operating costs, the cost of both gasoline (the largest operating cost) and maintenance grew from 1990 through 2014, while the cost of tires rose from 1990 through 2003, declined in 2004, and then increased slightly between 2008 and 2014. Looking at the most recent years, the average total cost of gasoline per mile has fallen from a high of 14.5¢ per mile in 2012. In 2014 the average total cost of operating a personal motor vehicle (assuming 15,000 vehicle miles per year) was 58.0¢ per mile (figure 5-21).

FIGURE 5-21 Average Cost of Owning and Operating an Automobile (assuming 15,000 vehicle-miles per year): 1990–2014



NOTES: Figure reflects the average cost of operating a vehicle 15,000 miles per year in stop and go conditions. Ownership costs include insurance, license, registration, taxes, depreciation, and finance charges.

SOURCE: American Automobile Association, Your Driving Costs (Heathrow, FL: Annual Issues), available at http://www.aaapublicaffairs.com as of Oct. 7, 2015.

According to the Consumer Price Index for Urban Consumers (CPI-U),[5] the average price of owning and operating a personal motor vehicle (private transportation in the CPI-U) rose (63.0 percent) between 1990 and 2015, albeit less than for all goods and services (81.3 percent). Of personal motor vehicle ownership and operating costs, motor vehicle insurance prices increased the most between 1990 and 2015, growing 158.9 percent. The average price of new vehicles grew the least, increasing only 21.2 percent over the same period. [USDOL BLS 2016a]

The total average price of owning and operating a personal motor vehicle grew less than public transportation. Between 1990 and 2015, public transportation prices increased 88.4 percent [USDOL BLS 2016a]. The rise in airfare and intracity transportation prices drove the growth in public transportation prices between 1990 and 2015 (figure 5-22).

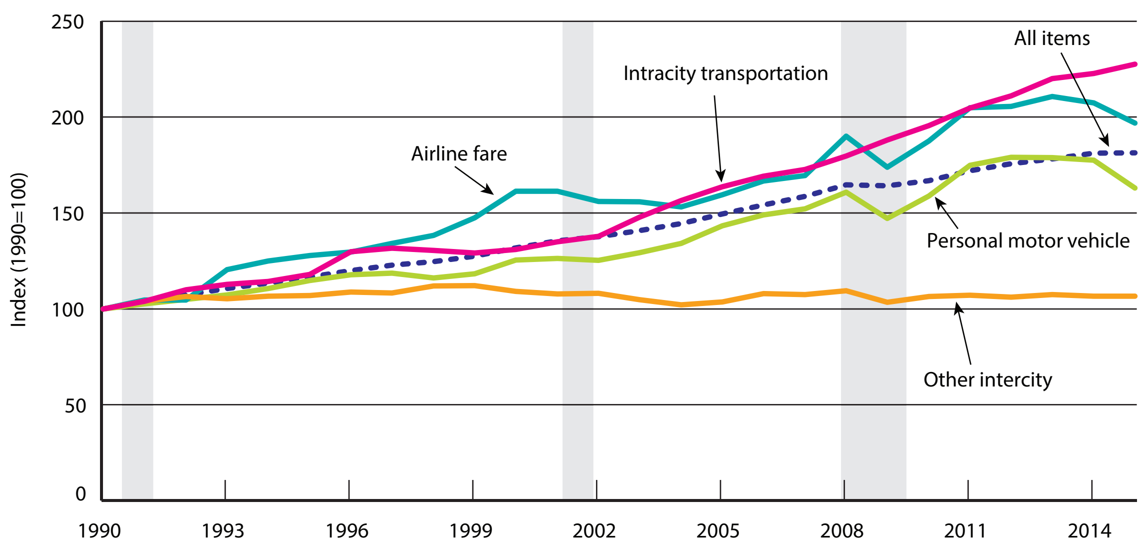
[5] The Consumer Price Index for Urban Consumers (CPI-U) measures the change in prices paid by urban consumers for particular goods and services, such as ones related to transportation.

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.

FIGURE 5-22 Average Changes to Transportation Prices Paid by Urban Consumers: 1990–2015



NOTES: Annual averages. Rebased to 1990. 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 May 2016.

The value of goods traded (the total value of exports and imports) was $3.8 trillion in 2015 (current dollars). After accounting for inflation, the real value of goods traded grew from 2000 to 2015, despite a slight decline during the 2007 to 2009 recession. Exports account for an increasing share of the total value of goods traded, but imports in goods continue to exceed exports. In 2015 the goods deficit (exports minus imports) was $775.7 billion in current dollars [USDOC BEA 2016e].

In 2015, 18.2 percent ($690.0 billion) of all goods traded internationally were related directly to transportation.[6] Fuel oil comprised an additional 1.8 percent of all goods traded in 2015 [USDOC BEA 2016d]. Across all goods traded related to transportation, new and used passenger cars accounted for the largest share. In 2015 imports of transportation-related goods exceeded exports except for civilian aircraft, aircraft engines and parts, and fuel oil[7] (figure 5-23).

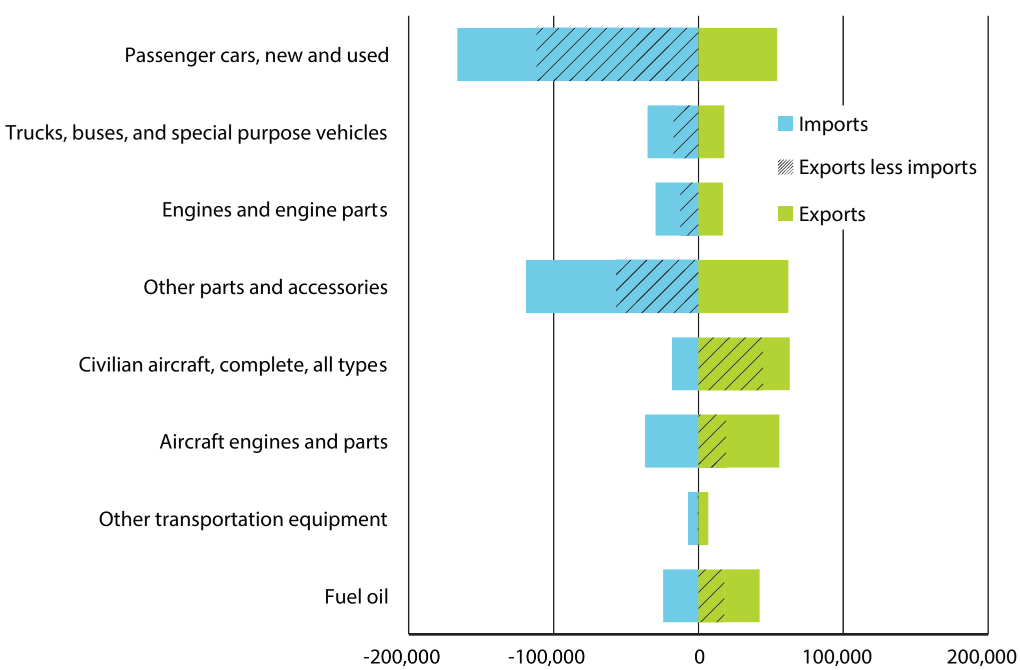
Transportation services are used to move goods from and to the United States. In 2015, $1.8 trillion (15.1 percent) of all services traded were related directly to transportation [USDOC BEA 2016c]. The value of transportation services traded captures the following:

1. passenger fares paid by U.S. residents (foreign residents) to airline carriers and

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

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

FIGURE 5-23 U.S. Trade of Transportation-related Goods: 2015
(millions of current dollars)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, International Transactions (ITA), Table 3.1 U.S. International Trade in Goods. Interactive, Annual. Available at http://www.bea.gov/itable/ as of May 2016.

vessel operators of other countries (of the United States),

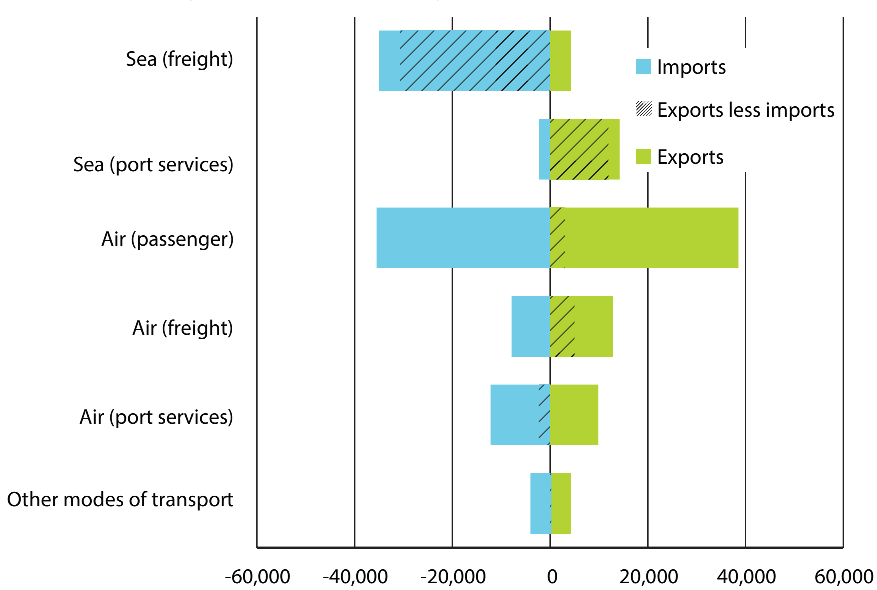
2. the freight charges for moving goods from and to the United States, and

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 2016f]

The fares and fees paid 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. However, since 2007 the amount received by foreign carriers for bringing goods and people to the United States accounts for an increasing share of total fares and fees paid to move goods and people to and from the United States [USDOC BEA 2016c].

Looking at individual modes, 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 5-24).

FIGURE 5-24 U.S. Trade of Transportation Services: 2015
(millions of current 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 Goods. Interactive, Annual. Available at http://www.bea.gov/itable/ as of May 2016.

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CHAPTER 6

Transportation Safety

Highlights

- Highway motor vehicle fatalities rose 7.2 percent in 2015 as the 35,092 highway deaths alone exceeded the 2014 number for all transportation fatalities (34,641).
- Fifteen highway rail crossings were identified as having 10 or more incidents (not necessarily involving fatalities) in the last decade.
- Pedestrian fatalities represent the third highest number of transportation related deaths in 2015 and have made up an increasing share of the total over the past 5 years, increasing from 12.3 percent in 2010 to 14.5 percent in 2015.
- The number of people injured in highway motor vehicle accidents increased by an estimated 105,000, to 2.44 million in 2015 – the first increase in the highway injury count since 2012.
- The total cost of motor vehicle crashes was estimated at $836 billion in 2010, with the broader societal costs, including lost quality of life, accounting for 71 percent of the total, far outweighing the economic costs at 29 percent.
- Motorcyclist injuries have increased 62.7 percent, from about 58,000 injured in 2000 to 92,000 in 2014.
- Alcohol use continues to be a major factor in transportation deaths and injuries. Alcohol involvement either by the driver or the pedestrian was reported in 48 percent of all fatal crashes involving pedestrians in 2014. Approximately 29 percent of motorcycle operators involved in fatal crashes were alcohol impaired, and alcohol use was a leading factor in 17 percent of fatal recreational boating accidents in 2015.
- Approximately 3,500 motor vehicle occupants and motorcyclists who died in crashes in 2015 might have lived if they had used seat belts or motorcycle helmets, and 85 percent of the boaters who drowned in 2015 were not wearing a life jacket.
- In 2014 pilots reported 238 unmanned aircraft sightings in the United States. There were about 5 times as many sightings (about 1,210) in 2015.

While highway fatalities and injuries increased from 2014 to 2015, highway safety, and transportation safety as a whole, have improved in recent decades, resulting in a notable decline in fatalities and injuries. Despite growth in the U.S. population, the number of licensed drivers, and increased travel by *all modes* (as discussed in chapters 1 through 3), there were about 7,300 fewer transportation fatalities in 2015 than in 2000—a reduction of about 16.5 percent in 16 years. Yet, transportation still accounted for 25.2 percent of the total deaths resulting from unintentional injury in the United States in 2015 [USDHHS CDC VITALITY 2016].

As shown in box 6-A, the timeframe and definitions used to attribute a fatality to a transportation crash or accident differ among modes, reflecting different data collection methods, reporting periods, and information management systems of the various reporting agencies. For example, a death that occurs

Box 6-A Fatality Definition by Mode

Mode (Source)	Definition	Citation
Air	Fatal injury means any injury which results in death within 30 days of the accident.	49 CFR 830.2
Hazardous material	Fatalities must be reported as soon as practical, but no later than 12 hours after the incident and death resulting from injury must be reported within one year of the date of incident	49 CFR 171.15 and 49 CFR 171.16
Highway	Fatality means any injury which results in the death of a person at the time of the motor vehicle accident or within 30 days of the accident.	49 CFR 390.5
Pipeline	Fatalities reported as soon as practical but not more than 30 days after detection of an incident.	49 CFR 191.3 and 195.50
Railroad	Fatality means the death of a person within 24 hours of an accident. Also if an injured person dies within 180 days from the date of the injury.	49 CFR 840.2 and *FRA Guide for Preparing Accident/Incident Reports*
Rail transit	A fatality at the scene; or where an individual is confirmed dead within 30 days of a rail transit-related incident;	49 CFR 659.33
Recreational boating	Fatalities means a person dies within 24 hours of the accident. 10 days of the occurrence or death if an earlier report is not required	33 CFR 173 and 174

within 30 days of a crash involving highway vehicles is considered a highway fatality, while a death that occurs within 180 days of a rail incident is considered a rail-related death. Such definitional differences pose challenges when comparing safety records across modes of transportation.[1]

[1] For further discussion of these different definitions, see chapter 6 of *Transportation Statistics Annual Report 2015* box 6-B.

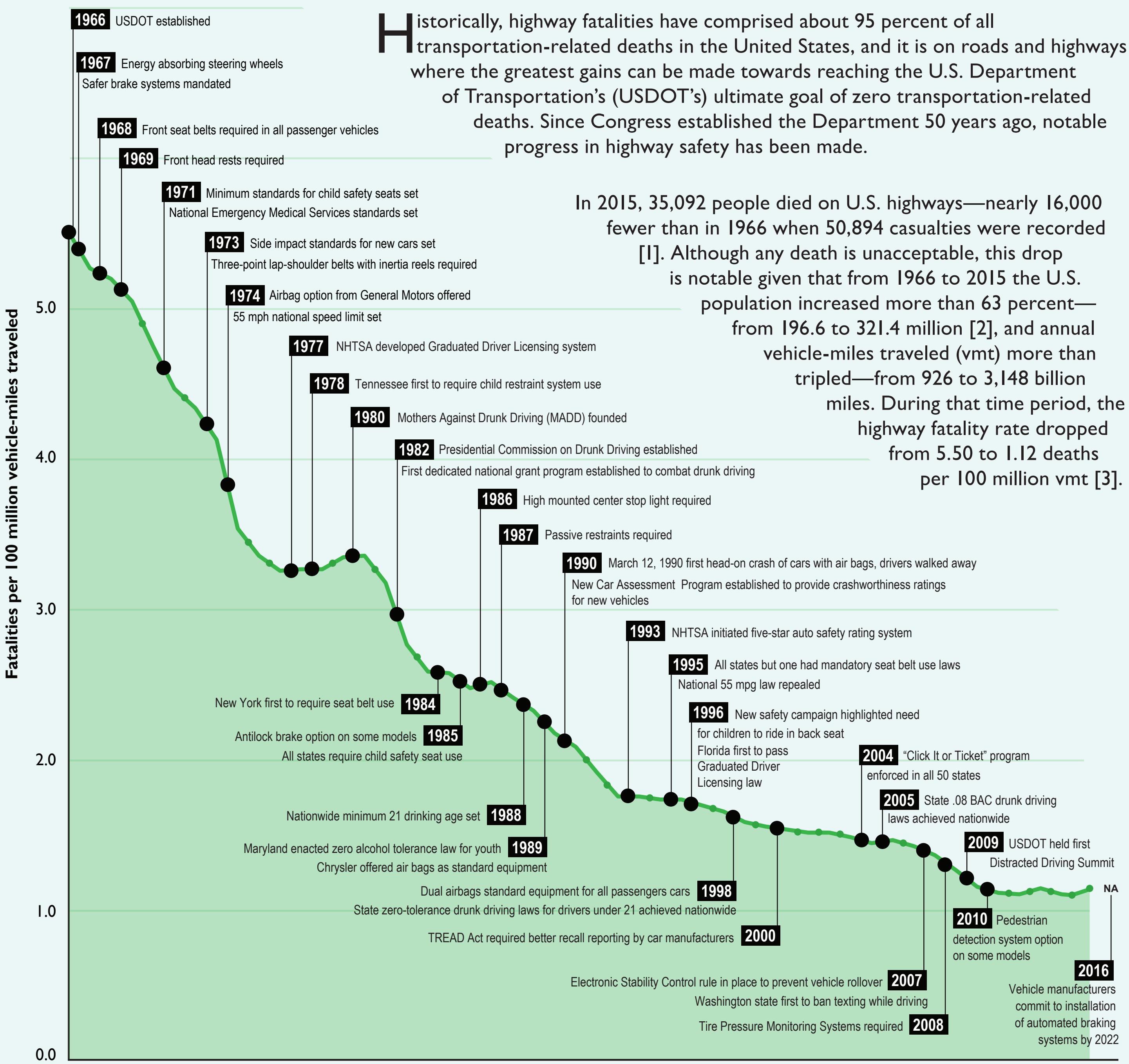
Fatalities by Mode

As shown in the figure 6-1*,* there has been a major decrease in both the number and rate of highway fatalities over the last 50 years—with deaths per hundred million miles of highway travel falling from over 5.50 in 1966 to 1.12 in 2015. While figure 6-1 shows that the most dramatic improvement occurred in the 1970s and 1980s, progress continues despite growth in the U.S. population and number of drivers (see figures 6-2 and 6-3).

FIGURE 6-1 A Half Century of Highway Safety Innovations–1966 to 2016

Historically, highway fatalities have comprised about 95 percent of all transportation-related deaths in the United States, and it is on roads and highways where the greatest gains can be made towards reaching the U.S. Department of Transportation's (USDOT's) ultimate goal of zero transportation-related deaths. Since Congress established the Department 50 years ago, notable progress in highway safety has been made.

In 2015, 35,092 people died on U.S. highways—nearly 16,000 fewer than in 1966 when 50,894 casualties were recorded [1]. Although any death is unacceptable, this drop is notable given that from 1966 to 2015 the U.S. population increased more than 63 percent—from 196.6 to 321.4 million [2], and annual vehicle-miles traveled (vmt) more than tripled—from 926 to 3,148 billion miles. During that time period, the highway fatality rate dropped from 5.50 to 1.12 deaths per 100 million vmt [3].



Final 2016 fatality data not available. Fatalities per 100 million vehicle-miles traveled climbed from 1.08 in 2014 to 1.12 in 2015 as fatalities increased 7.2 percent.

Using 1966 as the base year, this graph plots the cumulative effect of safety innovations, over time, on annual highway fatalities per 100 million vehicle-miles traveled.

1966—A Pivotal Year for Highway Safety

Fifty years ago, on September 9, 1966, in answer to an alarming growth in annual highway-related deaths, President Lyndon Johnson signed both the National Traffic and Motor Vehicle Safety Act and the Highway Safety Act into law [4]. And on October 15, 1966, Congress established the USDOT with a multimodal mission to "Serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system ..." [5]. This legislation also established the agency that 4 years later would become the National Highway Traffic Safety Administration (NHTSA).

Although these actions firmly established the Federal Government's responsibility for setting and enforcing transportation safety standards for all modes of transportation, the greatest impact would be on highway safety.

A Snowball Effect

Since 1966 there has been a dramatic drop in highway deaths. Many factors are responsible for this decrease—both regulatory and social:

• Safer vehicle designs and new safety technologies, such as seat belts, air bags, and electronic stability control, combined with programs to increase the use of seat belts and other safety equipment. NHTSA estimates that these technologies saved more than 600,000 lives from 1960 through 2012—nearly 28,000 in 2012 alone, of which more than half were saved by seat belts [6].

• Safer roads, including major new infrastructure, such as completion of the Interstate Highway System and gradual improvements to existing roads, such as guardrails, lighting, and rumble strips.

• Behavioral safety programs, such as high-visibility enforcement and child occupant protection campaigns, have encouraged more people to buckle up, use appropriate child safety seats, and to drive sober.

• More comprehensive and standardized emergency medical services, more effective transport and trauma treatment, and developments in medicine that made injuries more survivable [6].

While it is not possible to pin an exact number of lives saved to a particular safety factor, regulatory or otherwise, it is possible to show the cumulative effect of these innovations over time.

The 1960s

The decade of the 60s would see highway fatalities increase 47.1 percent, from 36,399 deaths in 1960 to 53,543 deaths in 1969. In near parallel, vehicle-miles traveled (vmt) increased 47.8 percent, from about 720 billion to more than 1 trillion miles during that same time period. The number of highway fatalities would continue to increase well into the 1970s, until the effects of new regulations and social reforms finally kicked in.

The 1970s

From 1970 through 1979, nearly a half million lives (498,356) were lost on U.S. roads. In 1972 U.S. highways would claim 54,589 lives—the highest number ever recorded. But as the decade closed, highway deaths per 100 million vmt had dropped from 4.74 in 1970 to 3.34 by 1979, even as vmt increased by 37.8 percent. Still, the 51,093 lives lost in 1979 nearly matched the 52,627 lost in 1970 [7].

The 1980s

At last, the decade of the 80s would show a notable drop in highway deaths, with 5,500 fewer lives lost in 1989 than in 1980 (45,582 v. 51,091). Even more remarkable, this drop occurred in the face of a 37.6 percent increase in vmt and a population that grew by nearly 20 million, pushing down the number of lives lost from 3.35 to 2.17 per 100 million vmt.

The 1990s

At first glance the drop in the annual number of lives lost at the beginning of the decade (44,599) versus those lost at the end of the decade (41,717) might seem unremarkable. But from 1990 through 1999 the U.S. population increased by more than 23 million, while the rate of lives lost on U.S. highways continued to fall, from 2.08 to 1.55 per 100 million vmt—a nearly 72 percent drop from the 5.50 deaths per 100 million vmt recorded in 1966.

A New Century

The first years of the 21st century saw the highway fatality rate per 100 million vmt drop more than 25 percent, falling from 1.53 deaths per 100 million vmt in 2000 to 1.12 by 2015 [8]. By 2004 the 0.08 blood alcohol limit and the "Click It or Ticket" campaign were enforced nationwide. Distracted driving emerged as a new challenge, and intelligent transportation systems, electronic stability controls, and the advent of self-driving cars ushered in a new era of innovations designed to mitigate the effects of human error.

Getting to Zero

A number of active safety systems are now available or are under development: forward collision warning, active braking, rear-view backup cameras, parking assist, lane departure, and blind spot warning—all technologies aimed at reducing or eliminating the effects of human error. In addition to these systems, connected and automated vehicle technologies are poised to play prominent roles in further reducing highway fatalities.

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Although the highway mode accounts for most of the decline in fatalities, other modes, including air carriers, railroads, transit, and recreational boating, also show improved safety records. In 2015 about 1,900 people died in accidents involving the non-highway modes as compared to 2,300 in the year 2000. Relatively few passengers die in train or bus crashes in an average year; however, it is almost an annual occurrence for 700 to 800 pedestrians or people in motor vehicles at highway-railroad crossings to die when struck by a train and by transit vehicles. Both general aviation and recreational boating result in the deaths of several hundred people each year.

Highway

Highway fatalities in 2015 grew by 2,353 (7.2 percent) over the 2014 level, from 32,744 to 35,092. This was the first annual increase in highway fatalities since 2012, and the greatest annual fatality total since 2008 [USDOT NHTSA 2016a]. Table 6-1 shows fatality change by highway component between 2014 and 2015; as shown, all categories of highway fatalities increased in 2015.

The biggest numerical increases from 2014 were for occupants of passenger cars and light trucks; the largest percentage increases were for bicyclists and other pedalcyclists, pedestrians, and motorcyclists [USDOT NHTSA 2016a]. The National Highway Traffic Safety Administration (NHTSA) also found that the highway fatality rate had increased from 1.08 deaths per 100 million highway vehicle-miles of travel in 2014 to 1.12 deaths in 2015.[2]

In addition to the fatality data, NHTSA also released highway injury estimates for 2015. Unlike fatalities, which are tallied from police accident reports, injuries are estimated from a sample and are subject to sampling errors. NHTSA estimated that injuries in 2015 increased by 4.5 percent in 2015 compared to

[2] NHTSA noted that the 2014 rate was the lowest since the agency began collecting fatality data through the Fatality Analysis Reporting System in 1975.

TABLE 6-1 Change in Highway Fatalities Between 2014 and 2015

	2014	2015	Net increase	Percent change
Total Highway Fatalities	**32,744**	**35,092**	**2,353**	**7.19**
Passenger car occupants	11,947	12,628	681	5.70
Light truck occupants	9,103	9,813	710	7.80
Pedestrians	4,910	5,376	466	9.49
Motorcyclists	4,594	4,976	382	8.32
Other highway incidents[1]	761	765	4	0.53
Pedalcyclists	729	818	89	12.21
Large truck occupants	656	667	11	1.68
Bus occupants	44	49	5	11.36

[1]Includes occupants of other vehicle types, other nonmotorists, and unknown.

SOURCE: U.S. Department of Transportation, National Highway Transportation Safety Administration, special tabulation, 2016.

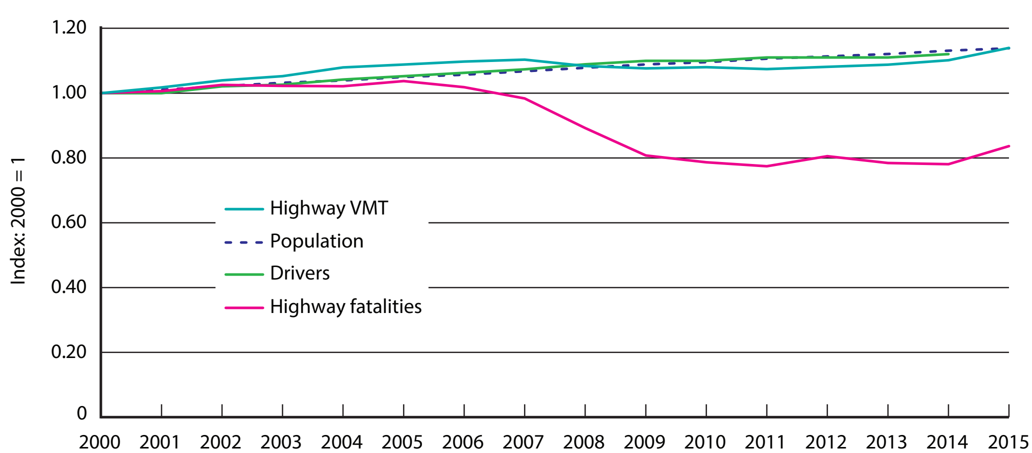
2014. The estimated number of injuries was about 2.42 million, up 105,000 from the 2014 estimate of 2.33 million.

Even with the recent spike in the highway fatality rate, from 2000 through 2015 the overall rate of highway fatalities per vehicle-mile of travel (VMT) declined by 26.8 percent (figure 6-2). Over time, occupant protection devices, advances in vehicle design, improved road design, graduated driver licensing for teenagers, expanded education and enforcement of drunk-driving laws, and many other preventative measures contributed to declines in highway vehicles deaths and injuries. Improvements in emergency medical response capabilities also played a role.

In 2015 occupants of passenger cars and other light-duty highway vehicles (e.g., sport utility vehicle, minivan, and pickup truck) comprised 63.9 percent of all transportation fatalities (tables 6-1 and 6-3). About 9,800 fewer occupants of passenger cars and light-duty vehicles died in 2015 crashes than in 2000 [USDOT BTS 2016]. Even with the 2015 fatality increases, there were nearly 10,000 fewer deaths in these two categories than in 2000.

Not all categories of highway fatalities are lower today than in 2000, however. In 2015, 4,976 motorcyclists died—nearly 2,100 more than in 2000 and 390 more than in 2014. Growing ridership is a contributing factor to this increase. Motorcyclists' share of all transportation fatalities also rose from 6.5 percent in 2000 to 13.5 percent in 2015, the last year for which data for all transportation modes were available. The increase not only reflects the drop in the share of deaths attributable to other highway categories but

FIGURE 6-2 Licensed Drivers, Resident Population, Highway Fatalities, Highway Vehicle-Miles Traveled (VMT): 2000–2014, 2015



SOURCES: Drivers and **Resident Population**: U.S. Department of Transportation (USDOT), Federal Highway Administration, *Highway Statistics 2014*, tables DV-1C, available at http://www.fhwa.dot.gov/policyinformation/statistics/2014 as of April 2016. **Highway Fatalities** and **Highway VMT**: USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, tables 1-35 and 2-1, available at www.bts.gov as of April 2016.

TABLE 6-2: Transportation Fatalities by Mode: 1990, 2000, and 2010-2015

	1990	2000	2010	2011	2012	2013	2014	2015
TOTAL fatalities	**47,297**	**44,276**	**35,036**	**34,570**	**35,696**	**34,685**	**34,641**	**36,982**
Air, total	866	764	477	34,570	450	430	444	404
Highway, total	44,599	41,945	32,999	32,479	33,782	32,894	32,744	35,092
Railroad, total[a]	1,297	937	735	682	674	700	768	759
Transit, total[b]	339	295	221	228	264	266	236	254
Water, total	865	701	821	904	765	650	674	692
Pipeline, total	9	38	19	12	10	8	19	10
Other counts, redundant with above								
Railroad, trespasser deaths not at highway-rail crossing	543	463	441	400	410	425	470	454
Railroad, killed at public crossing with motor vehicle	568	306	136	138	135	141	143	126
Passenger rail	202	220	215	189	199	195	216	250
Freight rail	1,095	717	520	493	476	505	553	503
Transit, non-rail	110	98	100	96	114	122	101	103
Transit, rail	229	197	120	132	150	144	135	151

[a] Includes Amtrak. Fatalities include those resulting from train accidents, highway-rail crossing incidents, and other incidents.
[b] 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 2001 and before is not comparable with later year due to a change in the reporting system. A change reporting requirements led to an increase in 2008.

KEY: NA = not available.

NOTES: To reduce double counting, the following adjustments are made to Total Fatalities: For Railroad, fatalities involving motor vehicles at public highway-rail grade crossings are excluded because such fatalities are assumed to be included in Highway fatalities. For Transit, non-rail modes, including aerial tramway, motor bus, bus rapid transit, commuter bus, demand response, demand taxi, ferryboat, jitney, publico, trolleybus, and vanpool fatalities are excluded because they are counted as Transit, Water, and Highway fatalities. Other counts, redundant with above help elminate doublecounting in the Total Fatalities.

SOURCES: Various sources as cited by U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-1, available at www.bts.gov as of January 2017.

also nonhighway modes of transportation. As is indicated in figure 6-3, there has been little or no improvement in the fatality rate per vehicle-mile of travel by motorcycle since 2007.[3]

Between 2012 and 2015, the number of pedestrian deaths each year exceeded pedestrian deaths in 2000, as did deaths of bicyclists and other human-powered cyclists. Pedestrians and bicyclists—who often share the roads with motor vehicles—accounted for 16.7 percent of total transportation-related deaths in 2015, compared to 12.3 percent in 2000.

Fatality rates (measured per 100,000 U.S. population) of pedestrians, bicyclists, bystanders, and other nonoccupants killed when struck by motor vehicles, declined less dramatically, about 10 percent between 2000 and 2014. Pedestrians are more likely to be struck in the dark (72 percent of pedestrian fatalities) and away from intersection crosswalks (71 percent of fatalities) [USDOT NHTSA 2016b].

[3] A methodology change makes it inappropriate to compare motorcycle fatality rates per vehicle-mile traveled for 2006 and prior years with rates for 2007 and subsequent years.

TABLE 6-3 Distribution of Transportation Fatalities: 2000 and 2010–2015

	2000		2010		2011		2012		2013		(R) 2014		(P) 2015	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
TOTAL fatalities	**44,276**	**100.0**	**35,036**	**100.0**	**34,570**	**100.0**	**35,696**	**100.0**	**34,685**	**100.0**	**34,641**	**100.0**	**36,982**	**100.0**
Passenger car occupants	20,699	46.7	12,491	35.7	12,014	34.8	12,361	34.6	12,037	34.7	11,947	34.5	12,628	34.1
Light-truck occupants	11,526	26.0	9,782	27.9	9,302	26.9	9,418	26.4	9,187	26.5	9,103	26.3	9,813	26.5
Pedestrians	4,763	10.8	4,302	12.3	4,457	12.9	4,818	13.5	4,779	13.8	4,910	14.2	5,376	14.5
Motorcyclists	2,897	6.5	4,518	12.9	4,630	13.4	4,986	14.0	4,692	13.5	4,594	13.3	4,976	13.5
Pedalcyclists	693	1.6	623	1.8	682	2.0	734	2.1	749	2.2	729	2.1	818	2.2
Highway, other incident	591	1.3	709	2.0	699	2.0	729	2.0	701	2.0	761	2.2	765	2.1
Heavy-truck occupants	754	1.7	530	1.5	640	1.9	697	2.0	695	2.0	656	1.9	667	1.8
Recreational boating	701	1.6	672	1.9	758	2.2	651	1.8	560	1.6	610	1.8	626	1.7
Railroad, trespassers	463	1.0	441	1.3	400	1.2	410	1.1	425	1.2	470	1.4	459	1.2
General aviation	596	1.3	458	1.3	452	1.3	438	1.2	391	1.1	424	1.2	376	1.0
Highway-rail grade crossing	425	1.0	261	0.7	246	0.7	231	0.6	232	0.7	262	0.8	235	0.6
Transit, other incident	N	NA	166	0.5	189	0.5	192	0.5	196	0.6	174	0.5	220	0.6
Rail, other incidents	39	0.1	25	0.1	30	0.1	24	0.1	32	0.1	31	0.1	52	0.1
Bus occupants	22	0.0	44	0.1	55	0.2	39	0.1	54	0.2	44	0.1	49	0.1
Water, freight	U	NA	22	0.1	18	0.1	14	0.0	19	0.1	18	0.1	40	0.1
Transit passenger/occupant[1]	N	NA	49	0.1	36	0.1	67	0.2	60	0.2	58	0.2	30	0.1
On-demand air taxi	71	0.2	17	0.0	41	0.1	12	0.0	25	0.1	20	0.1	27	0.1
Water, passenger	15	0.0	87	0.2	96	0.3	84	0.2	26	0.1	14	0.0	14	0.0
Train accidents	10	0.0	8	0.0	6	0.0	9	0.0	11	0.0	5	0.0	13	0.0
Water, industrial/other	U	NA	40	0.1	32	0.1	16	0.0	45	0.1	32	0.1	12	0.0
Gas pipeline	37	0.1	18	0.1	11	0.0	7	0.0	7	0.0	19	0.1	9	0.0
Train employee/worker	N	NA	6	0.0	3	0.0	5	0.0	10	0.0	4	0.0	4	0.0
Commuter carrier	5	0.0	0	0.0	0	0.0	0	0.0	5	0.0	0	0.0	1	0.0
Hazardous liquid pipeline	1	0.0	1	0.0	1	0.0	3	0.0	1	0.0	0	0.0	1	0.0
U.S. air carrier	92	0.2	2	0.0	0	0.0	0	0.0	9	0.0	0	0.0	0	0.0
Other counts, redundant with above														
Rail, freight operations	717	1.6	520	1.5	493	1.4	476	1.3	505	1.5	553	1.6	503	1.4
Rail, passenger operations	220	0.5	215	0.6	189	0.5	199	0.6	195	0.6	216	0.6	250	0.7
Transit, rail	197	0.4	120	0.3	132	0.4	150	0.4	144	0.4	135	0.4	151	0.4
Railroad, killed at public crossing with motor vehicle	306	0.7	136	0.4	138	0.4	135	0.4	141	0.4	143	0.4	126	0.3
Transit, non-rail	98	0.2	100	0.3	96	0.3	114	0.3	122	0.4	101	0.3	103	0.3
Water, commercial	187	0.2	95	0.3	70	0.3	85	0.3	90	0.4	64	8.4	66	0.2

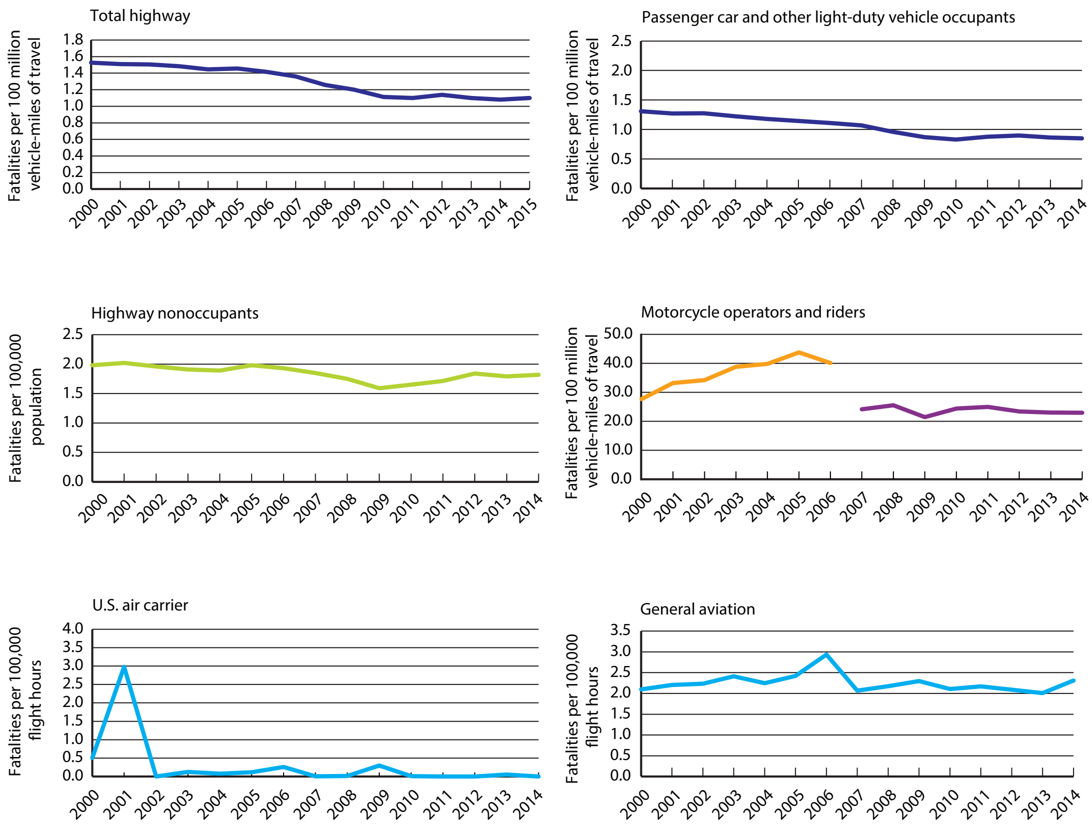
KEY: N = data do not exist; NA = not applicable; P = preliminary; R = revised; U= unavailable.

[1]Includes people struck while waiting for or leaving transit.

NOTES: Please see the *National Transportation Statistics* table 2-4 for complete source notes and an expanded time-series. To reduce double counting, the following adjustments are made to Total Fatalities: For Railroad, fatalities involving motor vehicles at public highway-rail grade crossings are excluded because such fatalities are assumed to be included in Highway fatalities. For Transit, non-rail modes, including aerial tramway, motor bus, bus rapid transit, commuter bus, demand response, demand taxi, ferryboat, jitney, publico, trolleybus, and vanpool fatalities are excluded because they are counted as Water and Highway fatalities. Other counts, redundant with above help eliminate double counting in the Total Fatalities. Water fatality data for 2001 and before is not comparable with later year due to a change in the reporting system.

SOURCES: Various sources as cited U.S. Department of Transportation, Bureau of Transportation, National Transportation Statistics, table 2-4. Available at www.bts.gov as of January 2017.

FIGURE 6-3 Fatality Rates for Selected Modes of Transportation: 2000–2014, 2015 (highway only)



NOTES: **Light-duty vehicles** includes passenger car, vans, mini-vans, sport utility vehicles, pickup truck and other light truck occupants. Motorcycle fatality rate before 2007 is not comparable to 2007 and beyond because of a change in methodology as indicated by the gap and change in line color. Air carrier fatalities resulting from the Sept. 11, 2001 terrorist acts include only onboard fatalities.

SOURCE: Calculated by U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS) based upon multiple sources as cited in USDOT, BTS, *National Transportation Statistics*. Tables 2-9, 2-14, 2-17, 2-19, 2-21, 2,22, and 2-23. Available at www.bts.gov as of April 2016.

There are about 5 million more females than males in the United States [USDOC CENSUS 2016]. Yet males comprise about 7 out of 10 highway fatalities. This difference is partially due to the fact that males, on average, drive more than females and thus have a higher rate of exposure to crashes.

Motor vehicle crashes continue to be the leading cause of death for teens aged 16 to 20 years [USDHHS CDC WISQARS 2015]. Teenagers and younger adults had the highest fatality numbers and fatality rates per 100,000 residents in 2014, although their deaths have declined considerably since 2000. A potential contributing factor is that those under the age of 30 in 2014 drove fewer miles than their counterparts in 2000, reducing the exposure to highway crashes.

At least 48 states have established some form of graduated driver licensing (GDL) program to help inexperienced, young drivers safely gain experience while limiting their exposure to high-risk driving conditions, such as night driving and carrying teenage passengers during early months of licensure [GHSA]. A recent review of state GDL program evaluations found that traffic crash outcomes were improved among 16 and 17 year old drivers by 16 and 11 percent respectively. However, this favorable association was not shown in a statistically reliable way for 18 and 19 year old drivers [Masten, S.V., et al.]

As in 2000, the number of males killed on U.S. highways exceeded the number of female fatalities for most age groups in 2015. Overall, males comprised 68.3 percent of highway fatalities in 2000 and 70.9 percent in 2015. Persons under the age of 30 continued to have the highest fatality numbers in 2015, although highway deaths for that age group were lower than for the same age grouping in 2000. The number of highway fatalities for males in their mid-40s to late 60s was higher in 2015 than it was for the men who were in the same age group in 2000 (figure 6-4). This cohort of males in 2015 was more numerous than their 2000 cohort and drove more miles—factors that likely contributed to the higher number of fatalities.

Since 2000 there has been a considerable decrease in highway fatalities per capita across all age groups for both genders. The greatest numbers of fatalities per capita age group in both 2015 and 2000 were among males between the ages of 18 and 30, followed by males 79 and older. Female fatalities per capita in both 2015 and 2000 peaked for those between 16 and 27 years of age, followed by females over the age of 80. The 2000 rates were again higher across all age groups and both genders (figure 6-5).

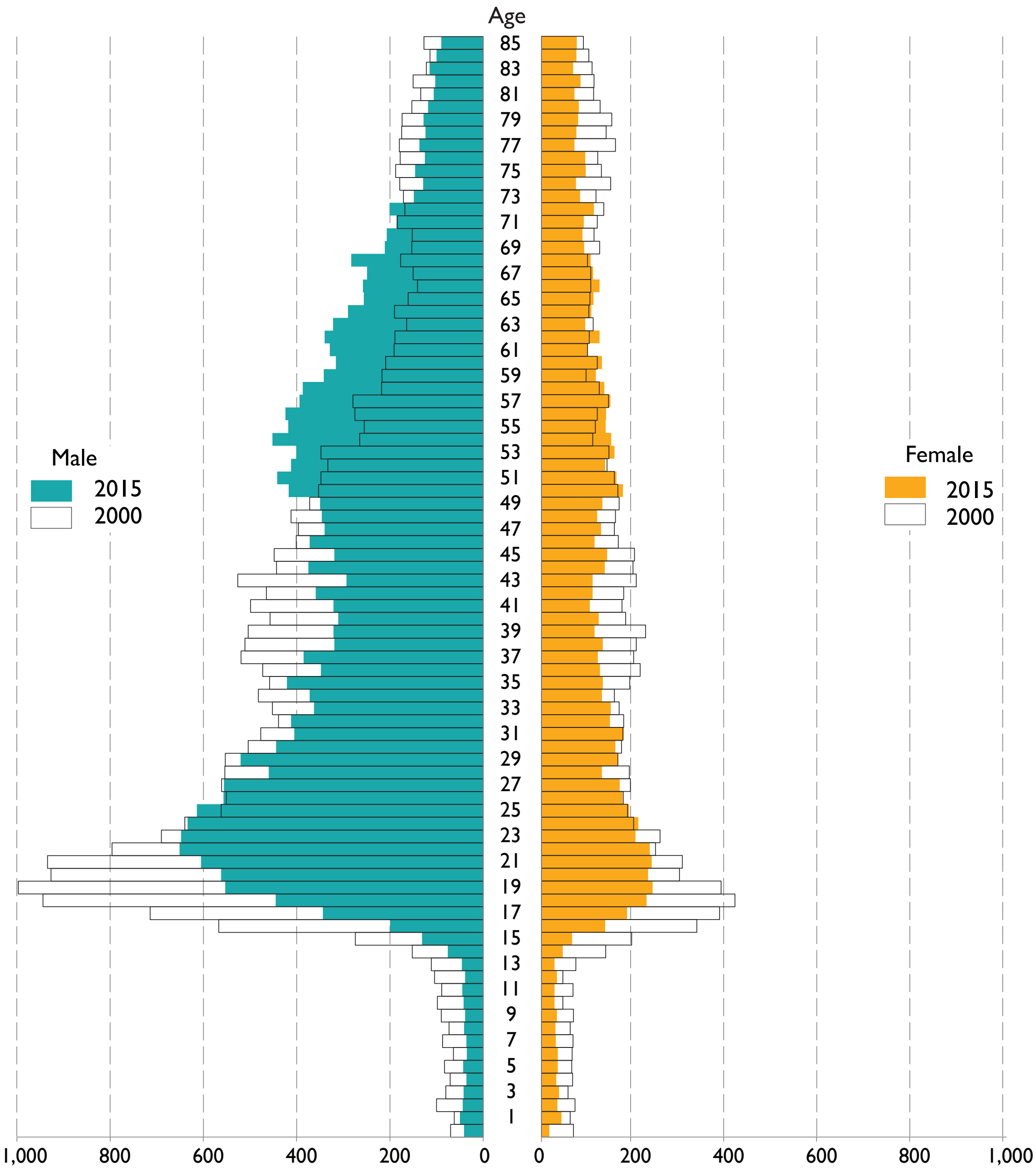
Aviation

U.S. air carriers and commuter airlines combined had zero fatalities in 2014 and 1 in 2015. In fact, in 7 of the last 16 years there were no fatalities recorded for flights by U.S. air carriers. During the other years, fatalities per 100,000 flight hours ranged from 0.1 to 3.0—the larger number dating to 2001, when 5 passenger planes crashed, including the 4 hijacked by terrorists on September 11 of that year. Since 2001, the air carrier fatality rate has remained stable and low.

General aviation (GA) fatalities have numbered in the hundreds every year since at least 1960. In 2015 some 376 people were killed in GA accidents, down from 424 in 2014 (table 6-2). Even so, this number is an appreciable drop from previous decades. In the 10 years spanning 1990 to 1999, an average of 716 persons per year died in GA accidents, followed by a drop to 567 deaths on average per year in the following decade. The average for the 2010–2015 period was 423 fatalities annually.

The GA fatality rate per 100,000 flight hours has fluctuated (figure 6-3). While the number of fatalities was fewer in 2015 (376 people) compared to 2000 (596), the number of flight hours in 2014 was 35 percent less, resulting in a higher fatality rate. Another metric of general aviation safety is the fatal accident rate per 100,000 flight hours. This rate is the same whether a plane has one or many occupants who die in a crash. According to preliminary estimates, the GA fatal accident rate for fiscal year 2015 (October 1 through September 30, 2015) was 1.03 per 100,000 flight hours, compared to a 1.10 fatal accident rate averaged over the five prior fiscal years [USDOT FAA 2016a].

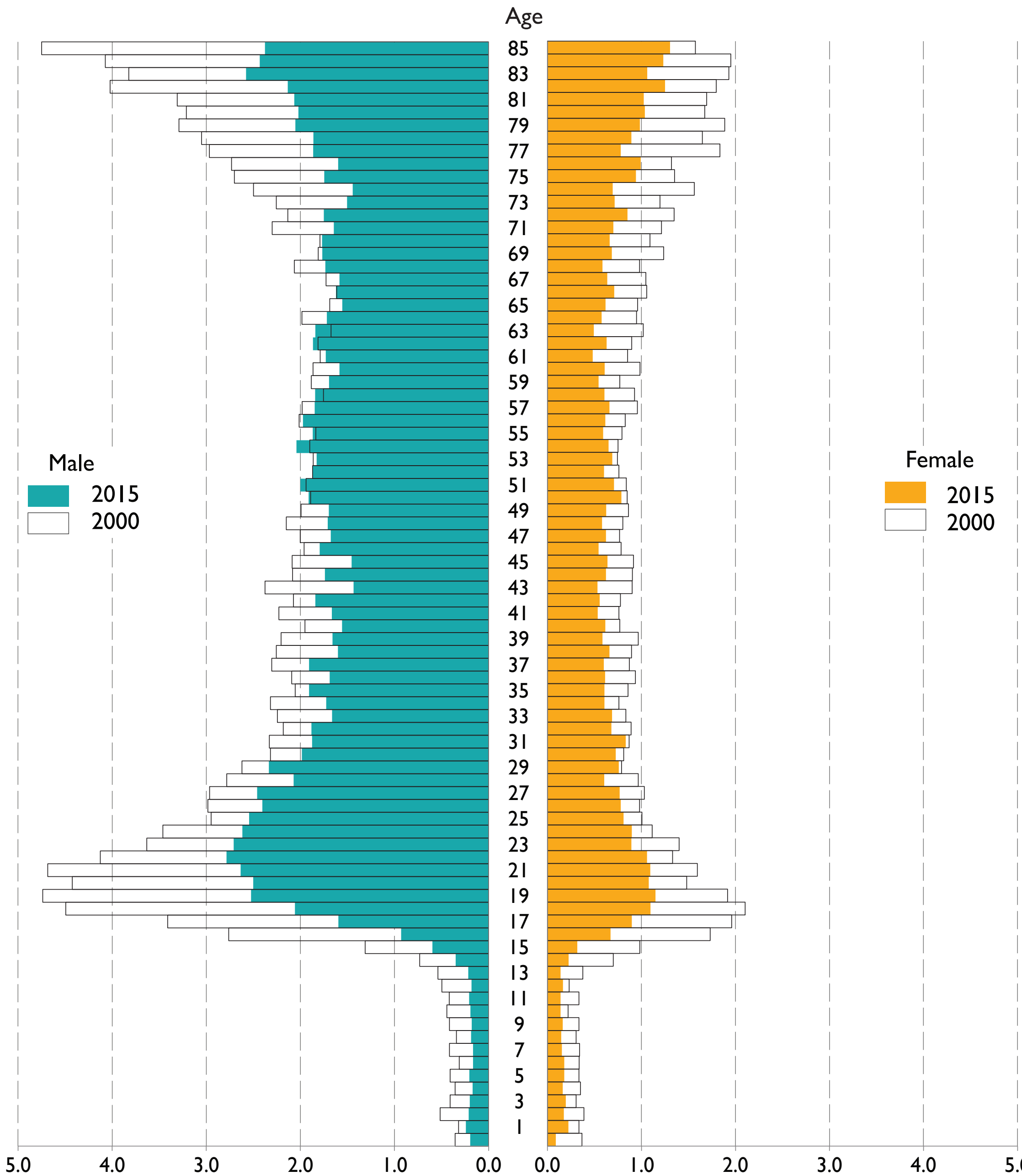
FIGURE 6-4 Fatalities Number by Age and Sex: 2000 and 2015



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Fatality Analysis Reporting System*, available at ftp.nhtsa.dot.gov as of March 2016.

FIGURE 6-5 Fatalities Rate by Age and Sex: 2000 and 2015

Fatalities per 10,000 people in specified age cohort



SOURCES: Fatality Data: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Fatality Analysis Reporting System*, available at ftp.nhtsa.dot.gov as of March 2016. **Population Data**: U.S. Department of Commerce, U.S. Census Bureau, available at www.census.gov as of March 2016.

Most general aviation accidents involve single-engine, piston-powered airplanes, which account for slightly more than 60 percent of general aviation aircraft and just over half of general aviation flight hours [USDOT FAA 2014]. The loss of inflight control contributes to the majority of fatalities, whereas loss of control on the ground and engine-related system malfunctions were associated with the majority of nonfatal accidents [NTSB 2014a]. General aviation accidents are widely dispersed across the country. In 2014 nearly two-thirds of fatal general aviation accidents resulted in a single fatality, another quarter resulted in two fatalities, and the remainder yielded multiple fatalities.

In addition to general aviation, many fatalities each year result from crashes involving commercial on-demand air services, such as air taxis. These fatalities averaged 24 annually between 2010 and 2015. The safety trend in air taxi and similar services seems to be improving: air taxi deaths averaged 43 deaths per year between 2000 and 2009 and nearly 64 deaths annually between 1990 and 1999.

The popularity of unmanned aircraft systems (UAS), or "drones," poses several challenges for aviation safety, which are discussed in box 6-B. There are now more than one million UAS in the United States, and there are increasing sightings of unauthorized drones near airports and airplanes.

Box 6-B Drones Pose Aviation Threat

Estimates suggest that people in the United States now own over one million unmanned aircraft systems (UAS), commonly known as drones, with the number growing each year. Recreational and other unregulated use of drones presents safety risks to manned aircraft, their crews, airline passengers, and anyone below their flight paths. Unauthorized UAS flights recently interfered with aerial tankers battling wildfires, which grounded the tankers and put firefighters on the ground at greater risk [USDOT FAA 2015a]. In April 2016 a pilot for a British Airways plane stated that a drone may have struck the plane as it landed at London's Heathrow airport. While the plane landed undamaged, and a subsequent investigation was halted due to lack of evidence, the prospect of a drone damaging a commercial flight attracted worldwide concern [theguardian.com].

In 2014 pilots reported 238 unmanned aircraft sightings in the United States alone. There were about 5 times as many sightings (about 1,210) in 2015 from pilots of all aircraft types, including large, commercial passenger aircraft. In June 2015, during the height of the summer season for hobbyists, 138 pilots reported seeing drones at altitudes up to 10,000 feet, a sizable increase from 16 reported sightings in June 2014. Many other drones were reported in unauthorized places, such as near airports [USDOT FAA 2016b].

Prior to operating unmanned aircraft, the Federal Aviation Administration (FAA) requires people to file a paper registration application for drones weighing 55 pounds or more. In December 2015, FAA also issued an interim final rule for online registration of drones weighing from 0.55 pounds up to just under 55 pounds, as an alternative to filing a paper application. Very light drones that weigh less than 0.55 pounds do not have to be registered [USDOT FAA 2015c]. The FAA announced in March 2016 that nearly 400,000 small drones under 55 pounds were registered.

Recreational Boating

Recreational boating resulted in 626 deaths in 2015, compared to 610 in 2014, and 560 in 2013—the lowest number in many decades (table 6-2). Despite these recent increases, the number of boating fatalities has trended downward over time. Fatalities averaged about 800 per year in the 1990s and about 700 annually between 2000 and 2009. According to the U.S. Coast Guard, many boating fatalities occurred on calm protected waters, in light winds, or with good visibility. Alcohol use, operator distraction, or the lack of training played key roles in fatal recreational boating accidents. About 76 percent of people who died in recreational boating incidents drowned [USDHS USCG 2016].

Railroad Operations

Unlike highway crashes, boating, or aviation accidents, most fatalities associated with train operations occur outside the train, such as by people who are trespassing (unauthorized presence on track rights-of-way or other railroad land) or who are struck at highway-rail grade crossings. Since 1990 the number of trespassing-related deaths has averaged about 483 per year. The number of trespasser deaths fell for several years beginning in 2007, reaching a low of 400 in 2011. However, the drop was of short duration; since then, there have been year-after-year increases—rising to 470 in 2014 and to 459 in 2015.

Highway-rail grade crossing fatalities averaged about 247 per year in the 2010–2014 period (see table 6-2). The number is far fewer than in the 1990s, when the average fatality count was 550 people per year, or the 2000 through 2009 period, which averaged about 350 fatalities per year [USDOT BTS NTS, table 2-1].[4] Many grade crossings are the locations of repeated incidents as shown in figure 6-6. The Federal Railroad Administration (FRA) recently identified 15 crossing locations where 10 or more incidents (not necessarily involving fatalities such as property damage only) took place in the last decade [USDOT FRA 2016a].

Of the total railroad fatalities in 2015, the Federal Railroad Administration (FRA) attributes 250 deaths to passenger train operations and 503 deaths to freight train operations, which involve far more train miles than passenger train-miles. Very few train passengers or crew members die in train accidents. In the 2010 to 2014 period, the total fatality count of people on the train was 39— less than 8 per year. Many trespassing and grade crossing fatalities are the result of suicide. In 2014 there were 266 suicides, according to FRA data [USDOT FRA 2016b].

Transit

Transit fatalities averaged about 245 per year between 2010 and 2015.[5] Like the railroad mode, most of the fatalities in transit-related accidents are not passengers or transit employees on the vehicle. According to the Federal Transit Administration (FTA),

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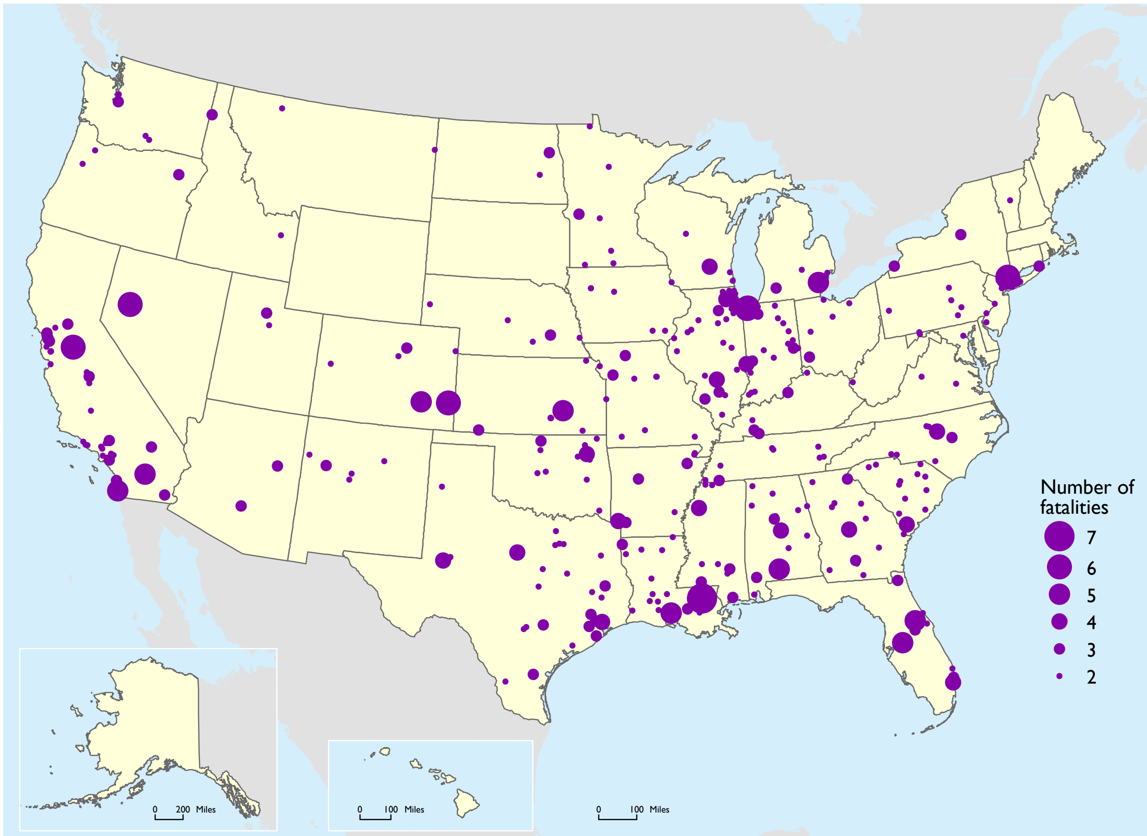
[4] Counts of highway-grade crossing fatalities are made for both rail and highway modes. In table 6-1, to avoid double-counting, these fatalities are included in the overall count for highways, but not for rail.

[5] Rail transit accounts for slightly more than half of the transit fatalities reported to FTA (table 6-2): however, commuter rail and Port Authority Trans Hudson (PATH) heavy rail system safety data are counted in Federal Railroad Administration data, not FTA.

FIGURE 6-6 Grade Crossing Fatalities: 2005–2015



NOTE: Data represent highway-rail grade crossing fatalities that occurred between 2005–2015.

SOURCE: U.S. Department of Transportation, Federal Railroad Administration, *Highway-Rail Grade Crossing Accidents*, Form 57, as of August 2016.

passengers on transit vehicles accounted for roughly 10.2 percent of the 236 fatalities in 2014; another 14.4 percent were people waiting for or leaving the vehicle; 16.1 percent were people in transit stations or other facilities (not including employees). Pedestrians accounted for 29.7 percent of the transit fatalities. Other fatalities involved people in nontransit vehicles and transit workers (4.1 percent). About 25.4 percent of the transit fatalities were considered suicides [USDOT FTA 2015].[6]

[6] In table 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. Pedestrians killed in transit accidents on highways, such as pedestrians struck by a transit bus, are reported as highway-related pedestrian deaths in table 6-2. To avoid double counting, pedestrians killed in transit accidents are included in table 6-2 under "Other counts, redundant with above" as "transit, rail" and "transit, nonrail."

Other Modes

There were about 66 fatalities involving waterborne commercial vessels in 2015; this was less than the 2010–2015 average of 78 deaths per year. Pipeline-related fatalities averaged about 13 deaths per year between 2000 and 2015, with gas pipelines accounting for most of the fatalities.

Injured People by Mode

Most modes showed a decline in injuries between 2000 and 2014. Highway modes, which accounted for 99.5 percent of 2014 transportation injuries, declined by 26.7 percent, bringing the estimated injuries down from 3.19 million in 2000 to 2.44 million in 2015 (table 6-4). However, the reduction in highway injuries was not uniform across vehicle types. The increase in motorcyclist injuries was 62.7 percent, from about 58,000 injured in 2000 to 92,000 in 2014 [USDOT BTS NTS]. This sobering increase was even higher than the 37.7 percent increase in motorcyclist fatalities in the same period. In contrast to fatality counts, which are pulled from police accident reports and a census of all fatal accidents, NHTSA estimates the total number of people injured in highway accidents from a sample because an exact number from the many millions of accidents that occur each year is impracticable to tally. This estimate indicates that about 6,700 people per day were injured in motor vehicle crashes in 2015.

In addition to the people injured on the Nation's highways, in 2014 about 20,000 people were injured in nonhighway-related incidents. Rail and rail transit together accounted for about 16,000 of these nonhighway injuries. These numbers do not count people injured in highway-rail crossing

TABLE 6-4 Transportation Injuries by Mode: 2000 and 2010–2015

	2000	2010	2011	2012	2013	2014	(P) 2015
TOTAL	**3,218,900**	**2,259,731**	**2,237,378**	**2,382,010**	**2,333,903**	**2,350,490**	**NA**
Air	359	278	363	274	148	266	NA
Highway	3,189,000	2,239,000	2,217,000	2,362,000	2,313,000	2,338,000	2,443,000
Railroad	12,057	(R) 8,378	(R) 8,438	(R) 8,454	(R) 8,732	8,702	(R) 8,906
Transit	56,697	(R) 25,376	(R) 23,013	(R) 23,367	(R) 24,764	24,045	24,229
Water	4,355	3,770	3,823	3,327	3,432	4,090	NA
Pipeline	81	(R) 103	(R) 51	(R) 54	(R) 42	95	(R) 50
Other counts, redundant with above							
Railroad, injured at public crossing with motor vehicle	1,029	718	827	763	(R) 777	663	812
Transit non-rail	42,713	(R) 16,705	(R) 14,743	(R) 15,089	(R) 15,923	16,532	16,839
Transit rail	13,984	(R) 8,671	(R) 8,270	8,278	(R) 8,841	7,513	7,390

KEY: NA = not available. P = preliminary. R = revised.

NOTES: *Water* for the year 2000 only includes recreational boating and does not include additiional categories of water injuries that are included in the 2010 to 2014 data. The sum of the modal numbers is greater than the **TOTAL** because some injuries are counted in more than one mode. *Other counts, redundant with above* help eliminate double counting in the injury **TOTAL**, as follows: For *Railroad, injuries involving motor vehicles at public highway-rail grade crossings* are excluded because such injuries are assumed to be included in Highway injuries. For *Transit, non-rail* mode injuries, including aerial tramway, motor bus, bus rapid transit, commuter bus, demand response, demand taxi, ferryboat, jitney, publico, trolleybus, and vanpool are excluded because they are assumed to be counted as Water and Highway injuries. Please see the National Transportation Statistics table 2-2 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*, table 2-2. Available at www.bts.gov as of April 2016.

incidents, as they are assumed to be included in the highway mode estimate. The water modes had about 3,400 injured people—mostly from recreational boating.

The injury rate for highway crashes per vehicle miles of travel in 2014 was about one-third less than it was in 2000. The air carrier injury rate (measured by the number of injuries per flight hour) remained relatively low and stable, as did the general aviation injury rate (measured by the number of injuries per flight hour) between 2000 and 2013 (figure 6-7).

Costs of Motor Vehicle Crashes

A 2014 study by the Centers for Disease Control focused on the health burden and medical costs of both fatal and nonfatal injuries to highway motor vehicle occupants in crashes. The medical costs of fatal injuries in 2011 totaled about $266 million, the latest year for which medical cost data are available. Nonfatal injuries to motor vehicle occupants from crashes in 2012 involved an estimated 2.5 million visits to emergency rooms or other emergency departments, with an estimated 188,000 visits resulting in hospitalization and lifetime costs of $18.4 billion. Put another way, in 2012, there were about 6,900 emergency department visits and over 500 hospitalizations per day resulting from nonfatal crash injuries to motor vehicle occupants [USHSS CDC 2014].

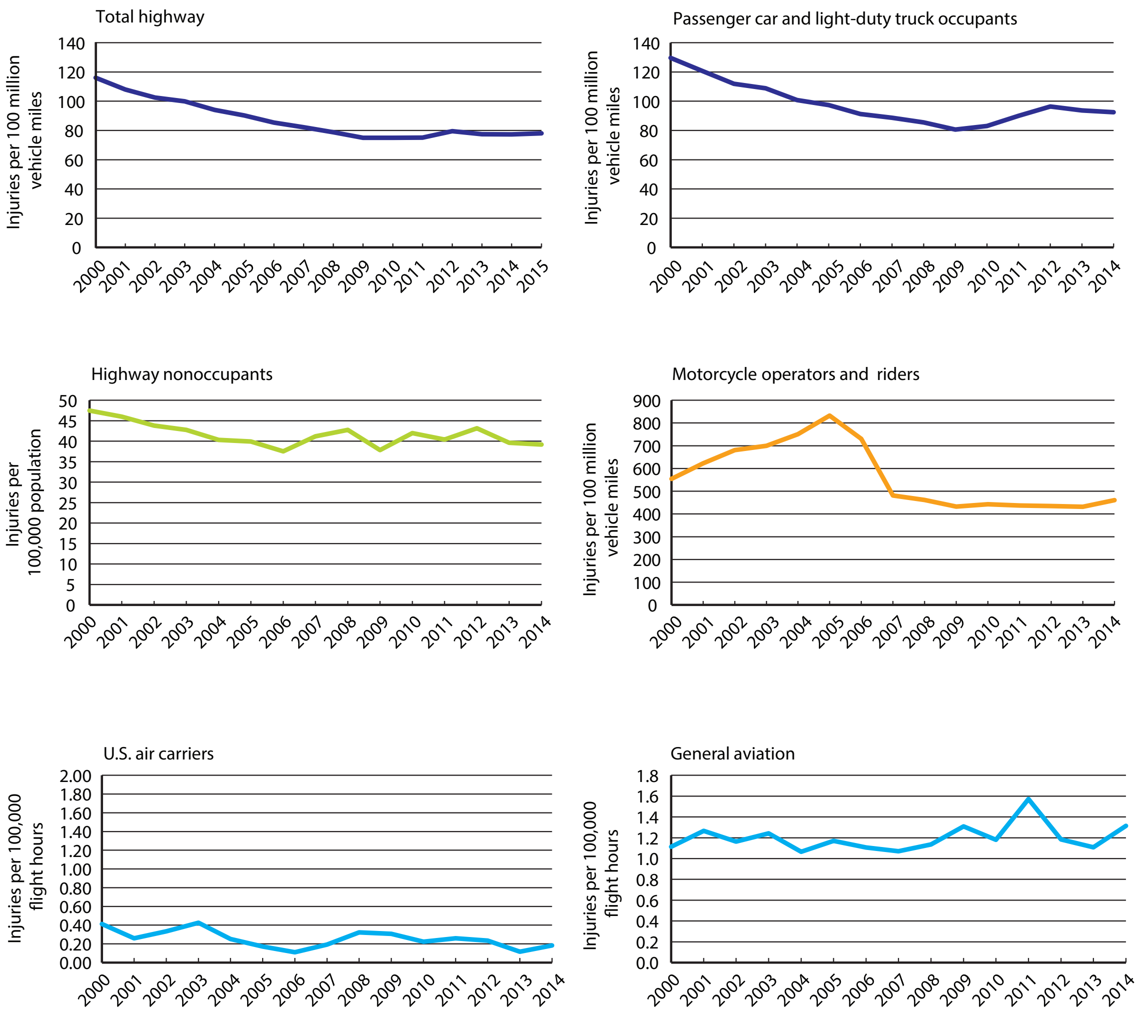
Medical costs are only one component of the costs of crashes. A separate study of the broader economic costs of motor vehicle crashes estimated these costs as $242 billion in 2010 (the latest year for which economic estimates are available) [USDOT NHTSA 2015e]. These economic costs include the following:

- lost workplace productivity—$57.6 billion (23.8 percent of economic costs),
- lost household productivity—$19.7 billion (8.2 percent),
- property damage—$76.1 billion (31.4 percent),
- medical expenses—$23.4. billion (10 percent),
- congestion impacts—$28 billion (11.6 percent), and
- other crash-related costs—$37.0 billion (15.3 percent).

If averaged across the U.S. population in the study year, motor vehicle crashes cost nearly $784 per person in 2010. When factoring in the $594 billion in comprehensive costs from the loss of life, pain, and injuries, the cost of 2010 motor vehicle crashes totaled about $836 billion. Of this total, economic costs represent 29 percent and lost quality of life represent 71 percent [USDOT NHTSA 2015e].

Compared to other motor vehicle crashes, these costs disproportionately involve motorcycle riders who die or incur serious injuries in crashes [USDOT NHTSA 2015e]. Motorcycles provide little protective shielding to riders, compared to enclosed vehicles; also, there has been a dramatic increase in motorcycle vehicles-miles traveled. Measured by VMT, a motorcyclist in a crash was about 30 times more likely to die than a passenger car occupant and 5 times more likely to be injured, according to the study. In 2010 motorcycle crashes cost $12.9 billion in economic impacts and $66 billion in comprehensive societal costs.

FIGURE 6-7 Injury Rates for Selected Modes: 2000–2014, 2015



NOTES: *Passenger car occupants* includes passenger car and light truck occupants. *Air* includes serious injuries only. *Nonoccupant* includes pedestrians and riders of nonmotorized bicycles and other pedal-powered vehicles. **Total Highway, Passenger Car Occupants, and Motorcycle Operators**: When comparing highway data from 2006 and before to data from later years, it needs to be understood that a revised methodology for estimating registered vehicles and vehicle miles traveled by vehicle type for the highway modes was applied to 2007 data and beyond, and this difference in methodologies needs to be taken into account.

SOURCE: Calculated by U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS) based upon multiple sources as cited in USDOT, BTS, *National Transportation Statistics*. Tables 1-35, 2-2, 2-9, and 2-14. Available at www.bts.gov as of April 2016.

Selected Contributing Factors

A multitude of human, environmental, and vehicle factors contribute to transportation crashes. The most commonly cited causes 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, while distracted, or while 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]. 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 are more likely than not to be recorded for fatal crashes involving passenger vehicles. In 2014 one or more driver-related human factors were recorded for 69.9 percent of the drivers of highway passenger vehicles (cars, vans, pickup trucks, and sport utility vehicles) involved in single-vehicle fatal crashes and 50.1 percent of drivers of passenger vehicles involved in multivehicle fatal crashes [USDOT FMCSA 2016a]. For comparison, one or more (driver-related) human factors were recorded for 55.9 percent of the drivers of large trucks involved in single-vehicle fatal crashes and for 28.4 percent of the drivers of large trucks involved in multivehicle fatal crashes [USDOT FMCSA 2016a].

Speeding topped the law enforcement list for driver-related violations for both passenger vehicles and large trucks. Distracted/inattentive driving was second on the list for large-truck drivers, while impairment (fatigue, alcohol, illness, etc.) ranked second for passenger vehicle drivers [USDOT FMCSA 2016]. In 2014 vehicle factors, most commonly truck tires, were recorded for 5.6 percent of the large trucks involved in fatal crashes and 3.0 percent of the passenger vehicles involved in fatal crashes [USDOT FMCSA 2016].

Alcohol and Substance 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]. Alcohol involvement either by the driver or the pedestrian was reported in 48 percent of all crashes involving a pedestrian fatality in 2014. Many pedestrians who were killed were inebriated [USDOT NHTSA 2016d]. Table 6-5 shows that over 12,000 people were killed in motor vehicle crashes in 2015 in which a driver or fatally struck nonoccupant or both had a BAC of 0.08 or higher.[7]

[7] 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 6-5 Fatalities by Highest Blood Alcohol Concentration (BAC) in Highway Crashes: 1990, 2000, 2010–2015

	1990	2000	2010	2011	2012	2013	2014	2015
Total fatalities	**44,599**	**41,945**	**32,999**	**32,479**	**33,782**	**32,893**	**32,744**	**35,092**
Fatalities in alcohol-related crashes (BAC = .01+)	**22,587**	**17,380**	**13,323**	**13,184**	**13,879**	**13,569**	**13,388**	**13,966**
Percent	50.6	41.4	40.4	40.6	41.1	41.3	40.9	39.8
BAC = 0.00								
Number	22,012	24,565	19,676	19,295	19,903	19,325	19,356	21,126
Percent	49.4	58.6	59.6	59.4	58.9	58.8	59.1	60.2
BAC = 0.01 - 0.07								
Number	2,980	2,511	1,861	1,795	1,920	1,938	1,873	1,918
Percent	6.7	6.0	5.6	5.5	5.7	5.9	5.7	5.5
BAC = 0.08+								
Number	19,607	14,870	11,462	11,388	11,960	11,631	11,515	12,048
Percent	44.0	35.5	34.7	35.1	35.4	35.4	35.2	34.3

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 October 2016.

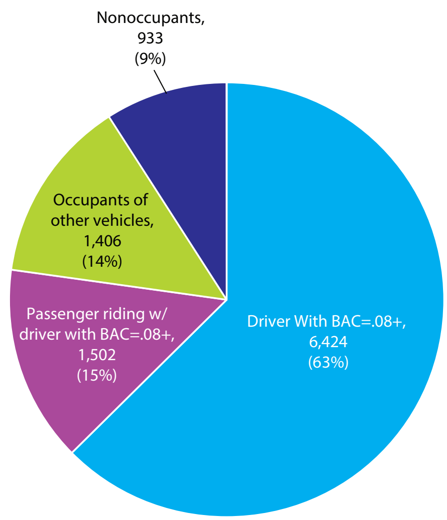
Figure 6-8 displays who died in fatal crashes when the driver had a BAC of 0.08 or higher. Drivers accounted for over 6,400 (62.6 percent) of the fatalities; about 2,900 were either passengers in the vehicle with an impaired driver or occupants of other vehicles (28.3 percent), and more than 900 were pedestrians or other nonoccupants (9.1 percent). Some 29 percent of motorcycle operators in fatal crashes are alcohol-impaired, the highest share of any highway motor vehicle drivers.

As for recreational boating, alcohol use is perennially listed by the U.S. Coast Guard as the leading contributing factor in fatal boating accidents. In 2014 the Coast Guard attributed 108 deaths, or 21 percent of boating fatalities and 248 injuries to alcohol [USDHS USCG 2015]. As of January 1, 2015, 47 states and the District of Columbia limit BAC to 0.08 percent for operators of recreational boats. The remaining four states, Michigan, North Dakota, South Carolina, and Wyoming, all have a 0.10 percent standard [USDHHS NIH NIAAA 2016].

A recent study by the National Transportation Safety Board (NTSB) analyzed toxicology reports on about 6,700 pilots who died in crashes between 1990 and 2012 to attempt to establish baseline data. About 96 percent of the crashes were in general aviation because there were few commercial aviation crashes during that period. The toxicology information was available because the Federal Aviation Administration is able to conduct this testing in follow-up fatal crash investigations.

FIGURE 6-8 Fatalities, by Role, in Crashes Involving at Least One Driver with a BAC of .08 or Higher: 2015

Total fatalities involving BAC ≥ 0.08 % = 10,265



KEY: BAC = blood alcohol concentration.

NOTES: 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 March 2016.

The NTSB examined illegal drugs (which were assumed to be impairing) and certain legally obtained over-the-counter (OTC) drugs that were considered potentially impairing. These legal pharmaceuticals were considered potentially impairing if the packaging contained a Food and Drug Administration label warning of possible effects from routine usage (e.g., cautions about driving or operating machinery, or possible side effects such as sedation, hallucinations, or behavior changes.) The toxicology results showed increased "use of all drugs, potentially impairing drugs, drugs used to treat potentially impairing conditions, drugs designated as controlled substances, and illicit drugs" during the 23-year period. Diphenhydramine, an antihistamine with sedating properties, was the most common drug found in the toxicology reports that was thought to be potentially impairing. Diphenhydramine is found in many over-the-counter allergy formulations, cold medications, and sleep aids. NTSB found few cases of illicit drug use, but noted that there was an increase in positive tests for marijuana usage during the last 10 years of the study (2002 to 2012).

NTSB examined whether pilots who had used potentially impairing drugs had increased risk of involvement in certain accident types. However, it found no statistically significant difference in the distribution of accident events from 2008 through 2012 in crashes involving pilots with and without evidence of potentially impairing drugs [NTSB 2014b].

In recent years, several states have legalized or are considering legalizing the use of marijuana. This trend has raised concerns about the effects of marijuana use on driver performance and traffic safety. The American Automobile Association (AAA) Foundation for Traffic Safety conducted several studies to quantify the prevalence of driving under the influence of marijuana. The AAA's annual online sample survey on traffic safety culture reported that 4.6 percent of respondents reported that they drove within one hour of using marijuana. (The annual survey was conducted from 2013 to 2015 and included 6,612 respondents.) Male drivers, 18 to 24 years of age, and those who lived in the Midwest were most likely to report having driven within one hour of using marijuana. Moreover, drivers who reported using marijuana within one hour of driving were less likely to believe that using marijuana increased the risk of crashing and more likely to believe that such usage does not affect or decreases the risk of crashing [AAA 2016a].

Another AAA study focused on marijuana involvement in fatal crashes in Washington State from 2010 to 2014. Using toxicology test data from the Washington State Safety Commission, AAA found that the number of drivers in marijuana-involved fatal crashes more than doubled from 49 (8.3 percent) in 2013 to 106 (17.0 percent) in 2014. Prior to legalization in December 2012, the number and proportion of drivers testing positive for marijuana were fairly stable but then began to rise about 9 months after the law was passed [AAA 2016b].

Distraction and Fatigue

In 2015 about 2,972 fatal highway crashes and an estimated 265,000 injury crashes involved distracted drivers. This was about 10 percent of fatal crashes, 16 percent of injury crashes, and 14 percent of property-damage-only crashes involving a motor vehicle (table 6-6). Those 20 to 29 years of age accounted for the largest share (29 percent) of distracted driving crashes [USDOT NHTSA 2016f]. Figure 6-9 shows the trend on the percent of distracted driving-related highway fatalities and injuries (the fatality data begin with 2010 due to a change in methodology, making earlier data not comparable).

Although many activities (e.g., cellphone use, eating, sipping coffee, smoking, grooming, adjusting a radio) are distracting to drivers, bicyclists and pedestrians, cell phone usage and texting have received the most attention as these devices have attained nearly universal usage in the last few years. Cellphones had been in use in about 13 percent of fatal crashes involving distracted driving in 2014, comprising about 1.3 percent of all fatal crashes [USDOT NHTSA 2016f]. Figure 6-10 shows that 14 states, the District of Columbia, and Puerto Rico prohibit drivers' use of handheld cell phones; and 46 states plus the District of Columbia and Puerto Rico ban texting while driving.

In 2014[8] drowsy and fatigued driving was considered a related factor in 846 highway fatalities (2.6 percent). However, it is likely that fatigue-related crashes are underestimated [AAA Foundation]. Measuring the exact number of drowsing-related fatalities is difficult, although research is underway to

[8] 2015 data are not available.

TABLE 6-6 Distraction-Affected (D-A) Motor Vehicle Crashes and D-A Crashes Involving Cell Phone Use: 2010–2015

Total Crashes

	Fatal crashes	Injury crashes	PDO crashes	Total
2010	30,296	1,542,000	3,847,000	5,419,000
2011	29,867	1,530,000	3,778,000	5,338,000
2012	31,006	1,634,000	3,950,000	5,615,000
2013	30,202	1,591,000	4,066,000	5,687,000
2014	30,056	1,648,000	4,387,000	6,064,000
2015	32,166	1,715,000	4,548,000	6,296,000

Distraction-Affected Crashes

	D-A fatal crashes	Share of all fatal crashes, percent	D-A injury crashes	Share of all injury crashes, percent	D-A PDO crashes	Share of all PDO crashes, percent	Total	Percent of total
2010	2,993	9.9	279,000	18.1	618,000	16	900,000	16.6
2011	3,047	10.2	260,000	17.0	563,000	15	826,000	15.5
2012	3,098	10.0	286,000	17.5	619,000	16	908,000	16.2
2013	2,923	9.7	284,000	17.9	616,000	15	904,000	15.9
2014	2,972	9.9	297,000	18.0	667,000	15	967,000	15.9
2015	3,196	9.9	265,000	15.5	617,000	14	885,000	14.1

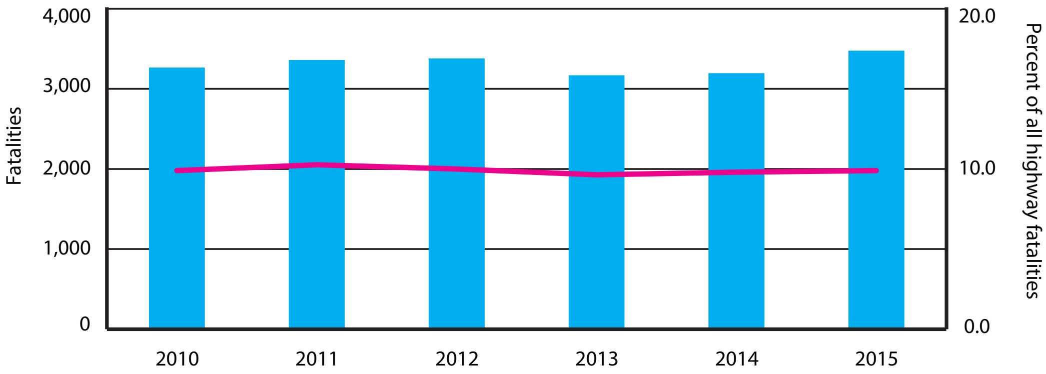
Distraction-Affected Crashes Involving Cell Phone Use (% of D-A Crashes)

	Cell phone use fatal crashes	Percent of all D-A	Injury crashes	Cell phone injury crashes as a percent of D-A crashes	PDO crashes	Cell phone PDO crashes as a percent of total D-A crashes	Total	Percent of total D-A crashes
2010	366	1.2	16,000	6.0	30,000	1	47,000	5.2
2011	354	12.0	15,000	6.0	35,000	1	50,000	6.0
2012	380	12.0	21,000	7.0	39,000	1	60,000	7.0
2013	411	14.0	24,000	8.0	47,000	1	71,000	8.0
2014	387	13.0	22,000	8.0	46,000	1	69,000	7.0
2015	442	14.0	21,000	8.0	48,000	8	69,000	8.0

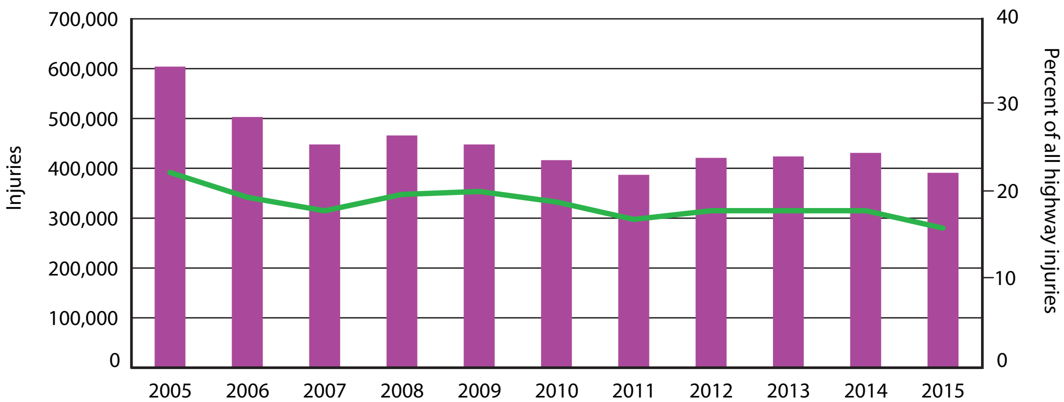
KEY: PDO = property damage only.

SOURCE: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA). *Distracted Driving 2014* (April 2016), Table 6. Available at http://www-nrd.nhtsa.dot.gov/ as of April 2016.

FIGURE 6-9 Distracted Driving Fatalities: 2010–2015



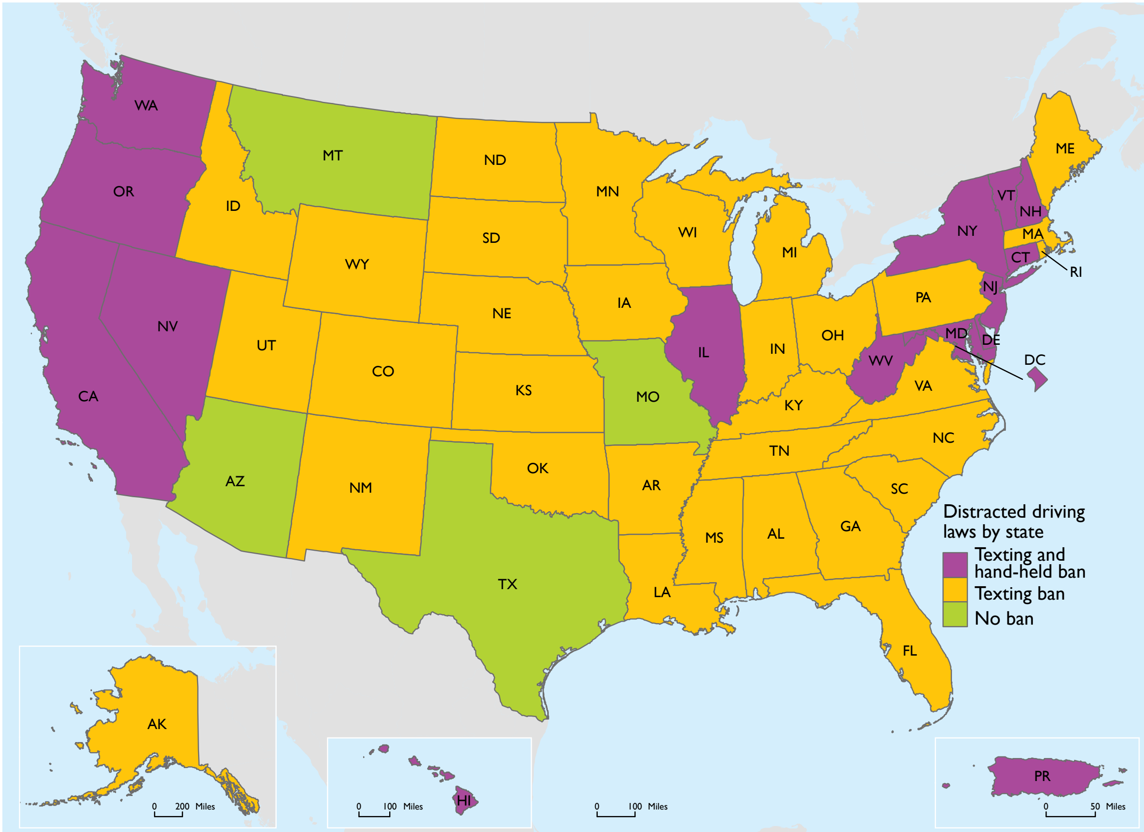
Distracted Driving Injuries: 2005–2015



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. Distracted driving fatality data for 2010 and on are not comparable with previous years due to changes in methodology.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts, Research Note, *Distracted Driving 2014*, available at www.nhtsa.gov as of April 2016.

FIGURE 6-10 State Laws on Distracted Driving Ban on Hand-Held Devices and Texting While Driving: February 2016



NOTES: A primary law means that an officer can ticket the driver for the offense without any other traffic violation taking place. A secondary law means an officer can only issue a ticket if a driver has been pulled over for another violation (like speeding).
Hand-held Cell Phone Use: 14 states, D.C., Puerto Rico, Guam and the U.S. Virgin Islands prohibit all drivers from using hand-held cell phones while driving. All are primary enforcement laws—an officer may cite a driver for using a hand-held cell phone without any other traffic offense taking place.
Text Messaging: Washington was the first state to pass a texting ban in 2007. Currently, 46 states, D.C., Puerto Rico, Guam and the U.S. Virgin Islands ban text messaging for all drivers.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, State Laws on Distracted Driving, available at http://www.distraction.gov/stats-research-laws/state-laws.html as of February 2016.

improve methods. 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 NHTSA 2016e]. 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 6.2 percent of fatal crashes involving large trucks in 2014 [USDOT FMCSA 2015a]. In addition, truck driver impairment (e.g. fatigue, drugs/alcohol, illness, etc.) was a factor in 3.9 percent of fatal crashes [USDOT FMCSA 2015a].

Distracted and fatigued vehicle operators are found in all modes of transportation, including airline pilots, bus drivers, train engineers, and tugboat operators [NTSB 2014c].

Lives Saved by Occupant Protection Equipment

When properly used, safety devices significantly reduce the risk of death or serious injury. NHTSA estimated that about 18,552 lives were saved on the highways in 2015—up from about 16,000 in 2000—by occupant protection devices, including seat belts, frontal air bags, child restraints, and motorcycle helmets, as shown in table 6-7. Seat belts saved 13,941 lives, frontal air bags about 2,600, child restraints about 266, and DOT-compliant motorcycle helmets nearly 1,772 lives in 2015 (table 6-7).

Another 3,544 lives might have been saved had these devices been used by all occupants—an estimated 2,800 more lives from universal seat belt use and about 740 more lives if all motorcycle riders wore DOT-compliant motorcycle helmets [USDOT NHTSA 2015d].

Seat Belt Use

About 90 percent of occupants of cars, vans, and sport utility vehicles (SUVs) used safety belts in 2015, up from 71 percent in 2000 and 85 percent in 2010. Pickup truck occupants had the lowest usage at 81 percent in 2015, up from 77 percent in 2014 (table 6-8).

Regionally, seat belt use is highest in the Western United States (about 95 percent) and lowest in the Midwestern states (82 percent). States with primary enforcement laws, allowing police to ticket vehicle occupants solely for not wearing seat belts, have higher belt usage (over 91 percent in 2015) than states with weaker enforcement (79 percent) [USDOT NHTSA 2016g].

Seat belt use is most effective in conjunction with air bags, which deploy automatically in crashes. Recalls to replace defective airbags and other occupant protection equipment sometimes are undertaken, most dramatically in the ongoing case of airbags (see Box 6-C).

TABLE 6-7 Estimated Lives Saved by Selected Safety Features: 2000, and 2010–2015

	Child restraints, age 4 and younger	Seat belts, age 5 and older	Frontal air bags, age 13 and older	Motorcycle helmets, all ages	Minimum drinking age law
2000	479	12,882	1,716	872	922
2010	303	12,670	2,403	1,551	560
2011	262	12,071	2,341	1,622	543
2012	285	12,386	2,422	1,715	537
2013	263	12,644	2,398	1,640	507
2014	253	12,801	2,400	1,673	486
2015	266	13,941	2,573	1,772	537

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 March 2016 as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-31. Available at http://www.bts.gov as of April 2016.

Box 6-C Air Bag Recall

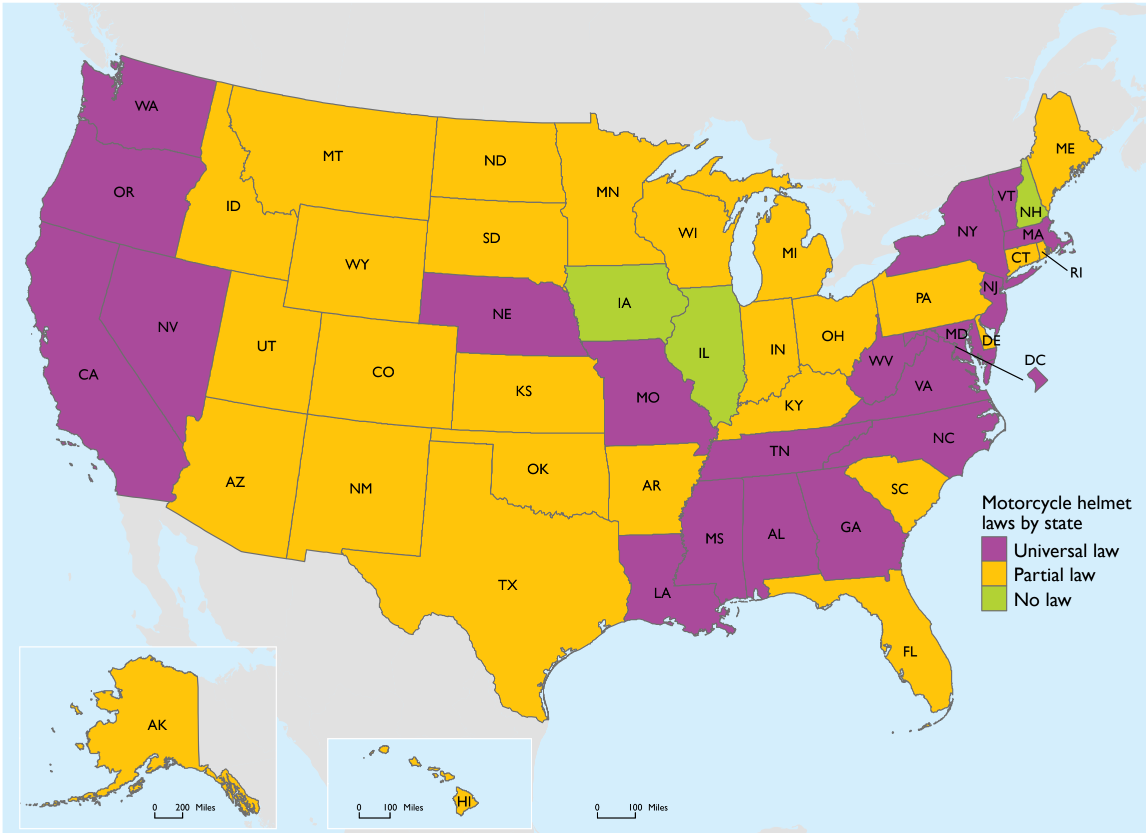
According to the National Highway Transportation Safety Administration (NHTSA), Takata air bags have been installed in tens of millions of U.S. vehicles. As of early October, 2016, 11 U.S. fatalities and more than 100 injuries have been linked to a defect in the airbag inflator and propellant devices, causing them to rupture and send metal shards into vehicle occupants during a crash [USDOT NHTSA 2016c and 2016h]. The root cause of the ruptures is the degradation of the ammonia nitrate propellant over time and when exposed to high humidity and fluctuating high temperatures, which in turn causes the propellant to burn too quickly and rupture.

NHTSA, which is charged with ensuring the safety of motor vehicles in the United States, initiated a formal defect investigation of the Takata air bag inflators in June 2014 [USDOT NHTSA 2015f], which resulted in a recall of 28.8 million airbags. Of that total, nearly 11.4 million have been repaired (5.1 million passenger-side air bags and 6.3 million driver side air bag) as of October 7, 2016 [USDOT NHTSA 2016b].

On May 4, 2016, NHTSA expanded the recall to include an additional 35-40 million air bag inflators to the already recalled 28.8 million. The expanded recall of inflators means that all Takata ammonium nitrate-based propellant air bag inflators that do not have a chemical drying agent, also known as a desiccant, will be recalled. The expanded recall will be handled in five phases over the May 2016 to December 2019 period, and based on risk factors, such as an inflator's age and its exposure to high humidity and fluctuating high temperatures [USDOT NHTSA 2016c].

The Takata air bag recall is the largest safety recall in U.S. history. Takata reached an agreement with NHTSA to pay $200 million in civil penalties and to phase out supplying ammonium nitrate inflators to fulfill existing contracts by no later than December 31, 2018 [USDOT NHTSA 2015c].

FIGURE 6-11 State Laws on Motorcycle Helmet Use: 2015



SOURCE: Insurance Institute for Highway Safety, Highway Loss Data Institute, *Motorcycle and Bicycle Helmet Use Laws*, available at www.iihs.org as of October 2013.

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]. Overall usage of DOT-compliant helmets has declined from 71 percent in 2000 to 64 percent in 2014 (table 6-8). 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), and 3 states (Illinois, Iowa, and New Hampshire) have no motorcycle helmet law (figure 6-11). Helmet use seems partially correlated to state requirements. In 2014, 89 percent of riders wore DOT-compliant helmets in states that required helmet use, while 48 percent of riders wore DOT-compliant helmets in states that do not require their use [USDOT NHTSA 2014c]. 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].

Life Jackets and Boat Safety Training

Drowning accounted for 76 percent of all fatalities in recreational boating accidents in 2015. Of these, 85 percent of victims were not wearing a life jacket [USDHS USCG 2016]. As of January 2013, 48 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands had laws or regulations requiring children to wear life jackets [NTSB 2013].

Even if not legally required, operators of boats can 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. Only 23 percent of deaths in fatal boating accidents in 2014 occurred in boats operated by a person known to have received boating safety education [USDHS USCG 2015].

Traffic Safety Enforcement

Traffic safety enforcement promotes good driving habits (e.g., wearing a safety belt) and discourages unsafe behaviors (e.g., impaired driving) [USDOT NHTSA 2014b]. According to the Bureau of Justice Statistics, in 2011 about 10.2 percent of the Nation's 212.3 million drivers were stopped by police while operating a motor vehicle, 5.3 percent of drivers were ticketed, 3.4 percent were given a verbal or written warning, and 1.4 percent were allowed to proceed with no enforcement action taken [USDOJ BJS 2013].

Speeding was cited as the leading reason for a traffic stop, accounting for 46.5 percent, followed by vehicle defects (e.g., broken tail light) with 14.1 percent. Males were more likely to be stopped and ticketed than females, accounting for 58.8 percent of ticketed drivers. Drivers who were 25 to 34 years of age accounted for about 22.4 percent of stopped drivers, which is the highest percentage among all age groups [USDOJ BJS 2013]. However, this age group accounted for only 13.7 percent of VMT [USDOT FHWA NHTS 2011].

In 2014, according to the Federal Bureau of Investigation, law enforcement agencies across the country made an estimated 1.11 million arrests for driving under the influence. Males accounted for three out of four DUI arrests [USDOJ FBI 2014]. 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 2016].

Commercial Motor Vehicles

The Federal Motor Carrier Safety Administration (FMCSA) is responsible for reducing crashes, injuries, and fatalities involving the Nation's approximately 521,000 interstate freight carriers,[9] 13,000 interstate buses, and 16,000 interstate hazardous material carriers [USDOT FMCSA 2015b]. FMCSA issued over 20,500 warning letters in fiscal year 2014 to commercial motor carriers whose safety data showed a lack of compliance with motor carrier safety regulations and

[9] Most of these are independent truckers or small trucking firms.

whose safety performance had fallen to an unacceptable level [USDOT FMCSA 2014]. Over 3.3 million roadside inspections were conducted in fiscal year 2015 (table 6-8). Vehicle violations put 20.3 percent of inspected vehicles out-of-service, while driver violations put 4.9 percent out-of-service, which commonly include hours-of-service noncompliance. As was discussed earlier, fatigue is a factor in many crashes. Box 6-D discusses shortages of public parking facilities for commercial motor vehicles. Such facilities would afford drivers with off-road places to stop to rest while not posing a safety hazard to others on the road.

Vehicle violations outnumbered driver violations 3 to 1, which commonly include defective lights, worn tires, or brake defects. Such violations must be corrected before the driver or vehicle can return to service.

Hazardous Materials Transportation

Transporting hazardous materials requires special precautions, handling, and packaging. Hazardous materials shipments by mode and hazard class are discussed in chapter 3. There are specialized safety regulations, standards, and reporting systems in place for pipelines, rail, highway, air, and marine

TABLE 6-8 Safety Belt and Motorcycle Helmet Use: 2000 and 2010–2015[a]

Percent

	2000	2010	2011	2012	2013	2014	2015
Overall Safety Belt Use	71	85	84	86	87	87	89
Drivers	72	86	84	87	88	87	89
Right-Front Passengers	68	83	82	84	85	86	87
Passenger cars	74	86	85	87	88	88	90
Vans and sport utility vehicles	NA	88	87	89	90	89	90
Pickup trucks	NA	75	74	77	78	77	81
Motorcycle Helmet Use[b]	71	54	66	60	60	64	NA
Operators	72	55	67	63	62	67	NA
Passengers	62	51	64	46	50	51	NA

KEY: NA = not available.

[a] Seat belt use is as of the fall of each year. Motorcycle helmet use is as of the fall of 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.

SOURCE: 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 2016 as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-30, available at http://www.bts.gov as of May 2016.

Box 6-D Truck Parking and Safety

Current Federal Hours of Service regulations require a truck driver to take 10 consecutive hours off after driving a maximum of 11 hours and to take 30-minute rest periods after 8 hours of driving [USDOT FMCSA 2011]. Because of these requirements, truck drivers need to find parking facilities that will accommodate long-term rest periods during an extended trip.

A recent FHWA Parking Survey showed that truck parking shortages are widespread and particularly acute along major freight corridors, such as I-95, I-40, and I-10, and in metropolitan areas. Thirty-seven states reported truck parking shortages at all times throughout the week [USDOT FHWA 2015]. Also, many states do not allow overnight or extended parking at public rest areas, making it more difficult for drivers to get required and needed rest [USDOT FHWA 2012].

Of the 300,000 truck parking spaces documented in the FHWA survey, more than 90 percent are located at private truck stops. Nearly 80 percent of private truck stop facilities had fewer than 100 truck parking spaces [USDOT FHWA 2015].

The shortage of truck parking facilities poses a safety risk to truck drivers as well as other motorists, according to the FHWA study. More than 75 percent of truck drivers reported having difficulty finding safe and legal parking during rest periods, and that number increased to 90 percent at night when drivers often wait for their drop-off destination to open for deliveries. The limitations on delivery times place considerable demands on truck parking facilities and on truck drivers to meet tight schedules, particularly in urban areas. The lack of parking spaces could result in a decision to continue driving while tired or to park in unsafe locations along road shoulders and highway entrance and exit ramps [USDOT FHWA 2015].

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 6-10 shows that more than 16,500 hazardous materials incidents were reported in 2015, excluding pipeline.

About 1.7 percent of hazardous materials transportation incidents were the result of an accident (e.g., vehicular crash or train derailment). Almost 90 percent of incidents related to the movement of hazardous materials occurred on highways or in truck terminals. Most hazardous materials incidents occur because of human error or package failure, particularly during loading and unloading.

Table 6-11 provides a summary of the over 700 hazardous liquid-related and gas-related pipeline incidents reported in 2015, which resulted in 11 fatalities, 50 injuries, and more than $320 million in property damage (down from $1.5 billion in 2010, reflecting the incident specific nature of property damage). Hazardous liquids accounted for well over half the incidents and property damage. Gas distribution and transmission accounted for all but one of the fatalities and all of the injuries in 2015 (table 6-11).

TABLE 6-9 Activity Summary of Roadside Safety Inspection by Motor Carrier Inspection Type: 2010 and 2015

	2010	2015
Roadside inspections	**3,569,373**	**3,383,789**
With no violations	1,225,324	1,394,227
With violations	2,344,049	1,989,512
Driver inspections	**3,470,871**	**3,264,036**
With OOS violations	183,350	160,072
Driver OOS rate	5.3%	4.9%
Vehicle inspections	**2,413,094**	**2,309,092**
With OOS violations	480,416	468,327
Vehicle OOS rate	19.9%	20.3%
Hazardous material inspections	**211,154**	**191,250**
With OOS violation	9,210	7,452
Hazmat OOS	Rate	4.4%

KEY: OOS = out-of-service.

NOTES: *Driver Inspections* were computed based on inspection levels I, II, III, and VI. *Vehicle Inspections* were computed based on inspection levels I, II, V, and VI. *Hazmat Inspections* were computed based on inspection levels I, II, III, IV, V, and VI when hazardous materials were present. Roadside inspection OOS rates depicted in this table include both large trucks and buses. For more information on roadside inspections and inspection levels, please refer to https://csa.fmcsa.dot.gov.

SOURCE: U.S. Department of Transportation, Federal Motor Carrier Safety Administration, Motor Carrier Management Information System (MCMIS), *Roadside Inspection Activity Summary for Fiscal Years*, April 2016.

TABLE 6-10 Hazardous Materials Transportation Incidents: 2010–2015

	2010	2011	2012	2013	2014	2015
Total incidents	**14,795**	**15,029**	**15,445**	**16,053**	**17,401**	**16,588**
Total Vehicular Accident / Derailment Incidents	**358**	**377**	**398**	**367**	**351**	**286**
Vehicular accident-related percent of total incidents	2.4%	2.5%	2.6%	2.3%	2.0%	1.7%
Air	1,295	1,401	1,460	1,441	1,327	1,074
Vehicular accident-related	2	2	2	3	3	2
Highway	12,648	12,812	13,254	13,882	15,310	14,923
Vehicular accident-related	320	335	363	333	330	251
Rail	747	745	661	667	717	567
Vehicular accident-related / derailment Incidents	35	40	33	31	18	32
Water[1]	105	71	70	63	47	24
Vehicular accident-related	1	0	0	0	0	1

[1] Water includes 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). Each modal total also includes fatalities caused by human error, package failure, and causes not elsewhere classified. *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* (as of Apr. 10, 2016), available at https://hip.phmsa.dot.gov/ as of April 2016.

TABLE 6-11 All Reported Hazardous Liquid and Gas Incidents: 2010–2015

TOTAL - All Reported

	Number	Fatalities	Injuries	Property damage as reported	Barrels spilled (Haz Liq)	Net barrels lost (Haz Liq)
2010	588	22	108	$1,509,635,198	100,558	49,452
2011	594	14	56	$426,819,470	89,111	57,374
2012	572	12	57	$228,451,836	45,884	29,247
2013	618	9	44	$349,045,145	117,467	85,696
2014	701	19	96	$311,242,875	47,297	22,913
2015	703	11	50	$323,646,586	NA	NA

Gas Distribution

	Number	Fatalities	Injuries	Property damage as reported
2010	122	11	44	$21,289,283
2011	120	13	53	$27,789,531
2012	90	9	46	$25,557,235
2013	105	8	36	$18,411,114
2014	112	18	94	$74,859,503
2015	104	4	36	$29,978,128

Gas Gathering

	Number	Fatalities	Injuries	Property damage as reported
2010	9	0	0	$2,120,878
2011	10	0	0	$1,786,922
2012	12	0	0	$2,937,821
2013	6	0	0	$1,977,657
2014	9	0	0	$5,965,427
2015	5	0	0	$3,121,758

Gas Transmission

	Number	Fatalities	Injuries	Property Damage as Reported
2010	107	10	61	$594,031,047
2011	118	0	1	$123,710,870
2012	103	0	7	$55,031,817
2013	105	0	2	$50,129,334
2014	132	1	1	$52,278,127
2015	143	6	14	$43,186,319

Hazardous Liquid

	Number	Fatalities	Injuries	Property damage as reported	Barrels spilled	Net barrels lost
2010	350	1	3	$1,075,193,990	100,558	49,452
2011	346	1	2	$273,532,147	89,111	57,374
2012	366	3	4	$144,914,963	45,884	29,247
2013	401	1	6	$278,525,540	117,467	85,696
2014	445	0	0	$131,449,399	46,973	21,688
2015	449	1	0	$247,327,746	101,897	82,880

continued next page.

TABLE 6-11 *continued*

	LNG			
	Number	Fatalities	Injuries	Property damage as reported
2010	NA	NA	NA	NA
2011	NA	NA	NA	NA
2012	1	0	0	$10,000
2013	1	0	0	$1,500
2014	3	0	1	$46,690,419
2015	2	0	0	$32,625

KEY: *Haz Liq* = Hazardous Liquid, LNG = Liquefied Natural Gas, NA = Data are not available.

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 April 2016.

SOURCE: U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Hazardous Materials Safety, *HAZMAT Intelligence Portal* (as of April 10, 2016). Available at https://hip.phmsa.dot.gov/ as of April 2016.

A new challenge for freight transportation safety relates to accidents involving tanker trucks and trains carrying hazardous materials. Chapter 3 discusses the rapid growth in domestic transportation, some of which involves hazardous materials. According to the Commodity Flow Survey, liquid hazardous materials tonnage increased 15.6 percent between 2007 and 2012; part of the increase could be a result of increased CFS coverage [USDOT BTS 2015]. Some 58.7 percent of hazardous liquid tonnage was moved by truck and 2.1 percent by rail in 2012. As for flammable solids, rail moved 32.9 percent of the tonnage and trucks transported 59.7 percent. Liquid hazardous materials include gasoline, fuel oils, and ethanol, while flammable solids include metal powders, shavings, and cuttings; rubber scrap; and molten sulfur, among other spontaneous combustible materials.

There has been a dramatic increase in hazardous liquid train traffic, as discussed in chapter 3, and several derailments resulting in explosions and fireballs have occurred in this country, resulting in evacuations of several communities. In Canada, the rail catastrophe in Lac-Mégantic, Ottawa, resulted in 47 deaths in 2013. Oil spills from pipelines and railroad tanker cars are discussed in more detail in chapter 7.

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CHAPTER 7

Transportation Energy Use and Environmental Impacts

Highlights

- Despite transportation's continued dependence on petroleum, recent trends show decreasing import dependence, small reductions in greenhouse gas emissions, and sharply reduced emissions of other air pollutants. U.S. dependence on imported oil decreased from a high of 60.3 percent in 2005 to 24.0 percent in 2015, largely as a result of increased domestic oil production.
- Transportation continues to rely almost entirely on petroleum to move people and goods. However, the sector's dependence on petroleum decreased from a peak of 97.3 percent of transportation energy use in 1978 to 91.7 percent in 2015. This reduction is due in part to increases in domestically produced ethanol in gasoline and improved fuel economy.
- The highway mode continues to dominate transportation energy use. Highway vehicles used 84.1 percent of total transportation energy in 2014, with personal vehicles accounting for 73.2 percent of highway energy use and 61.6 percent of total transportation energy use.
- The energy required to move one person one mile or one ton of freight one mile has generally declined over time. In 1975 the average miles per gallon (mpg) for all highway vehicles was 13.3 mpg. In 2014 the average was around 21.4 mpg and has continued to improve.
- Transportation is the second largest producer of greenhouse gas emissions (GHG), accounting for 26.0 percent of total U.S. emissions in 2014. Aside from greenhouse gases, the six most widespread or common air pollutant emissions from transportation are below their 2000 levels and continued to decline from 2009 to 2015 due to many factors, including motor vehicle emissions controls that have contributed to considerable reductions.
- Across 161 monitored urban areas, the total number of very unhealthy air quality days that could trigger health emergency warnings decreased from 290 in 2000 to 15 in 2015.
- Since 1990, hybrid and electric vehicles have grown to nearly 3.0 percent of the U.S. market for new vehicles. However, with petroleum prices low, the sale of these alternative fuel vehicles has decreased and sales of pickup trucks and SUVs have increased.

This chapter reviews the patterns and trends in transportation energy use, other aspects of energy associated with our Nation's transportation system, and transportation's impact on the environment. Energy use is closely tied to the transportation sector as most vehicles in the United States rely on petroleum as a fuel. Therefore, developments in domestic oil production, alternative fuels, and improvements in vehicle energy efficiencies play a critical role in the vitality of the transportation system. Environmental impacts under consideration include greenhouse gas (GHG) emissions caused by the transportation sector and petroleum spills. These energy and environmental aspects of the transportation system are also important measures of performance, along with such primary measures as system reliability, efficiency, and safety.

Recent trends show reduced U.S. dependence on imported oil as a result of increased domestic production, improved fuel economy for vehicles, and the growth in advancements for alternative energy sources. U.S. dependence on imported oil peaked at 60.3 percent in 2005, but has since decreased by more than half, from 49.2 percent in 2010 to 24.0 percent in 2015 [USDOE EIA 2016c].

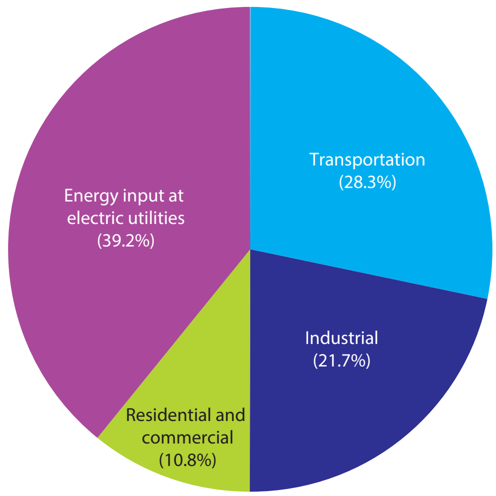
In 2015 the U.S. transportation sector used 27.6 quadrillion Btu (British thermal unit) of energy, second only to electricity generation but down from the peak of 28.8 quadrillion Btu in 2007 (figures 7-1 and 7-2). Transportation activities relied on petroleum for 91.7 percent of the transportation-related energy used in 2015, down from a record of 97.3 percent in 1978 (figure 7-2). The United States consumed more than 19.7 million barrels of oil per day, of which 13.8 million barrels (70.1 percent) were consumed by the U.S. transportation system in 2015 [USDOE EIA 2016c]. Despite transportation's continued dependence on petroleum, recent trends show decreasing import dependence, small reductions in greenhouse gas emissions, and sharply reduced emissions of other air pollutants.

Greenhouse gas (GHG) emissions (carbon dioxide, hydrofluorocarbons, methane, and nitrous oxide) have historically closely paralleled transportation energy use and, as a result, were 3.2 percent lower in 2014 than in 2000, while transportation sector GHG emissions decreased by 4.0 percent [USEPA 2016a]. Transportation sector GHG emissions peaked in 2005, but saw an overall downward trend with a low point in 2012 due to increased use of alternative fuels and improved fuel economy tied to increased fuel prices. Since then GHG emissions have begun to increase due to lower fuel prices resulting in increases in both miles traveled and use of SUVs and light trucks [USEPA 2016a].

Energy Use Patterns and Trends

Transportation's petroleum dependence decreased from 96.3 percent in 2005 to about 91.7 percent in 2015, chiefly due to increased blending of domestically produced ethanol from biomass in gasoline [USDOE EIA 2016c]. Today almost all gasoline sold in the United States contains 10.0 percent ethanol (E10). Nearly all transportation-related natural gas consumption, shown in figure 7-2, is used to fuel pipeline compressors. Natural gas use by motor vehicles remains a small fraction of total transportation energy use (figure 7-2).

FIGURE 7-1 U.S. Energy Use by Sector: 2015
Total = 97.6 Quadrillion Btu

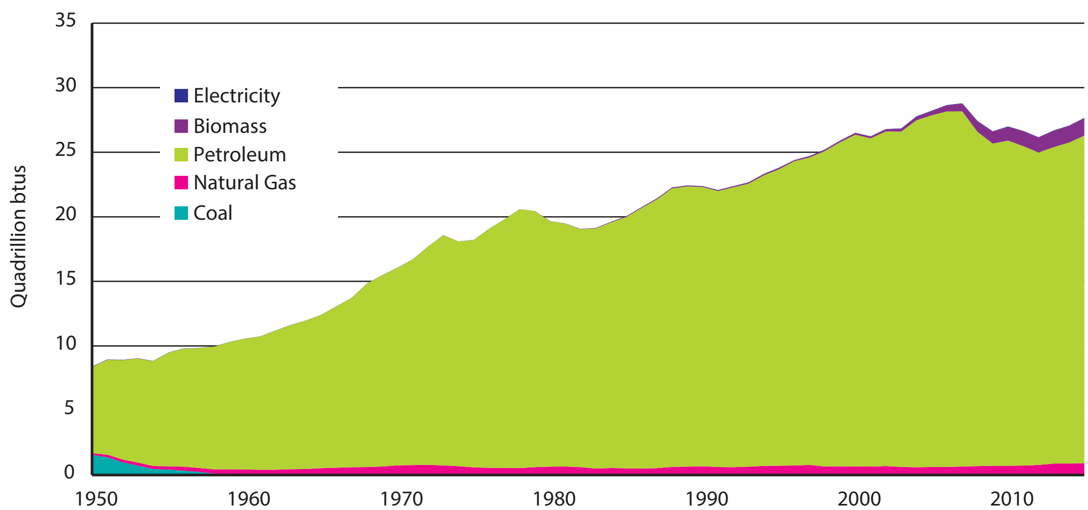


KEY: Btu = British thermal unit

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 Energy, Energy Information Administration, *Monthly Energy Review*, Table 2-1, Available at http://www.eia.gov/totalenergy/ as of April 2016.

FIGURE 7-2 Transportation Energy Use by Energy Source: 1950–2015



KEY: Btu = British thermal unit

SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 2.5. Available at http://www.eia.gov as of April 2016.

Transportation's petroleum use is expected to remain at about 13.5 million barrels per day through 2040 and beyond, despite decreases in personal vehicle gasoline use as a consequence of more stringent fuel economy standards [USDOE EIA 2016a]. This leveling off of petroleum consumption is expected because declining personal vehicle petroleum use is projected to be offset by growth in petroleum demand by other modes, particularly medium- and heavy-duty trucks. According to the Freight Analysis Framework (FAF), freight tonnage is forecast to grow 1.3 percent annually during this period (table 3-1 in chapter 3).

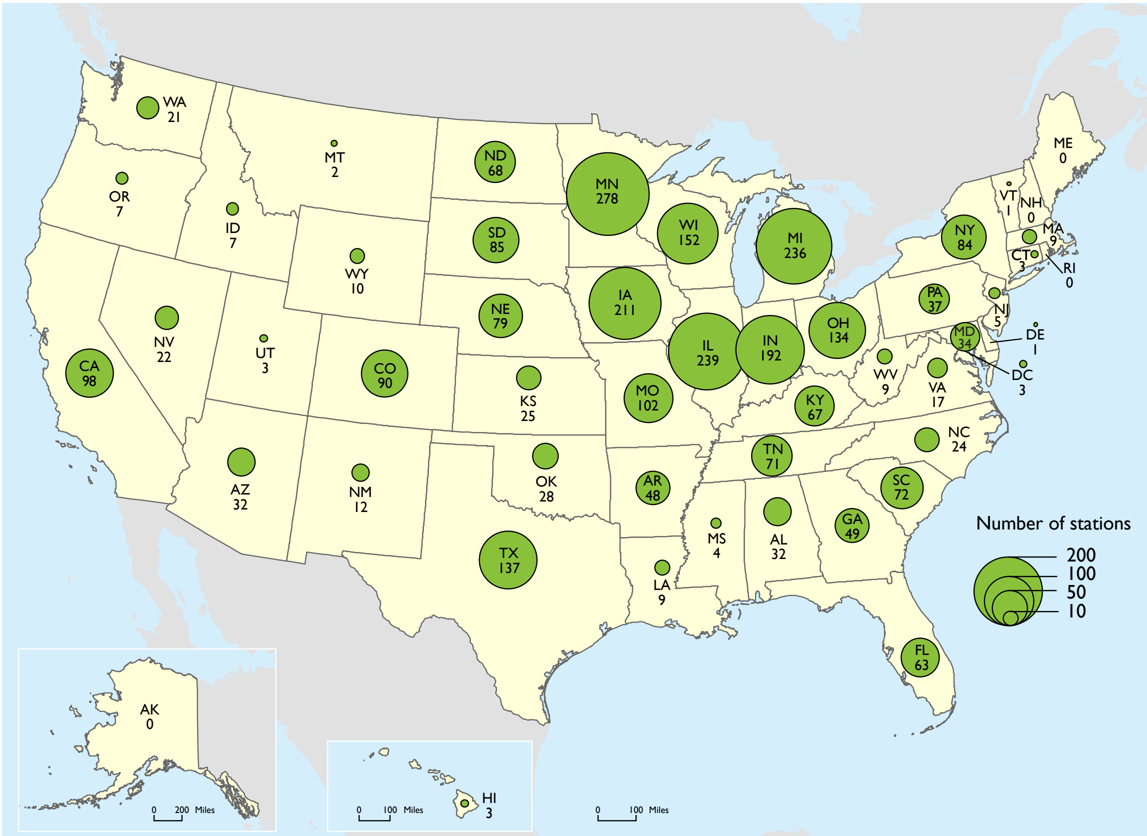
Alternative fuel use (excluding gasohol) by motor vehicles increased by 12.7 percent from 2010 to 2011 (the latest year for which data are available) [USDOE EIA 2016b]. Total alternative fuel use exceeded 500 million gasoline-equivalent gallons in 2011. In comparison, gasoline consumption[1] in the United States grew from about 134 billion gallons in 2011 to more than 140 billion gallons in 2015—approximately 385 million gallons per day [USDOE EIA 2016c]. In terms of overall energy consumption, compressed and liquefied natural gas accounted for almost one half of the total alternative energy used by transportation activities, followed by E85, propane, electricity, and hydrogen. E85 is a blend of between 51 and 85 percent denatured ethanol and gasoline and can be used safely by approximately 10 million flex-fuel vehicles operating on U.S. roads. However, E85 is predominantly available in the Midwest corn-belt states as indicated in figure 7-3.

The highway mode dominates transportation energy use (figure 7-4). Highway vehicles accounted for 84.1 percent of the total, and used five times more energy than all other modes combined in 2014.[2] Light-duty vehicles (passenger cars, sport utility vehicles, minivans, and pick-up trucks) accounted for 73.2 percent of highway energy use and 61.6 percent of total transportation energy use. Air transport came in a distant second with 6.2 percent of transport energy use, but this number excludes energy for international flights. Jet fuels supplied to international flights originating in the United States amounted to 931.6 trillion Btu [USEPA 2015a], which is nearly five times the amount of fuel used by domestic flights. Water transportation is third with 3.8 percent, but once again most of the energy used in international shipments is not included in this figure. An estimated 455.2 trillion Btu were supplied to international ships at U.S. ports [USEPA 2015a], an amount more than double that used by domestic waterborne shipping. Rail freight accounted for 2.0 percent of transportation energy use, although it carries roughly 30 percent of U.S. freight ton-miles. Pipelines used 3.4 percent of transportation energy, much of which is natural gas to fuel pipeline compressors. Transit operations accounted for 0.6 percent of transportation energy use.

[1] The U.S. Energy Information Administration (EIA) uses product supplies to approximately represent consumption of petroleum products. It measures the disappearance of these products from primary sources, such as refineries, natural gas processing plants, blending plants, pipelines, and bulk terminals.

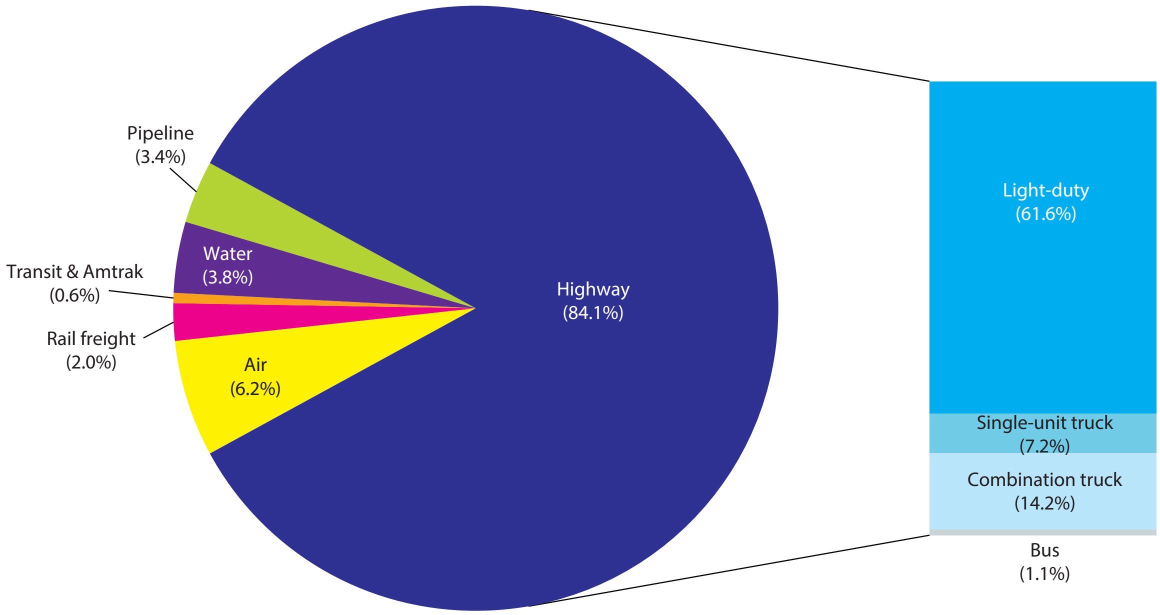
[2] Data on energy use by mode from 2013 and beyond are projected data.

FIGURE 7-3 E85 Refueling Stations by State: 2015



SOURCE: U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Alternative Fuels Data Center*. Ethanol Fueling Station Locations. Available at http://www.afdc.energy.gov/ as of October 2015.

FIGURE 7-4 Energy Use by Mode of Transportation: 2014
Total = 26 quadrillion Btu



KEY: Btu = British thermal unit

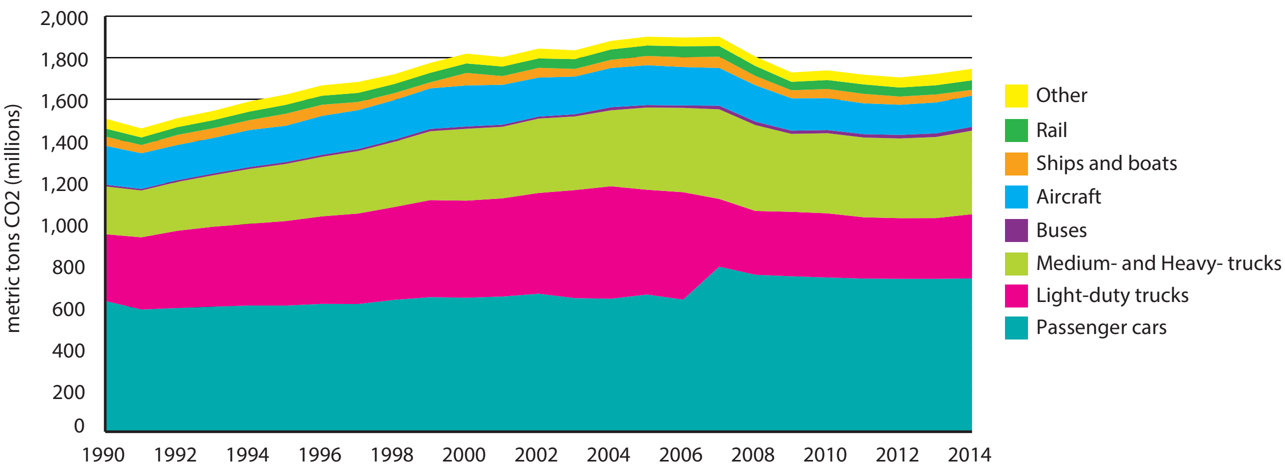
NOTES: The following conversion rates were used:
Jet fuel = 135,000 Btu/gallon.
Aviation gasoline = 120,200 Btu/gallon.
Automotive gasoline = 125,000 Btu/gallon.
Diesel motor fuel = 138,700 Btu/gallon.
Compressed natural gas = 138,700 Btu/gallon.
Distillate fuel = 138,700 Btu/gallon.
Residual fuel = 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: Air–Bureau of Transportation Statistics, Office of Airline Information. **Rail**–Association of American Railroads. **Transit**–Federal Transit Administration. **Amtrak**–National Railroad Passenger Corporation (Amtrak), personal communication with Energy Management Department and Government Affairs Department. **Water**– U.S. Department of Energy, Energy Information Administration and U.S. Department of Transportation, Federal Highway Administration. **Pipeline**– U.S. Department of Energy, Energy Information Administration. **Highway**– Federal Highway Administration as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 4-6, available at www.bts.gov as of June 2016.

Greenhouse Gas Emissions

The transportation sector is the second largest producer of greenhouse gas (GHG) emissions, accounting for approximately 26.0 percent of total U.S. emissions in 2014 [USEPA 2016a]. Electricity generation is the highest GHG producer. In recent years, transportation-related GHG emissions have been trending upward, but are below their 2005 peak (figure 7-5). Carbon dioxide (CO_2) produced by the combustion of fossil fuels in internal combustion engines is the predominant GHG emitted by the transportation sector. In 2014 passenger cars were the largest source of CO_2 from transportation, accounting for 42.2 percent, followed by freight trucks (23.0 percent) and light-duty trucks (17.7 percent). Domestic operation of commercial aircraft

FIGURE 7-5 CO_2 Greenhouse Gas Emissions by Mode: 1990–2014



NOTES: *Other* greenhouse gas emissions are from motorcycles, pipelines, and lubricants. International bunker fuel emissions (not included in the total) result from the combustion of fuels purchased in the United States but used for international aviation and maritime transportation. *U.S. Total, all modes; Aircraft;* and *Ships and boats* include emissions data for only domestic activity only as do all other data shown. International emissions from bunker fuels purchased in the United States are not included. Alternative-fuel vehicle emissions are allocated to the specific vehicle types in which they were classified (i.e., *Passenger cars, Light-duty trucks, All other trucks,*and *Buses*).

SOURCE: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (2016), table 2-13, available at http://epa.gov/climatechange/emissions/usinventoryreport.html as of April 2016.

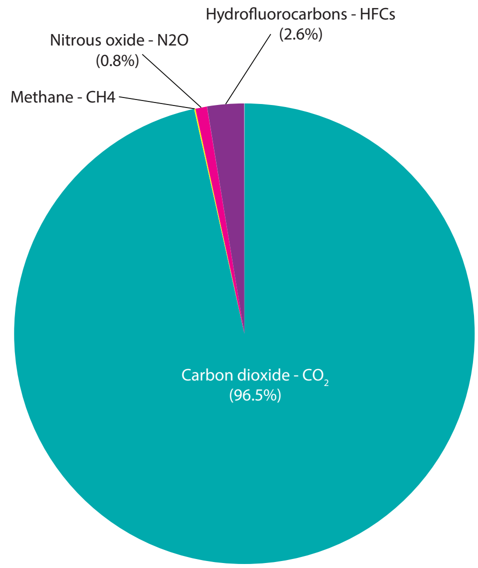
produced 6.6 percent of transportation CO_2 emissions; however, as mentioned in chapter 2, there are now more air passenger miles in international flights originating and ending in the United States than there are domestic passenger miles, leaving much of the air travel emissions unaccounted for. Pipelines were responsible for 2.7 percent of emissions, followed by rail (2.6 percent) and ships and boats (1.6 percent) [USEPA 2016a].

Hydrofluorocarbons (HFC), methane (CH_4), and nitrous oxides (N_2O) are the other principle GHGs emitted by the transportation sector. Each GHG has a different global warming potential, but all are reported using a common metric of equivalent grams of CO_2 for each emission (figure 7-6). Hydrofluorocarbons, such as those once used in automotive air conditioners,[3] are second in abundance behind CO_2. HFCs are the most detrimental GHGs known. GHG emission regulations for personal vehicles give manufacturers credits for reducing these HFC emissions, and it is likely that these emissions will decrease in the future. Nitrous oxides are chiefly produced in the catalytic converters of motor vehicles, and a very small quantity of methane emissions is produced by incomplete combustion of fossil fuels or by leakage.

Because 96.5 percent of transportation GHG emissions are CO_2 produced by fossil fuel combustion and because petroleum comprises 91.7 percent of transportation energy use,

[3] The original coolants were chlorofluorocarbons (CFCs), which when released into the atmosphere were found to create holes in the stratospheric ozone layer that helps to protect the Earth's surface from harmful radiation.

FIGURE 7-6 Transportation-Related Greenhouse Gas Emissions: 2014
Total = 1,810 Teragrams or million metric tons of CO_2 Equivalent Units



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% due to rounding.

SOURCE: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (2015), table 2-12 and table ES-6, available at http://epa.gov/climatechange/emissions/usinventoryreport.html as of April 2016.

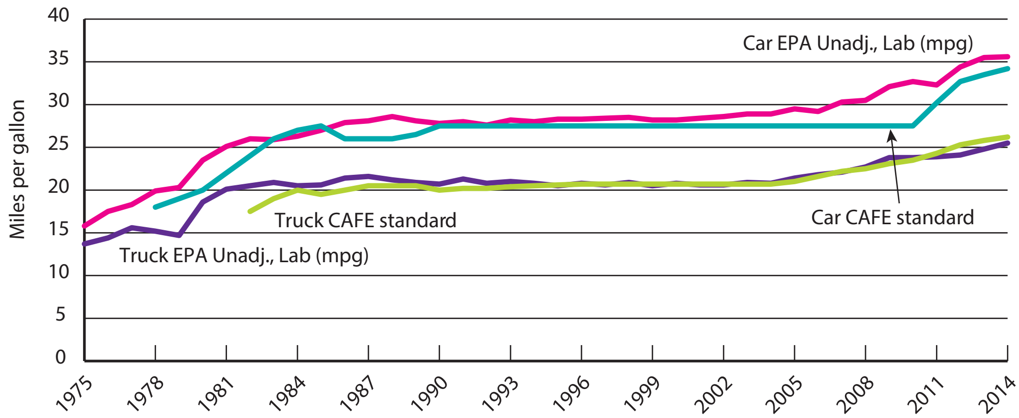
modal GHG emissions closely track modal energy use. Transportation GHG emissions increased from 2000 to 2007 (figure 7-5), fell by 5.0 percent during the economic recession in 2008, and then stabilized at slightly under 1,800 teragrams (million metric tons) in the 2009 to 2014 period [USEPA 2016a]. The short-term decrease in economic activity and the related decline in transportation demand contributed, in part, to the decrease in CO_2 emissions during the recession. Total transportation GHG emissions were 4.0 percent lower in 2014 than in 2000. Both the recession and also the improvements in availability of energy efficient vehicles likely contributed to this reduction [USEPA 2016a].

Evident in figure 7-7 are the results of the U.S. Environmental Protection Agency's (EPA's) decision to change the definitions of passenger cars and light trucks in 2007. Many vehicles formerly classified as light trucks, but designed predominantly for passenger transportation, were reclassified as passenger cars, causing an apparent jump in passenger car emissions that were offset by a compensating drop in light-truck emissions.

Energy Efficiency

Historically, improvements in the efficiency with which energy was used have enabled reduced energy consumption in the transportation sector. Fuel economies of passenger cars and light trucks have closely

FIGURE 7-7 Car and Truck Corporate Average Fuel Economy (CAFE) and Miles per Gallon (MPG): Model Years 1975–2014



KEY: MPG = miles per gallon; EPA = U.S. Environmental Protection Agency.

NOTES: 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: All Car and All Truck CAFE Stds: Davis, S.C., S.W. Diegel and R.G.Boundy. *Transportation Energy Data Book*, Edition 34 (September 2015), Oak Ridge National Laboratory, Oak Ridge, TN. Tables 4-20 and 4-21. Available at cta.ornl.gov/data as of April 2016. **Car and All Truck EPA MPG**: U.S. Environmental Protection Agency (EPA), *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 - 2015*. Table 9.1. Available at http://epa.gov/otaq/fetrends.htm as of April 2016.

tracked the Corporate Average Fuel Economy (CAFE) standards since they took effect in 1978 (figure 7-7). The miles per gallon (mpg) values shown in figure 7-7 are the unadjusted test values on which compliance with the standards is based. The actual mpg values seen on window stickers and in public advertising are adjusted downward to better represent the fuel economy drivers will likely experience on the road.

The apparent decrease in on-road fuel economy estimates after 2005 more likely reflects a change in the definitions of passenger cars and light trucks and the methods used to estimate their travel and fuel use than an actual decrease in mpg.

Another change in reporting (noticeable in figure 7-7) occurred when the U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA), started using the classifications of short- and long-wheelbase light-duty vehicles in 2007 rather than the previous categories of passenger cars and two-axle, four-tire trucks.[4] As a result, the post 2006 on-road fuel economy data are not consistent with the data from 2006 and earlier years, unless the categories are combined.

Personal vehicle travel and fuel use before 1975 typically moved in parallel tracks (figure 7-8). Fuel economy improvements after 1975

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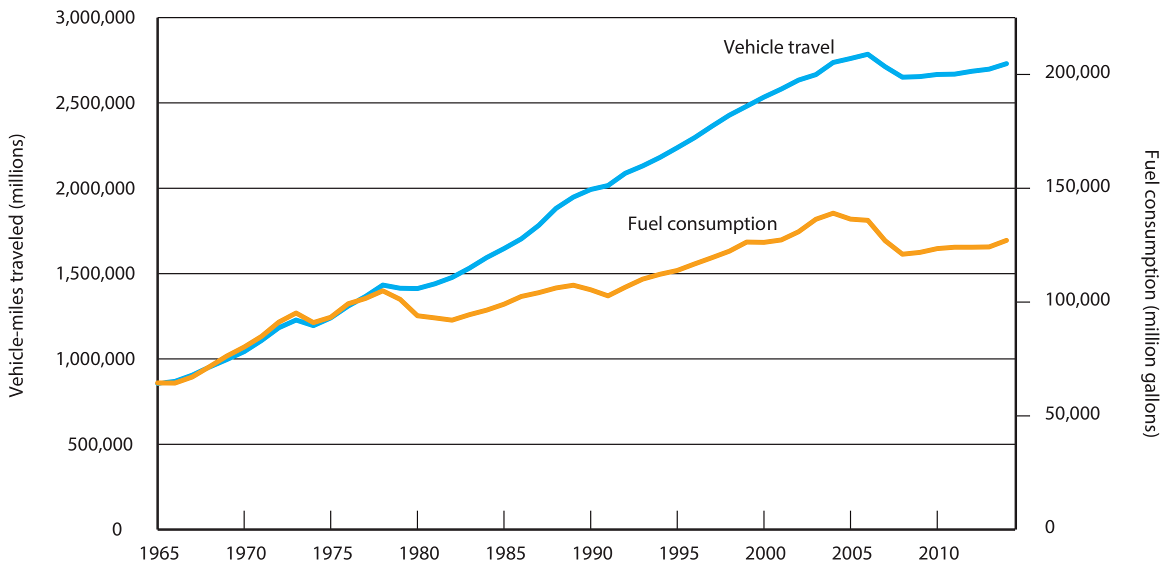
[4] A vehicle's wheelbase is the distance from the center of its rear axle to the center of its front axle. "Short-wheelbase" light-duty vehicles include passenger cars, pick-up trucks, vans, minivans, and sport-utility vehicles with wheelbases less than or equal to 121 inches. The same types of vehicles with wheelbases longer than 121 inches are classified as "long-wheelbase" light-duty vehicles. Typically, light-duty vehicles have gross vehicles weights of less than 10,000 pounds.

FIGURE 7-8 Vehicle-Miles of Travel and Fuel Use by Personal Vehicles: 1965–2014



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.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (multiple years), Table VM-1, available at http://www.fhwa.dot.gov/policyinformation/statistics.cfm as of April 2016.

broke the close connection as the amount of fuel used per vehicle-mile of travel steadily decreased. The gap widened as newer, higher mpg vehicles came to dominate the on-road fleet, eventually raising average mpg from 13.3 in 1975 to 21.5 in 2014, which is a slight increase from recent years due to a recent increase in consumer demand for light trucks and SUVs associated with low fuel costs [USEPA 2016f]. However, drops in fuel use are tempered somewhat by increases in travel stimulated by improvements in fuel economy, a phenomenon known as the "rebound effect." The average price of regular gasoline in the United States in 2015 was $2.33 per gallon, or $2.00 before motor fuel taxes, compared to an average total cost of $3.55 per gallon in 2012, the highest annual average since 2000 [USDOE EIA 2016d]. As gas prices hover at these low values, auto manufacturers that had focused on small, fuel efficient vehicles are now seeing drivers once again demanding the large trucks and SUVs of earlier years, but due to CAFE standards, they are now more fuel efficient [WOODYARD 2015].

On August 28, 2012, the USDOT and the EPA set fuel economy and GHG emissions standards for passenger cars and light trucks through 2025. Nominally, the standards require a total fleet average of 54.5 mpg (163 grams of CO_2 equivalent) for new personal vehicles by 2025 [USEPA 2012]. However, this is based on laboratory test cycles rather than real world driving and does not consider the many ways manufacturers can earn fuel economy credits. Credits may be earned for solar panels on hybrids, engine shut off at idle, and other features that improve real world fuel economy but which are not reflected in the test cycle.

Furthermore, the new standards vary with the size of the vehicles a manufacturer produces. Medium- and heavy-duty highway vehicles (e.g., combination trucks and buses) are the second largest energy users among modes, accounting for 22.7 percent of transportation energy use in 2013 [ORNL 2015]. In 2011 the USDOT and the EPA announced the first fuel economy and emission standards for this vehicle class for model years 2014–2018 [USEPA 2011]. By 2018 the requirements for combination tractor trailers specify fuel economy improvements ranging from 9 to 23 percent, depending on the truck type. Similar improvements are required for the diverse class of single unit commercial trucks and buses—vehicles as various as delivery trucks, dump trucks, cement mixers, and school buses. If a manufacturer produces mostly large vehicles, then its actual fuel economy requirement will be lower than if it produces mostly small vehicles.[5] Taking all these factors into account, USDOT and EPA estimated that manufacturers would achieve fuel economy levels of 46.2 to 47.4 mpg on the laboratory test cycles [FEDERAL REGISTER 2012]. Fuel economies achieved in actual driving would likely be 15 to 20 percent lower.

The energy intensities[6] of passenger modes have generally declined over time, with five out of six passenger modes now averaging less than 4,000 Btu per person-mile, or about 30 person-miles per gallon of gasoline equivalent (figure 7-9). These declines are largely the result of more aerodynamic vehicles and efficient engines as well as improved operating efficiencies (e.g., higher air carrier load factors). From 2000 to 2014, the energy intensity of short- and long-wheel base light-duty vehicles and bus transit rose while the energy intensity of other passenger modes—air and Amtrak—declined.

The energy intensity of rail freight transport decreased at an average annual rate of 1.6 percent per year since 1990. Moving one ton of freight one mile in 2013 required 88.4 percent as much energy as it did in 2000. This reduction was accomplished mostly through reducing energy use per freight car-mile by about 2.1 percent [USDOT BTS NTS 2015].

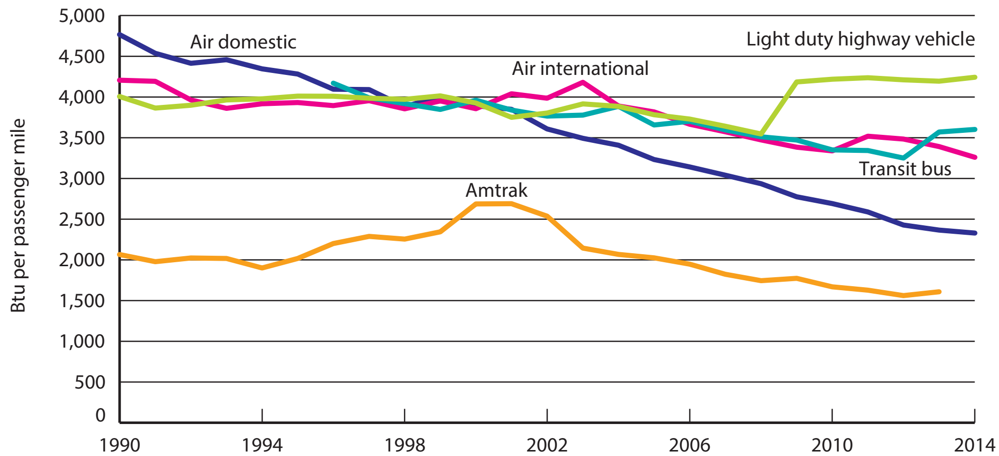
Alternative Fuels and Vehicles

A large part of the growing use of biofuels in transportation, shown in figure 7-2, can be attributed to the requirements of the Federal Renewable Fuels Standard (RFS). Enacted as part of the *Energy Policy Act* of 2005 (Pub. L. 109-58) and extended by the *Energy Independence and Security Act* of 2007 (Pub. L. 110-140), the RFS requires the introduction of increasing amounts of renewable energy into gasoline and diesel fuels each year, ultimately

[5] The size of a vehicle is defined as the rectangular "footprint" formed by its four tires. A vehicle's footprint is its track (width) multiplied by its wheelbase (length).

[6] Energy intensity is the amount of energy used to produce a given level of output or activity (e.g., energy use per passenger-mile of travel).

FIGURE 7-9 Energy Intensity of Passenger Modes: 1990–2014
Btu per passenger-mile



KEY: Btu = Britsh thermal unit

NOTES: Light-duty highway vehicles include passenger cars, light trucks, vans, and sport utility vehicles. Highway data for 2007-2011 were calculated using a new methodology and are not comparable to previous years. A change in vehicle occupancy rates derived from the National Household Travel Surveys results in a shift of highway passenger-miles between 2008 and 2009. Energy Intensity (Btu per Passenger mile) = Energy Use (Btu) / Passenger Miles, Energy Use calculated by using fuel and electricity usage and converting to energy by using BTS conversion rates. The following conversion rates were used: Diesel =138,700 Btu/gallon. Compressed natural gas = 22,500 Btu/gallon. Bio-Diesel = 126,200 Btu/gallon. Liquefied natural gas = 84,800 Btu/gallon. Gasoline = 125,000 Btu/gallon. Liquefied petroleum gas = 91,300 Btu/gallon. Methanol = 64,600 Btu/gallon. Ethanol = 84,600 Btu/gallon. Bunker fuel = 149,700 Btu/gallon. Kerosene = 135,000 Btu/gallon. Grain additive = 120,900 Btu/gallon. Electricity 1KWH = 3,412 Btu, negating electrical system losses. This table includes approximate electrical system losses, and thus the conversion factor is multiplied by 3.

SOURCE: Highway–Federal Highway Administration. **Air**–Bureau of Transportation Statistics, Office of Airline Information. **Amtrak**–National Railroad Passenger Corporation (Amtrak), personal communication with Energy Management Department and Government Affairs Department and Association of American Railroads. **Transit**–Federal Transit Administration as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 4-21, 4-22, 4-24, and 4-16, available at www.bts.gov as of May 2016.

reaching 36 billion gallons by 2022 [USLOC CRS 2013b and 2015]. At least 16 billion gallons are required to be cellulosic ethanol,[7] and no more than 15 billion gallons can be ethanol produced from corn starch. In 2014 the United States consumed nearly 13.5 billion gallons of fuel ethanol and 1.4 billion gallons of biodiesel [USDOE EIA 2016c]. More than 37 billion gallons of diesel fuel were consumed by vehicles in 2013 [USDOE EIA 2016e]. Diesel vehicles offerings, including new, clean diesel technologies are hitting the market, and these vehicles are providing more fuel efficiencies than similar-sized gasoline engines. Diesel fuel can provide up to 15 percent more energy than the equivalent amount of gasoline [USDOE and US EPA 2016]. These vehicles are a small percentage of the Nation's fleet of motor vehicles, mostly medium and heavy trucks. As of April 2016, Ultra Low Sulfur Diesel (ULSD) prices were averaging $2.11 compared to $2.15 for regular grade gasoline at the pump[8] [USDOE EIA 2016d]. In 2015 there were an estimated 1.74

[7] Cellulosic ethanol is produced from non-food based feedstock, such as wood and crop residues (corn husks, cobs and stalks), and switch grass.

[8] Gas prices reported are from a weekly survey of approximately 800 fuel retailers across the United States of prices paid at the pump including taxes.

million turbocharged direct injection (TDI) light-duty diesel vehicles in the United States out of 210.2 million conventional cars and light-duty trucks [USDOE ORNL 2015].

Ethanol

At present there is limited capacity to produce cellulosic ethanol, which has led the EPA to reduce cellulosic ethanol requirements each year, and the blending of ethanol from all sources with gasoline is very close to market saturation at the current 10 percent level. Additional ethanol production can only be absorbed by expanding the current distribution network of high ethanol blend fueling stations and increasing the numbers of vehicles capable of using these higher blends—up to and including E85 (85 percent ethanol, 15 percent gasoline). In 2013 the EPA decreased the requirement for cellulosic ethanol from 14 billion to 6 million gallons per year, less than one one-thousandth of the statutory amount, reflecting the absence of adequate production capacity for cellulosic ethanol [USEPA 2014b]. The EPA also has expanded the types of biofuels that can qualify under the RFS program to include such fuels as gasoline produced from biomass. At present, however, the capacity does not exist to produce these fuels in volumes that could make a meaningful contribution to achieving the RFS goals.

Nearly all U.S. gasoline now contains up to 10 percent ethanol. All automobile manufacturers' warranties allow 10 percent ethanol/90 percent gasoline blends (E10). In 2015 motor vehicles used more than 140 billion gallons of gasoline, including almost 13.9 billion gallons of ethanol [USDOE EIA 2016a]. Higher levels of ethanol of up to 15 percent (E15) may pose difficulties and is not recommended for motorcycles, older vehicles, and off-highway engines [USEPA 2016e]. The 10-percent limit has been termed the "blend wall," in that it appears to constrain the amount of ethanol that can be safely mixed with gasoline as a strategy for meeting the RFS. In 2011 after extensive study, the EPA issued a rule permitting E15 use in model year 2001 and newer motor vehicles. However, concerns exist about the potential for misfueling of older vehicles not capable of using E15 and risking mechanical problems. E15 is not widely available. It is currently sold at more than 100 stations largely concentrated in the Midwest. As a result of the United States Department of Agriculture's Biofuels Infrastructure Partnership, $210 million has been set aside for the installation of new ethanol infrastructure in 2016, which will increase the availability of E15 [USDOE AFDC 2016b].

Flexible-fuel vehicles (FFVs) can safely use mixtures of up to 85 percent ethanol (E85) with gasoline.[9] FFVs accounted for 75.7 percent of the nearly 19.7 million alternative fuel vehicles operating on U.S. roads in 2015 [USDOE EIA 2016a]. However, most on-road FFVs are fueled with gasoline or gasoline/E10 blends only. Until 2016 automobile manufactures can earn extra credits toward meeting CAFE standards by making and selling FFVs. Future FFV sales are uncertain because the credits will be largely phased out unless actual use of E85 increases

[9] E85 may contain anywhere from 51 percent ethanol to 85 percent ethanol. Because fuel ethanol is denatured with approximately 2 percent to 3 percent gasoline, E85 is typically no more than 83 percent ethanol.

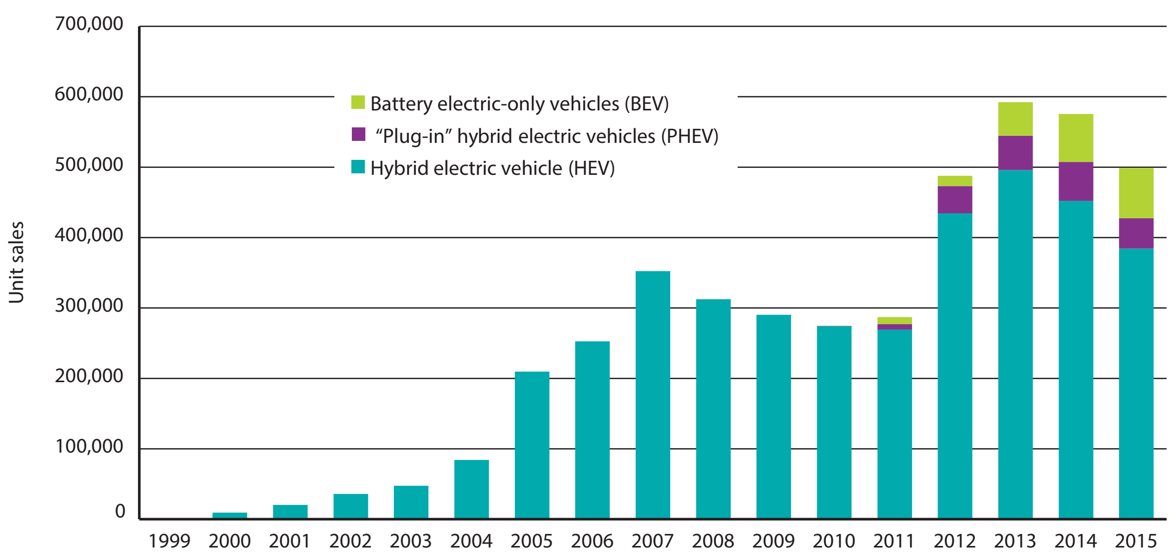
substantially. Together, liquid petroleum gas/propane and compressed/liquefied natural gas-powered vehicles accounted for approximately 4.5 percent of alternative fuel vehicles in use in 2015 [USDOE EIA 2016a]. Electrically driven motor vehicles are gaining popularity in the consumer market; however, their limited range of travel on a single battery charge and the limited availability of charging infrastructure are hindering their acceptance in the mass market.

Hybrid and Electric Vehicles

Until recently gasoline or diesel fuel alone powered nearly all motor vehicles. The first mass-produced hybrid electric vehicle (HEV), powered by an internal combustion engine and an electric motor, was introduced in 1999. The internal combustion engine continues to provide energy for this kind of hybrid vehicle, but kinetic energy normally wasted during braking is instead used to generate electricity that is stored in an onboard battery for later use by the electric motor. Hybrid vehicles have become popular since the early 2000s as a replacement for traditional gasoline- or diesel-fueled vehicles. All hybrid electric vehicle[10] sales have grown from 17 vehicles sold in 1999 to a high of 592,000 vehicles in 2013, before starting to decline in 2014. In 2015 about 499,000 HEVs were sold in the United States (figure 7-10). This decline is attributed mostly to the decline in gasoline prices at the same time, which in turn made HEVs less attractive for their fuel savings. In 2015, 54 makes and models of HEVs were offered for sale in the United States [USDOE and USEPA 2015b]. According to the U.S. Department of Energy (USDOE), Energy

[10] The total includes hybrid electric vehicles, "plug-in" hybrid electric vehicles, and battery electric-only vehicles.

FIGURE 7-10 Sales of Hybrid, Plug-in Hybrid and Battery Electric Vehicles: 1999–2015



SOURCES: HybridCars, December Dashboards, annual issues, available at www.hybridcars.com as of April 2016.

Information Administration (EIA), there were approximately 3.9 million hybrid electric vehicles (passenger cars and light trucks) or 1.6 percent of the approximately 230 million cars on the road in 2015 [USDOE EIA 2015a].

The first mass-produced "plug-in" hybrid electric vehicles (PHEV), able to draw electric power from the utility grid and store it on-board, were 2011 model year vehicles sold in 2010. In 2010 just 19 electric-only and 326 plug-in hybrid vehicles were sold. By 2015 combined sales of grid-connected vehicles totaled more than 115,000 units, a decrease of 9,000 units from 2014 [HYBRIDCARS 2016]. Over the same period, the number of new to the market makes and models of battery electric-only vehicles increased from 3 to 12, while plug-in hybrid offerings increased from 1 to 15 [USDOE and USEPA 2016b].

Hybrids and grid-connected vehicles comprised about 2.87 percent of the 17.4 million vehicle sales in 2015—a reduction of 75 thousand sales from 2014 [HYBRIDCARS 2016]. Both types of vehicles face several challenges: reducing costs, overcoming the market's unfamiliarity with the new technology, decreasing the length of time required for recharging batteries, and developing a recharging infrastructure.

Refueling and Recharging Stations

The geographical distribution of refueling stations for alternative fuels partly reflects the numbers of vehicles in each state but also reflects the interests of residents and public policies (table 7-1). Considerable progress has been made in creating a nationwide recharging infrastructure. As of October 2016, there were more than 17,000 recharging stations including privately-owned stations with more than 37,000 nonresidential charging outlets across the United States, up from almost 3,400 outlets in 2011 [USDOE AFDC 2016a].[11]

E85 stations are disproportionately concentrated in states that grow corn and produce ethanol (figure 7-3). The distribution of electric vehicle recharging stations tends (figure 7-11) to favor states that have opted into California's Zero Emission Vehicles (ZEV) standards.[12] Manufacturers selling electric vehicles in these states earn credits towards meeting the ZEV requirements. The distribution of compressed and liquefied natural gas refueling stations, on the other hand, more closely reflects the number of CNG/LNG vehicles registered in a state (figure 7-12).

Transportation's Energy Outlook

The EIA has projected the likely effects of current trends and existing policies on transportation's future energy use and GHG emissions. The 2016 projections anticipate transportation energy use remaining at or near the current level of 27 quadrillion Btu through 2040 [USDOE EIA 2016a]. Existing

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[11] A single electric vehicle recharging station may include multiple recharging outlets. Residential recharging locations are included in the station count. *Transportation Statistics Annual Report 2015* presented the number of recharging outlets rather than both stations and outlets as noted here.

[12] Connecticut, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Washington, Delaware, Georgia, and North Carolina have adopted the California Air Resources Board (CARB) regulations for a vehicle class or classes in accordance with the Section 177 of the *Clean Air Act*.

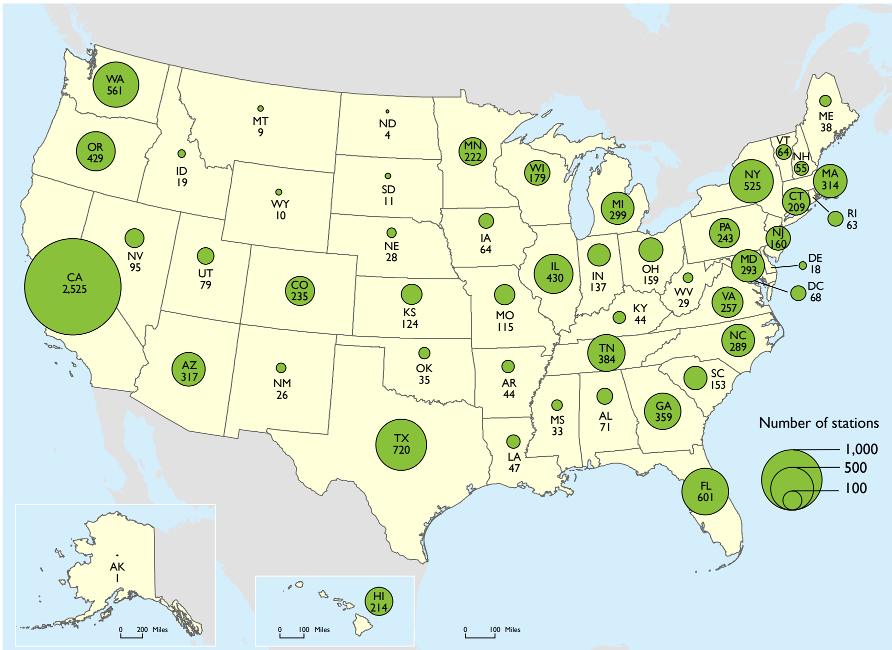
TABLE 7-1 Alernative Fuel Stations by State: April 2016
Total Public and Private Alternative Fueling Station Counts

State	E85-ethanol	Electric vehicle recharging outlets	Compressed and liquefied natural gas
Alabama	31	217	33
Alaska	0	5	1
Arizona	30	928	46
Arkansas	47	82	16
California	116	11,394	353
Colorado	89	802	46
Connecticut	4	548	18
Delaware	1	55	1
District of Columbia	4	263	2
Florida	79	1,779	55
Georgia	58	1,270	46
Hawaii	3	523	1
Idaho	6	96	18
Illinois	266	1,037	55
Indiana	201	299	35
Iowa	209	169	10
Kansas	25	653	19
Kentucky	73	120	10
Louisiana	9	112	27
Maine	0	122	2
Maryland	33	989	13
Massachusetts	6	1,146	23
Michigan	253	951	26
Minnesota	294	610	24
Mississippi	3	43	10
Missouri	100	643	23
Montana	2	57	0
Nebraska	81	66	10
Nevada	20	415	10
New Hampshire	0	152	3
New Jersey	5	454	30
New Mexico	10	122	16
New York	82	1,477	84
North Carolina	57	898	44
North Dakota	55	5	0
Ohio	143	458	59
Oklahoma	31	83	115
Oregon	8	1,175	17
Pennsylvania	44	566	65
Rhode Island	0	187	4
South Carolina	68	338	12
South Dakota	80	38	0
Tennessee	77	901	23
Texas	200	2,120	141
Utah	3	278	100
Vermont	1	310	3
Virginia	20	832	24
Washington	21	1,686	26
West Virginia	11	76	4
Wisconsin	159	401	60
Wyoming	11	48	13
Totals by fuel	**3,129**	**37,999**	**1,776**

NOTE: Shaded areas denote major corn producing states.

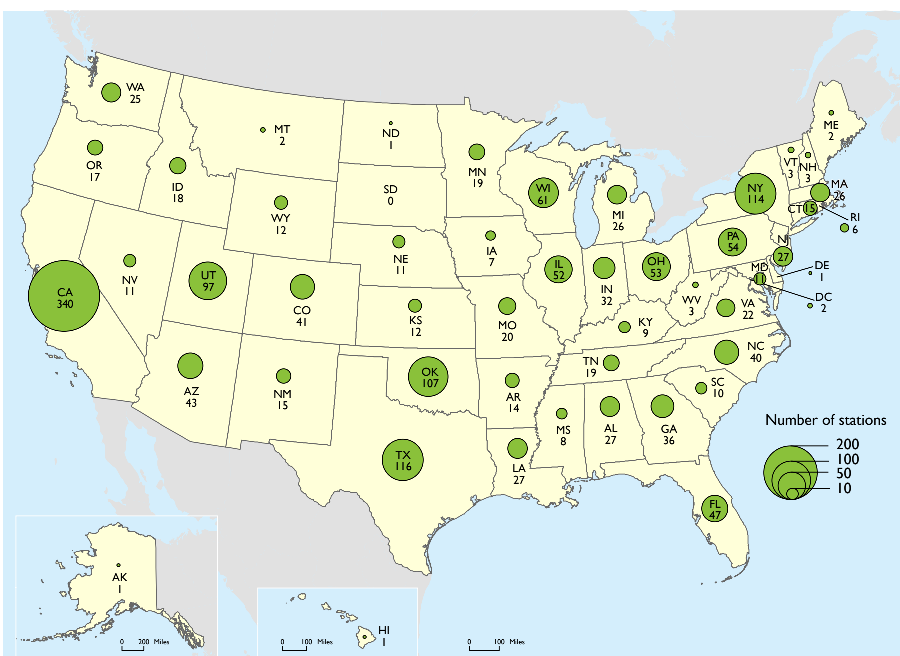
SOURCES: U.S. Department of Energy, *Alternative Fuels Data Center*, Alternative Fueling Station Counts (as of 04/28/2016), available at http://www.afdc.energy.gov/fuels/stations_counts.html as of April 2016.

FIGURE 7-11 Electric Vehicle Refueling Stations by State: 2015



SOURCE: U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Alternative Fuels Data Center*. Ethanol Fueling Station Locations. Available at http://www.afdc.energy.gov/ as of October 2015.

FIGURE 7-12 CNG and LNG Refueling Stations by State: 2015



SOURCE: U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Alternative Fuels Data Center*. Ethanol Fueling Station Locations. Available at http://www.afdc.energy.gov/ as of October 2015.

fuel economy and GHG emissions standards are expected to decrease light-duty vehicle energy use by 19.7 percent by 2040, resulting in approximately 12.6 quadrillion Btu of energy use (figure 7-13). Most of this reduction is expected to be offset by growth in energy use by medium- and heavy-duty trucks, although that could change if fuel economy and emissions standards for those vehicles are further tightened.

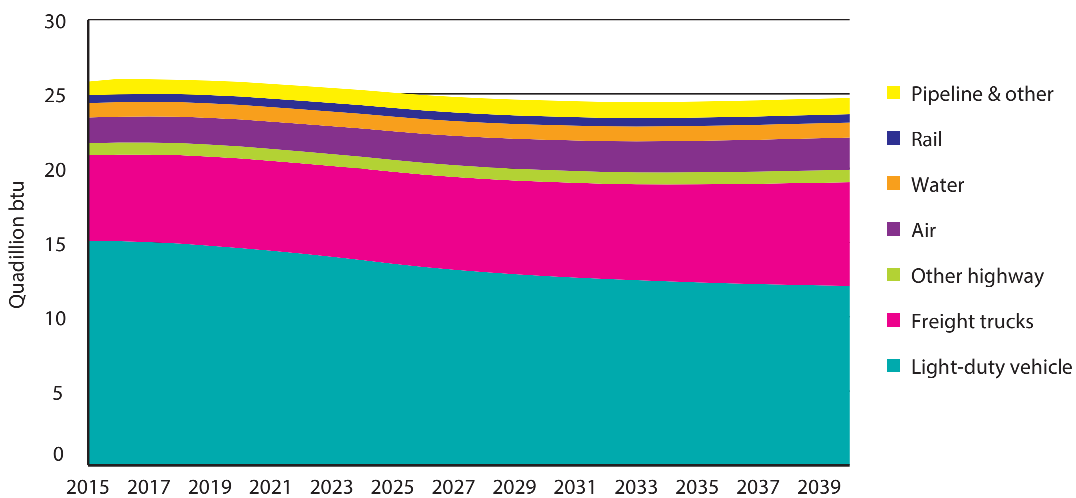
For all other modes, activity growth is approximately balanced by improvements in energy efficiency. These projections are based on existing policies and increasing oil prices.[13] Natural gas use by motor vehicles in compressed and liquefied form is projected to increase from just 0.06 quads in 2015 to 0.66 quads by 2040 [USDOE EIA 2016a]. EIA attributed all of the projected increase in natural gas use by motor vehicles to medium- and heavy-duty trucks and buses.

According to the EIA, the 2011–2025 fuel economy standards, together with the market's response to higher gasoline prices, are projected to save personal vehicle owners about 40 billion gallons of motor fuel in 2025, compared to what consumption would have been at the same level of vehicle travel without any increase in fuel economy (figure 7-14).

By fuel type, EIA projects gasoline use to decline from 17.0 quads in 2015 to 12.6 in 2040, in line with light-duty vehicle energy use. Diesel fuel use will increase from 6.7 to 8.0 quads, which is consistent with the growth

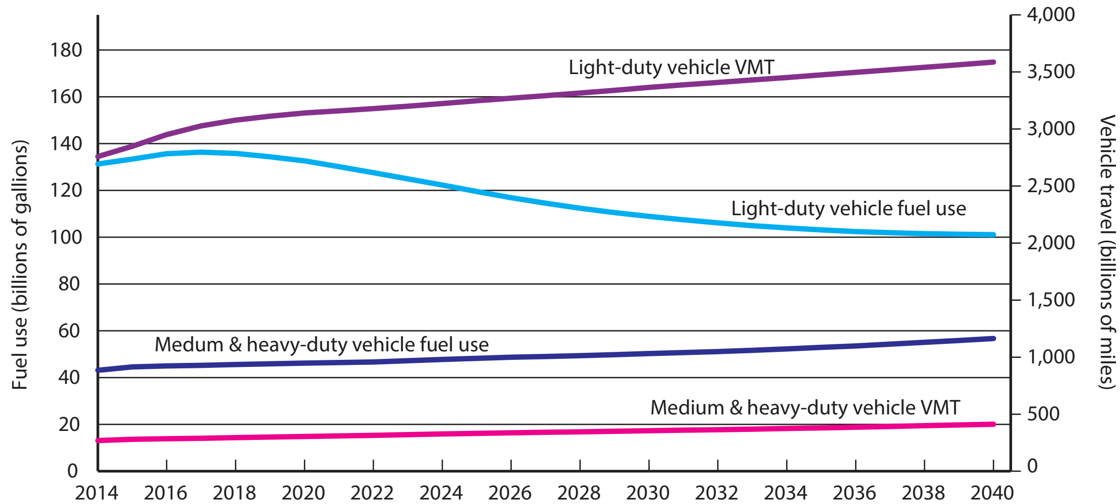
[13] EIA's *Annual Energy Outlook* include multiple scenarios, one of which includes oil price decreases over the 2014-2040 period. However, for this TSAR report, the Reference Case was used, which is based upon existing policies and increasing oil prices.

FIGURE 7-13 Transportation Energy Use: Projected 2015–2040



SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2015*. Transportation Sector Energy Use by Mode and Type. Available at http://www.eia.gov/forecasts/aeo/ as of June 2015.

FIGURE 7-14 Highway Vehicle Fuel Use and Travel: 2014–Projected to 2040



KEY: VMT = Vehicle-miles traveled.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2015*. Reference Case table 7. Available at http://www.eia.gov/forecasts/aeo/ as of April 2016.

of truck freight energy use. E85 and electricity use will increase but will still amount to only 0.28 quads and 0.06 quads of energy in 2040, respectively [USDOE EIA 2015a].

Air and Water Quality, Noise, and Habitat Impacts

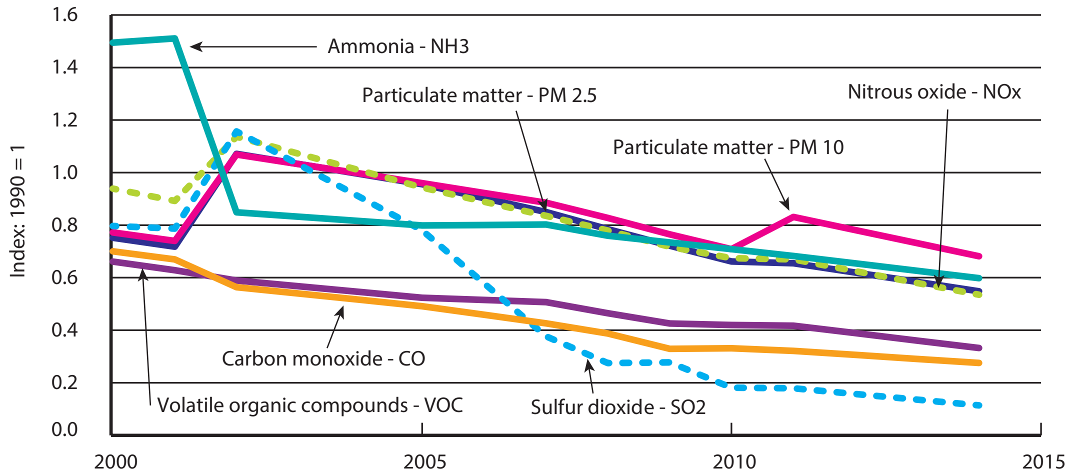
Beyond the greenhouse gases addressed earlier in the chapter, vehicle emissions controls and other policies have reduced transportation's other six most common criteria air pollutant emissions to below their 2000 levels, a trend that continued through 2014[14] (figure 7-15). Smog-forming emissions of volatile organic compounds (VOC) and nitrogen oxides (NO_x) were 49.8 and 43.0 percent lower, respectively, in 2014 than they were in 2000. In recent years, NO_x emissions have decreased more rapidly, partly due to more advanced diesel emission controls and the use of cleaner, ultra-low sulfur diesel fuel.

Transportation's share of total U.S. PM-2.5 emissions decreased by 27.1 percent from 2000 to 2014, while the share of PM-10 emissions decreased by 11.7 percent over the same period.

Emissions of sulfur dioxide (SO_2) were 85.7 percent lower in 2014 than in 2000, due in large part to reductions in the sulfur contents of gasoline and diesel fuel. The *Clean Air Act* of 1970 led to the reduction in lead emissions, once a major air pollutant from transportation;

[14] Often called "criteria pollutants" because the U.S. Environmental Protection Agency sets permissible levels for these air pollutants using criteria based on scientific guidelines on human health or welfare under the *Clean Air Act*.

FIGURE 7-15 Indexes of Key Air Pollutant Emissions from U.S. Transportation: 2000–2014



SOURCE: U.S. Environmental Protection Agency, *National Emissions Inventory Air Pollutant Emissions Trends Data, 1970-2014*, Average Annual Emissions All Criteria Pollutants, Available at https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data as of April 2016.

lead is not shown in the figure because it has been virtually eliminated from transportation with the phase-out of leaded gasoline.

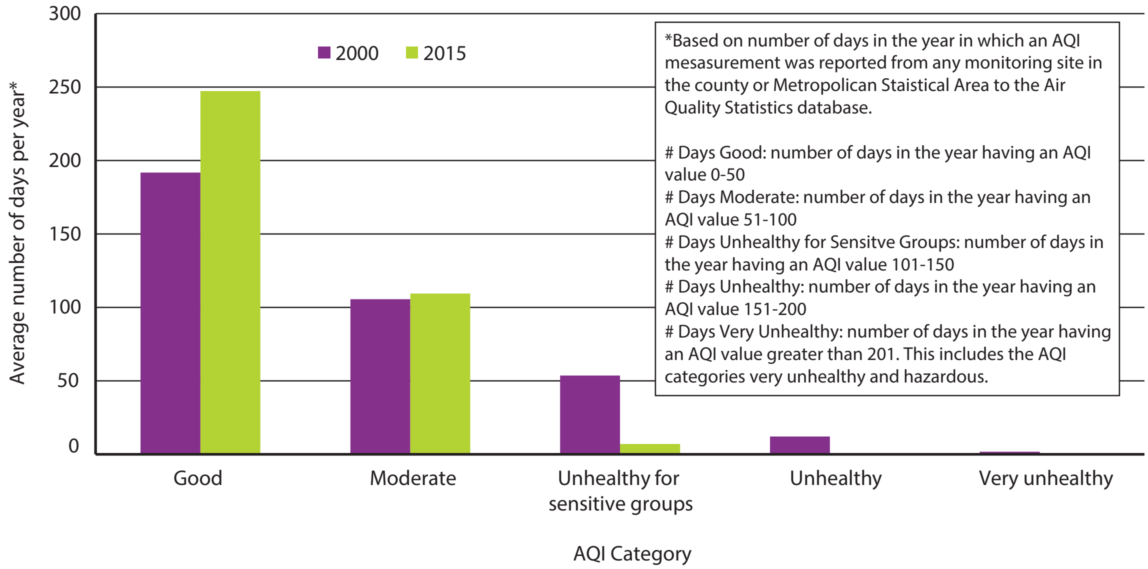
Emissions of ammonia (NH_3), another air pollutant, also shows a significant decline from 2000 levels with a reduction of 60.0 percent in 2014. Transportation comprised 2.6 percent of total U.S. emissions of ammonia in 2014 [USEPA 2016b].

Reductions in transportation's air emissions have contributed to improved air quality in the Nation's urban areas. Figure 7-16 compares air quality days for 161 continuously monitored urban areas in 2000 and in 2015. The average number of days from the 161 urban areas in which air quality was reported to be unhealthy for sensitive groups (e.g., people with lung disease, young children, and older adults) dropped from 53.6 in 2000 to 7.1 in 2015; the average number of days with unhealthy air quality for the population as a whole declined from 12.2 in 2000 to 0.9 in 2015, and the total number of very unhealthy days (which could trigger health emergency warnings for the public) decreased from an average of 1.8 in 2000 to 0.1 in 2015. The great majority of days had good or moderate air quality in both 2000 and 2015, but 2015 had many more days of good or moderate air quality in these cities [USEPA 2016b].

Pipelines, ships, railroad cars, and tank trucks are among the sources of spills of crude oil and petroleum products into surface waters and navigable waterways.[15] The annual volume spilled varies greatly from year to year and is strongly affected by infrequent, large events (figure 7-17). For example, in 2005 Hurricane Katrina caused numerous spills into navigable waterways from a variety of sources in Louisiana and Mississippi as the

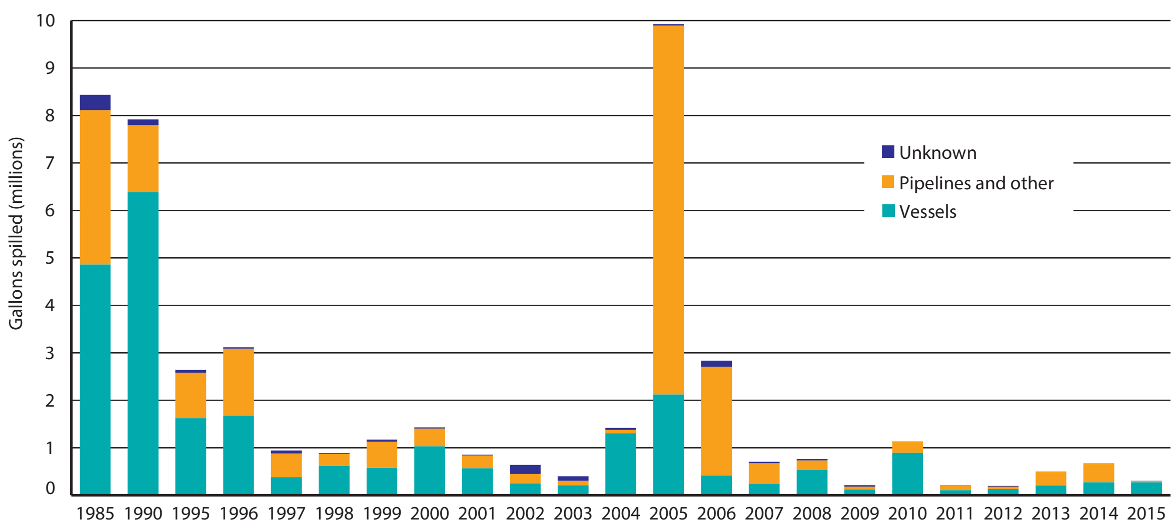
[15] Safety issues associated with spills of hazardous materials are covered in Chapter 6.

FIGURE 7-16 Air Quality Index for 161 U.S. Cities: 2000 and 2015



SOURCE: U.S. Environmental Protection Agency, Air Quality Index Information. Available at http://www.epa.gov/airtrends/aqi_info.html as of June 2016.

FIGURE 7-17 Petroleum Spills Impacting Navigable Waterways: 1985, 1990, and 1995–2015



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 April 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 amout 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 http://www.bts.gov as of May 2016.

volume of petroleum spilled jumped to 9.9 million, more than three times the amount of petroleum spilled in any other year from 1995 through 2015.[16] While the number fluctuates from year-to-year, the 1,375 spill incidents from vessels in 2015 were slightly less than the number of incidents in 2010 of 1,508 and much less than the 5,560 in 2000. The 681 spill incidents from pipelines and other non-vessel sources into navigable waters in 2015 show a similar declining trend from the 1,008 incidents in 2010 and 1,645 in 2000, indicating improvements in safety measures for all petroleum transport modes.

Pollution of waterways from spills, however, is not the only environmental challenge posed by marine transportation. Port and vessel operations can negatively impact air quality and have other detrimental impacts on the environment (see box A).

Additionally, the USDOT Pipeline and Hazardous Materials Safety Administration (PHMSA) reports that the number of serious pipeline incidents from 2000 to 2014 is down from 62 to 28. There is also a general declining trend in the number of fatalities associated with pipeline incidents, from 38 to 9, for that period [PHMSA 2016].

In 1985, in response to a congressional requirement, EPA began an effort to regulate underground storage tanks that can contaminate ground water, to clean up leaks, and prevent them in the future [USEPA 2016c].

[16] The much larger Deepwater Horizon oil platform fire and spillage in the Gulf of Mexico of 207 million gallons is not considered to be a spill into navigable waters of the United States or a spill from a transporting vessel (USLOC CRS 2013a).

Since then, the number of new leaks from storage tanks has been reduced by nearly an order of magnitude and over 85 percent of all leaks have been cleaned up (figure 7-18).

As rainwater or snowmelt runs off transportation infrastructure, like roads, parking lots, and bridges, it picks up de-icing salts, rubber and metal particles from tire wear, antifreeze and lubricants, and other wastes that may have been deposited on infrastructure surfaces. The runoff carries these contaminants into streams, lakes, estuaries, and oceans. An in-depth study of road-salt impacts on water quality examined U.S. Geological Survey historical data collected between 1969 and 2008 from 13 northern and 4 southern metropolitan areas. During the November to April period, when road salt application is most common, the concentration of chloride (an ingredient of salt) chronically surpassed EPA's water-quality criteria at 55 percent of the monitoring locations in northern metropolitan areas; chloride levels acutely surpassed the criteria at 25 percent of these northern stations. From May to October, only 16 percent of the northern stations chronically exceeded the criteria, and just 1 percent showed acute exceedances. At southern sites, where road salt is less frequently applied, there were few samples in any season that exceeded the chronic water-quality criteria, and none exceeded the acute criteria [CORSI, ET AL. 2010].

Highways and other transportation infrastructure also affect wildlife via road kills, habitat loss, and habitat fragmentation. Numerous projects have been undertaken across the United States to mitigate these

Box 7-A Environmental Challenges Associated With Marine Transportation

According to the Freight Analysis Framework, the water mode moved more than 1 billion tons of goods valued at $831 billion in 2015, accounting for 5.7 percent of the weight and 4.3 percent of the value of all domestic freight shipments [USDOT FHWA and BTS 2016]. Marine transport of this large volume of goods accounted for about 3 percent of transportation sector energy use, which is expected to double by 2040. [USDOE EIA 2015]. The use of petroleum-based fuels in marine transport and port operations produces air pollutants that impact air quality and also result in unintended oil and fuel spills that negatively affect our Nation's waterways.

Emissions Associated With Marine Transport

U.S. marine vessels contributed approximately 24 million metric tons of CO2 to our atmosphere in 2014, which is less than half of what it was in 2000 [USEPA 2016a]. Commercial marine transportation contributes approximately 44,000 tons of particulate matter (PM-10) emissions annually, accounting for nearly 24 percent of the 185,600 tons attributed to freight-related transportation, second only to heavy-duty trucks. This level of emissions is projected to remain constant through 2020, while both truck and rail emissions are expected to decrease [USDOT FHWA 2011]. In 2010 the International Maritime Organization's Marine Environment Protection Committee adopted a North American Emission Control Area that created new limits on emissions of sulfur oxides (SOx), nitrogen oxides (NOx), and particulate matter within 230 miles of U.S. or Canadian coasts [FMC 2016]. These emissions limits are to be attained through new engine standards for vessels, which include advancements in exhaust gas cleaning technology and use of low-sulfur fuel [USEPA 2016b].

The 360 commercial ports in the United States generate emissions in concentrated areas. In addition to emission-generating cranes, drayage trucks, and other dedicated equipment, ports also serve as a multimodal hub, with heavy-duty trucks moving cargo in and out of the ports. Clean diesel fuel (discussed earlier in this chapter) is one means of reducing port-related emissions. Alternate marine power (AMP), sometimes called cold ironing, is another means of reducing emissions while ships are docked for loading or unloading. AMP provides shore-side power for basic ship functions, such as lights and air-conditioning, reducing the need to run the ships' diesel engines [MARINE INSIGHT 2016].

Climatic Change Considerations for Marine Transport

Climate change has the potential to impact marine transportation. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change, published in 2014, predicts frequent and longer heat waves (which may lead to more drought periods), intensified and frequent precipitation events in some regions, and additional rise of mean sea levels [IPCC 2014]. While these are global, model-based predictions, recent U.S. climate history supports these forecasts.

The 2012 upper mid-west drought affected crop production as well as the transport of crops and other goods to market. Barges had to reduce load sizes to navigate lower water levels in the Mississippi River and other waterways. Energy production also heavily relies on barge transport of coal to power plants across the eastern and middle United States [National Geographic 2013]. Flooding can also affect barge movements on the inland waterway system, necessitating reduced tow sizes as well as restrictions on night-time navigation due to fast-moving currents.

continued next page

Box 7-A (continued)

While sea level rise is anticipated, the Atlantic and Gulf coasts are already experiencing some impacts and have seen approximately one inch per decade increases in the 20th century. Efforts are underway at many ports to assess and prepare for climate change by constructing protective infrastructure, developing reinforcement mechanisms, elevating infrastructure, and creating more robust plans for normal and emergency operations.

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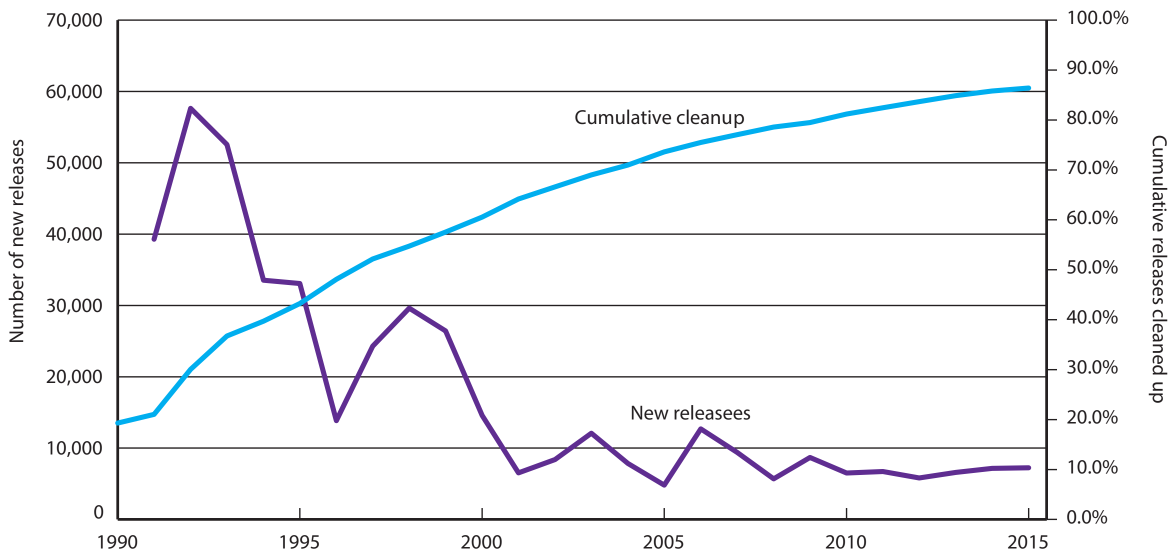
FIGURE 7-18 Leaking Underground Storage Tank Releases and Cleanup: 1990–2015



NOTES: All data are cumulative from the start of the U.S. Environmental Protection Agency's Underground Storage Tank program, which began in 1984. Data represent fiscal year, October 1 through September 30.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-55, Available at http://www.bts.gov as of April 2016.

impacts, from salamander and badger tunnels to mountain goat underpasses on highways to fish passages through culverts.[17] There are no systematic estimates of the numbers of wildlife killed by transportation vehicles in the United States. In certain circumstances, the population effects of road kill have been shown to be substantial, even threatening the survival of endangered species. In general, the number of bird kills exceeds the number of mammals killed. Insurance industry records indicate that there are between one and two million reported collisions between animals and vehicles each year. These numbers only include reported incidents; collisions with small animals resulting in no vehicle or human damage are not generally reported [GASKILL 2013].

Transportation noise is pervasive and difficult to avoid in the United States [USDOT FHWA HEP 2006]. It is generated by engines, exhaust, drive trains, tires, and aerodynamic drag. At freeway speeds tire-pavement noise dominates for highway vehicles, while exhaust and aerodynamic noise dominate for aircraft. However, a national noise exposure inventory does not exist. The United Kingdom has developed a noise inventory for 23 large urban areas by estimating noise levels using computer models that are based on transportation activity data [UKDEFRA 2016]. BTS in conjunction with the John A. Volpe National Transportation Systems Center is

[17] While there are no comprehensive statistics on mitigation efforts, numerous case studies of highways mitigation efforts can be found at http://www.fhwa.dot.gov/environment/wildlife_protection/index.cfm/.

currently developing a national, multimodal transportation noise inventories.

Unwanted noise can have a variety of impacts including annoyance, sleep disruption, interference with communication, adverse impacts on health and academic performance, and consequent reductions in property values. There is almost no part of the United States in which transportation noise is not noticeable [WAITZ 2007]. When transportation noise levels are below 45 decibels (dB), the level of annoyance in the population is negligible, but when noise levels exceed 65 dB, impacts can be severe.[18] Although highways are the most widespread source of transportation noise, exposure to transportation noise is systematically measured only for aircraft. In 2014, 321,000 individuals lived in high noise (>65 dB) areas around U.S. airports. The number of people residing in high noise areas around U.S. airports was down from nearly 7 million over 30 years ago and 847,000 in 2000. The number was reduced through a combination of changes in engine and airframe design and operational strategies [USDOT BTS NTS 2015]. Take-off and landing operations are the primary source of annoying aircraft noise, which per dB is generally more annoying to the public than highway or rail noise.

Under certain circumstances, unwanted and unnecessary light is considered “light pollution” [MRSCW 2016]. Transportation vehicles and facilities can be sources of light pollution. While light pollution is a special concern for facilities like astronomical observatories, it is also known to adversely affect biodiversity in urban areas and to have harmful effects on human metabolism [COE 2010]. No systematic data on light pollution due to transportation in the United States exists.

In addition to the primary performance measures of how efficiently, reliably, and safely people and goods move on the system, transportation’s energy usage and its environmental impacts are also important measures of how well the transportation system performs its societal function. In recognition of this, there have been efforts to mitigate transportation’s dependence on petroleum and environmental impacts. As detailed in this chapter, transportation has become more efficient over the past few decades in its use of energy and has reduced many of its environmental impacts even though activity levels have increased. It continues, however, to be the second leading emitter of greenhouse gases in the United States and has had other major impacts on the environment, such as oil pollution, habitat loss, and noise. Going forward, appropriate and accurate data will be needed to monitor progress and determine whether societal efforts to improve the system’s performance are having the desired effect.

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[18] Noise (sound) is measured in decibels (dB) on a logarithmic scale. Each increase of 10 dB represents a doubling of the noise level.

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CHAPTER 8

The State of Transportation Statistics

Highlights

- Progress is being made on quantifying the contributions of transportation to the economy and the uses of transportation by major industries.
- BTS is improving the frequency of updates to data on the extent and characteristics of transportation infrastructure, and has compiled a National Transit Map to fill a long-standing gap in data on the transportation network.
- BTS is establishing a new port performance freight statistics program to publish annually nationally comparable measures of capacity and throughput.
- Extensive data are available on local passenger travel and most long-distance freight movement, but data gaps continue for long-distance travel, domestic movement of international trade, and local freight movement.
- Cost data are available for most forms of passenger travel but are limited for freight movement.
- 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.
- "Big data" and other alternative data sources may offer ways to update and improve the detail of traditional statistics, but research is needed to determine the reliability and validity of statistics from these sources, to establish institutional arrangements for access to large proprietary databases, and to integrate these new data sources with traditional forms of data and analysis to provide effective information for decision makers. Real-time data may offer ways to validate traditional statistics.
- The Bureau of Transportation Statistics (BTS) has achieved significant progress in improving the state of transportation statistics over the last 25 years and will continue to create increasingly robust, credible statistics that support evidence-based decision making and that are useful and used throughout the Nation.

Congress requires that the *Transportation Statistics Annual Report* includes an assessment of the state of transportation statistics and efforts to improve those statistics. Transportation statistics cover the following:

- transportation safety;
- the state of good repair of transportation infrastructure;
- the extent, connectivity, and condition of the transportation system;
- 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;
- 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.[1]

2016 marks the 50th anniversary of the *Department of Transportation Act of 1966*,[2] which established the Department and gave the Secretary authority to "promote and undertake the development, collection, and dissemination of technological, statistical, economic, and other information relevant to domestic and international transportation."[3] Shortly after its creation, the new department published its agenda for improving the state of transportation statistics, including establishment of surveys of passenger travel and freight movement, development of data integration and analysis methods, development of geo-coding systems and data on transportation networks, establishment of best practices for data collection by local governments, and research into new methods of data collection with an emphasis on reducing respondent burden [USDOT 1969].

2016 also marks the 25th anniversary of the *Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991*, which established the Bureau of Transportation Statistics (BTS).[4] Several of the BTS provisions in ISTEA paralleled recommendations in a special report by the Transportation Research Board that called for collection of passenger and freight flow data, development of a national transportation performance monitoring system, and research into new methods of data collection such as electronic linking of administrative records and capturing data from traffic monitoring systems [TRB 1991].

BTS highlighted the history of transportation statistics since ISTEA in *Two Decades of Change in Transportation: Reflections from*

[1] 49 U.S.C. § 6302(b)(3)(B)(vi)

[2] Public Law 89-670, Oct. 15, 1966

[3] 49 U.S.C. § 301

[4] Section 6006 of Public Law 102-240, December 18, 1991

Transportation Statistics Annual Reports, 1994–2014. That report noted that most measures requested by public officials today are variations on those that BTS was mandated to collect or compile in the 1990s. *Two Decades* documented significant progress in providing the requested measures, identified persistent gaps in desired information that remain, and highlighted promising new data sources [USDOT BTS 2015]. A major challenge facing BTS today is how to interpret and establish the credibility of new data (such as "big data" and administrative records) that can be applied to long-standing topics for decision makers in transportation.

This chapter reviews the current strengths and weaknesses of transportation statistics, identifies major gaps in those statistics, and explores new data sources that could be used to fill the gaps. The chapter concludes with strategies for assuring that statistical information provides adequate support for evidence-based decision making.

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 gaps 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 and ports are limited because those entities are either privately owned or privately operated on leased public facilities.

BTS publishes the underlying data on the extent and characteristics of the nation's transportation network in the National Transportation Atlas Database (NTAD). Until 2016 the NTAD was published once each year. BTS has established a system to update the

TABLE 8-1 Statistics on the Extent, Use, Condition, and Performance of the Transportation System

Topic	Coverage of existing statistics	Major gaps in existing statistics	Why the gaps 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 Transit Map	• Piecemeal representation of intercity bus service coverage • Little data on social service and non-profit transportation coverage	• Identify localities that are isolated from economic opportunities, social services, and upward mobility • Identify portions of the transportation network that are vulnerable to disruption
Vehicle, aircraft, train, and vessel volumes	• Number of vehicles on highway segments • Number of aircraft by airport; number of carloadings by rail segment; number of vessels by port and waterway	• Inconsistent differentiation among types of highway vehicles (car, bus, truck) • Pipeline volumes by segment	• Different vehicle types have very different consequences for traffic flow and congestion, pavement and bridge wear, exposure to safety risks, and air quality • Pipeline volumes affect markets of competing modes and exposure to safety risks
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 throughput data for ports • Condition of urban bus and rail transit maintenance facilities, and rail transit infrastructure • Comprehensive metrics for identifying network resiliency	• Identify bottlenecks, vulnerabilities to disruption, and other potential losses of efficiency in moving freight and passengers to guide investments in transportation facilities and rolling stock

NTAD continuously as new geos-spatial data files are made available. BTS has also added the National Transit Map to the NTAD in 2016, filling a long-standing data gap.

While extensive statistics exist on the extent, use, condition, and performance of the transportation system, some of the underlying data are collected for different reasons and are not comparable across parts of the system. In response to the 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 publish annually nationally consistent measures of port capacity and throughput.[5] The FAST Act requires an annual report of the statistics and a working group to recommend measures and methods for obtaining the measures.

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 system designed to

[5] Section 6018 of Public Law 114-94, Dec. 4, 2015

spread 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, causing missed connections, deliveries, or appointments. 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. Delay is generally a greater problem for perishable or high-valued goods than for bulk commodities. Statistics on travelers, shippers, and carriers who use the transportation system, on the purposes of travel, and on the goods being moved are required to understand whether problems with transportation system performance warrant public action.

Strengths and Weaknesses of Current Statistics on Passenger Travel

Table 8-2 summarizes existing statistics on passenger travel and gaps in those statistics. Existing statistics include total travel on sections of the 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 2015], the Federal Transit Administration's National Transit Database [USDOT FTA NTD 2014], the BTS monthly passenger enplanement data [USDOT BTS

TABLE 8-2 Transportation Statistics on Passenger Travel

Topic	Coverage of existing statistics	Major gaps in existing statistics	Why the gaps 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 • Travel by general aviation • Domestic travel of international visitors by traveler and trip characteristics	• Guide investments in airports, intercity rail passenger service, and interregional highways • Maximize the economic benefits of travel and tourism • Evaluate regulations related to the total contribution of local and long-distance travel to safety risks and environmental problems
Local travel	• Sporadic national 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	• Guide investments in streets and public transportation • Manage exposure to safety risks • Provide physical connections between mobility-challenged citizens and services and employment opportunities

2012a], and the National Census of Ferry Operators [USDOT BTS NCFO 2014].

Statistics on the characteristics of travelers and trips come from programs that collect data at the individual traveler's level (without identifying personal identifiable information) from which travel patterns and traveler characteristics for the population as a whole can be estimated. The most prominent program in this group is the National Household Travel Survey (NHTS), sponsored mainly by the Federal Highway Administration (FHWA) and with increased cosponsorship by states and metropolitan planning organizations [USDOE ORNL 2015].

The NHTS collects not only information on individual trips but also demographic, household vehicle ownership and neighborhood characteristics as well as other factors that influence a household member's 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. Improvements to the 2016 edition of the NHTS are highlighted in Box 8-A.

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 averaged over several years, while the 374 metropolitan statistical areas, as defined by the Office of Management and Budget, are the lowest levels of geography covered by the NHTS [USDOC ACS 2011].

Strengths and Weaknesses of Current Statistics on Freight Movement

In addition to travelers, the transportation system serves the movement of freight. Table 8-3 summarizes existing statistics on freight movement and gaps 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. 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

TABLE 8-3 Transportation Statistics on Freight Movement

Topic	Coverage of existing statistics	Major gaps in existing statistics	Why the gaps 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 through the United States between other countries	• Support connections between local and global economies • Assess the role international flows play in domestic travel • Assess the role of transportation in US international economic competitiveness
Intercity freight movement	• Tonnage and value of region-to-region flows by commodity and mode	• Relationships between industry supply chains and region-to-region commodity flows	• Guide investments in transportation facilities • Give local economies access to suppliers and markets • Manage exposure to safety risks • Understand the consequences of safety and other regulations • Expand access to international opportunities of poorly served areas • Diagnose and address freight bottlenecks that are barriers to economic development and competitiveness
Local freight movement	• Freight movement only in the rare cases where state and metro area surveys are conducted	• County-to-county and intra-county flows of freight • Freight passing through the local area to and from distant locations	• Guide investments in last-mile transportation facilities • Support local supply chains • Assess the impacts on local congestion of freight movements • Manage exposure to safety risks

areas. 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 the data on freight flows across U.S. land borders and data on the international movement of air cargo collected by BTS [USDOT BTS 2012b].

The FAF is based on observed data wherever possible, but must turn to models and assumptions to fill the remaining data gaps in the 5-year benchmarks and to make annual updates and forecasts. Among the data gaps in the 5-year benchmarks 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 measured since the 1970s. The FAF includes benchmarks every 5 years based on the CFS, annual updates, and 30-year forecasts.

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 gaps 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 the costs paid by households and businesses for transportation services, employment in transportation industries and occupations, and the value of transportation infrastructure and equipment. 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.

TABLE 8-4 Statistics on Transportation's Role in the Economy

Topic	Coverage of existing statistics	Major gaps in existing statistics	Why the gaps 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	• Fiscally constrained 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	• Purpose of transportation investment by public and private entities	• Transportation investments for maintenance would support current economic growth while investments that expand capacity potentially increase economic returns
Transportation costs and prices	• Gasoline and diesel prices • Costs of automobile ownership • Air carrier costs for selected categories • Air 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 travel time by households using the transportation system • Value of transportation system and services to the economy and society	• Input to establishing the appropriate size of investment programs and levels of revenue collection

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 nontransportation industries, such as truck fleets operated by large retail companies.

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 2012c]. 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.

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 gaps in those statistics.

Of the unintended consequences, safety is the main focus for several of the largest statistical programs in the USDOT. The National Highway Traffic Safety Administration (NHTSA) and the Federal Motor Carrier Safety Administration (FMCSA) account for 40 percent of the expenditures on major statistical programs in the Department [EOP OMB 2015]. 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.

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. The National Aeronautics and Space Administration (NASA) provides a close calls reporting system for the Federal Aviation Administration that allows airline employees to make confidential reports that can be used to identify and mitigate safety problems. Nearly 5,000 reports are filed each month [NASA 2012]. NASA provides a similar reporting system for Amtrak. BTS has initiated the first urban close calls reporting system with a major transit system. The BTS program for confidential reporting of close calls, conducted under the Confidential Information Protection

TABLE 8-5 Statistics on the Unintended Consequences of Transportation

Topic	Coverage of existing statistics	Major gaps in existing statistics	Why the gaps matter
Safety	• Transportation fatalities and injuries for all modes • Safety incidents involving hazardous materials; precursor events (close calls) for aviation, selected railroads and 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, green house gasses, air quality	• Air quality by type of pollutant and air shed • Relationship of vehicle emissions to type of vehicle and vehicle speed	• In-use fuel economy and emissions • Amount of vehicle travel by type of vehicle and vehicle speed in each air shed	• Estimates of air quality issues are based primarily on laboratory conditions and assumed operating patterns and should be tested against actual operating conditions
Noise, water quality, habitat dislocation	• Noise footprints around airports • Environmental disruptions related to individual transportation projects	• National and regional inventories of noise exposure from all modes • Natural habitat disruption	• Geographic distributions of noise exposure and habitat disruption identify mitigation investment needs and target mitigation measures
Community disruption	• Social and economic characteristics of populations adjacent to transportation facilities	• Social and economic connections among neighborhoods	• Improve planning to avoid or mitigate community disruption from transportation facilities and to provide physical connections between mobility-challenged citizens and services and employment opportunities

and Statistical Efficiency Act,[6] is also being expanded to off-shore oil extraction and connecting pipeline operations.

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 (CO_2) 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 2015], and transportation's contributions to greenhouse gases and other emissions are tracked by the Environmental Protection Agency [USEPA OTAQ 2015]. 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

[6] Title V of Public Law 107-347, Dec. 17, 2002

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 more than 10 years out of date [USDOC CB VIUS 2002]. A plan by FHWA, BTS, the Department of Energy, the Environmental Protection Agency, and the Department of Agriculture to revive the VIUS is currently under consideration.

Energy and safety concerns converge over the transportation of crude petroleum, ethanol, and other hazardous cargos by railroad. In response to the FAST Act,[7] BTS is establishing a data program to monitor 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 is also collecting data on the construction of new tank cars and conversion of old tank cars to the new standards.

Statistical Information Gaps and Challenges

Considering the wide range of transportation data sources and information needs for public decisions, key gaps in statistical information are apparent:

- Long-distance, intercity travel remains poorly measured for surface modes of transportation.
- Understanding of 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.
- 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 data gaps, 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 2 decades. The last 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

[7] Section 7308 of of Public Law 114-94, Dec. 4, 2015

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.

The tables in this chapter include many areas of improved statistical information in recent years. The FAF, built primarily on data collected by BTS, provides a comprehensive picture of goods movement throughout the United States. The Transportation Satellite Account, featured in chapter 6, provides a more complete accounting of transportation's role in supporting other sectors of the national economy. The safety tables in *National Transportation Statistics* enumerate fatalities and injuries across all modes of transportation with double counting removed. Many other improvements are highlighted in previous editions of the *Transportation Statistics Annual Report* and in Box 8-A.

Box 8-A Examples Of Major Improvements to Transportation Statistics in 2016

- FHWA initiated data collection for the National Household Travel Survey (NHTS) in March 2016, increasing the reporting period, deploying several methods of data collection (including mail, telephone, and Internet), and changing the sample from telephone-based to address-based to improve response rates, capture seasonal variations in travel, and provide better links NHTS data with to results of the American Community Survey.
- NHTSA continued to implement major improvements to its data systems, including: updates to the 30-year old sampling strategy for the National Automotive Sampling System (NASS) to obtain more robust and detailed understanding of the cause of crashes; modernization of information technology used to collect and link data in the NASS and the Fatality Analysis Reporting System (FARS); and establishment of the Product Information Catalog and Vehicle Listing to provide a centralized, public and authoritative data source for Vehicle Identification Numbers (VIN) and VIN-related data.
- BTS assembled the first edition of the National Transit Map, a geographic database that supports the analysis of accessibility of populations to centers of employment and services.
- The Federal Railroad Administration and BTS released the North American Rail Network, a significantly improved database on the location and characteristics of railroad infrastructure in the United States, Canada, and Mexico.
- The Federal Aviation Administration launched its External Data Access initiative to increase and improve public access to its data, starting with online access to aeronautical charts.

Challenges facing BTS and its partners are not limited to filling data gaps. The simple availability of data does not assure that robust statistics exist to help answer the questions of decision makers. Significant quality issues and inadequate methods for analyzing data to create useful information can undermine the effectiveness of key data programs. All data sources have quality issues, but some questions about statistical quality and information objectivity have greater potential consequences for misguiding decision makers and for undermining the credibility of evidence-based decisions with the public.

Credibility is also undermined by the perception that the information has been subjected to political influence. To assure objectivity, the products of principle federal statistical agencies are protected from political review by Statistical Policy Directive No. 1.

New Data Sources

"Big data" is frequently proposed as an answer to data gaps and inadequate statistics, especially with the executive order making government data available to the public[8] and with increased awareness of applications in the private sector. Big data typically involves transactions or tracking systems that support government or private operations, ranging from bills of lading and sales transactions to real-time flight information from the air traffic control system and digital imagery from traffic monitoring cameras. Big data also refers to massive collections of tweets and other postings to the Internet. Big data sources typically involve unstructured data that are frequently updated and require very large data storage and processing technology.

Big data analytics 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. The potential for adapting these forecasting methods to explain underlying causes of change to support program evaluation and other evidence-based decision-making is not clear. Research has been initiated to determine the reliability and validity of statistics from these data sources and methods, to establish institutional arrangements for access to large proprietary databases, and to integrate these new data sources with traditional forms of data and analysis to provide effective information for decision makers.

Real-time data are frequently identified with big data as a source of effective information to guide decisions. Real-time data are essential for operating the transportation system, whether for keeping airplanes apart in the air traffic control system or synchronizing traffic signals in an urban street network or managing inventory in a warehouse or dispatching vehicles to deliver packages, pick up trash, or respond to emergencies. Public agencies and private entities that are directly responsible for these functions must maintain the instantaneous flow of data from sensors

[8] Executive Office of the President of the United States (EOP), Office of Management and Budget (OMB), *Open Data Policy-Managing Information as an Asset*, Memorandum, M-13-13, (May 9, 2013). Available at https://www.whitehouse.gov/ as of November 2015.

and transaction systems and act on moment-to-moment updates.

Beyond daily operations of the transportation system, most decisions involve more deliberative data and analysis. Investments in transportation infrastructure and equipment, safety and other regulations, and large-scale deployments of transportation services are based on an understanding of trends and their associated factors and future scenarios. Analysis of historical and aggregated real-time data are valuable for keeping traditional statistics up to date and for identifying important temporal and geographic variations in trends and current conditions, but are not a replacement for richer statistics that have the depth, breadth, and statistical rigor required to support transportation planning, programming, and policy.

Evidence-Based Decision Making

Congress directed BTS to ensure that the Bureau's statistics support transportation decision making.[9] This mandate is consistent with the current emphasis of the Congress and the Executive Branch on evidence-based decision making throughout the Federal Government. "Agencies are encouraged to allocate resources to programs and practices backed by strong evidence of effectiveness while trimming activities that evidence shows are not effective" [EOP OMB 2013a]. Congress established a Commission on Evidence-Based Policymaking in 2016 to recommend approaches for integrating administrative, survey, and other data into analyses of programs and for incorporating "outcomes measurement, institutionalized randomized controlled trials, and rigorous impact analysis into program design."[10]

Statistics to support evidence-based decisions go beyond simple tabulations of the types of performance measures characterized in table 8-6. While decisions to try a public action may be based on basic indicators of performance and measures of actionable conditions, the

[9] 49 U.S.C. § 6302(b)(3)(B)(i)

[10] Public Law 114-140, Mar. 30, 2016

TABLE 8-6 Examples of Safety Performance Measures

Question to be answered	Type of performance measure	Examples
What is the state of the world?	Basic indicators	• Fatalities per quantity of travel on the transportation system
What aspects of the state of the world are problems to fix or opportunities to pursue?	Actionable conditions	• Fatalities involving distracted driving
What actions are taken to fix problems or pursue opportunities?	Outputs	• Federal investment in distracted driving countermeasures • Number of states with distracted driving laws • Number of local school districts that include distracted driving in driver education courses
Have the actions made a difference?	Outcomes	• Evidence that fatalities involving distracted driving were reduced as a consequence of the investments, laws, or courses

decision to continue or change a public action requires effective measures of outputs and outcomes. Outputs can be hard to define when the public action has multiple components and involves multiple levels of government. Outcomes are even harder to measure because they are not just changes in a basic indicator or actionable condition. Simple correlation is not enough. To be an outcome, some evidence of causality is required. Randomized controlled trials provide the strongest evidence, but are often not possible. A variety of methods are available to approximate controlled trials. Known as quasi-experimental designs, these methods range from simple before-and-after studies to sophisticated time-series analysis. A systematic approach to evaluating technologies, projects, and programs, such as the Service and Methods Demonstration Program for transit in the 1970s, could serve as a useful model for supporting evidence-based decision making throughout the field of transportation [USDOT UMTA 1979].

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 [EOP OMB 2014].

While other prominent data programs exist in DOT, BTS stands alone because

- BTS is the Department's only source of statistics that cover all modes of transportation
- BTS is the Federal Government's primary source of original information on commercial aviation
- BTS is the only part of DOT 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 21st Century statistical agency, BTS must:

- Provides fresh, recent information in small bytes.
- Be flexible and nimble to address emerging issues.
- Focus on new technology for collection and delivery of information, especially through mobile devices and apps.
- Adhere to Statistical Policy Directives of the Office of Management and Budget to assure that statistics are objective, accurate, timely, and credible.

Toward these ends, BTS will expand its statistical products, publish to the web before printing 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 2013b]. 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. 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. The initial focus of this research is on methods to supplement or replace portions of 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 (1) statistical expertise to advise the design of performance measures and program evaluations, (2) portals to data that can be used in performance measurement and program evaluations, and (3) 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 25 years. The Bureau will continue to strive in the years ahead to create increasingly robust, credible products in each of the topic areas identified in legislative mandates and departmental goals. BTS will continue to enhance timeliness, improve quality of its products, and produce statistics that are useful, relevant, and used throughout the Nation.

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APPENDIX A Legislative Responsibilities Including Cross Reference

BTS compiles these and other statistics under Section 52011: Moving Ahead for Progress in the *21st Century Act* (Public Law No. 112-141), which requires information on:

i. transportation safety across all modes and intermodally;

ii. the state of good repair of United States transportation infrastructure;

iii. the extent, connectivity, and condition of the transportation system, building on the national transportation atlas database developed;

iv. economic efficiency across the entire transportation sector;

v. the effects of the transportation system on global and domestic economic competitiveness;

vi. demographic, economic, and other variables influencing travel behavior, including choice of transportation mode and goods movement;

vii. transportation-related variables that influence the domestic economy and global competitiveness;

viii. economic costs and impacts for passenger travel and freight movement;

ix. intermodal and multimodal passenger movement;

x. intermodal and multimodal freight movement; and

xi. consequences of transportation for the human and natural environment

FIGURE/TABLE No.	HEADING/TITLE	i Safety…	ii Good repair…	iii Extent…	iv Economics…	v the effects…	vi Demographics…	vii …variables…	viii Transport Costs…	ix Moving People…	x Moving Goods…	xi Environment…
	Introduction											
	Chapter 1–*Extent and Physical Condition of the U.S. Transportation System*											
FIGURE 1-1	Annual Average Daily Traffic on the National Highway System			x								
FIGURE 1-2	Bridge Condition by Age Group		x	x								
FIGURE 1-3	Licensed Drivers, Vehicle Registrations, and Resident Population			x			x					
FIGURE 1-4	Enplanements at the Top 50 U.S. Airports			x						x		
FIGURE 1-5	Class I Railroad System Mileage v. Ton-miles of Freight			x							x	
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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.