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Transportation Statistics Annual Report 2015

U.S. Department of Transportation

Bureau of Transportation Statistics

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2015

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Notice

Data Sources

The data used throughout this document reflect the latest numbers available at the time of publication. The table below shows the year of the data and statistics compiled from a wide range of U.S. Department of Transportation operating administrations and other statistical agencies throughout the Federal Government.

Data category	Year of data
Airports and aircraft	2013
Air passenger enplanements, flights	2014
Ferry passengers, terminals	2009
Foreign trade and transportation	2014
Freight transportation patterns	2012 (CFS)
	2013 (FAF)
GDP, labor force, personal expenditures	2013
Highways, public roads and street mileages, bridges, lane-miles, motor vehicles, PMT, VMT	2013
Passenger enplanements, RPM, and enplaned revenue ton-miles	2014
Passenger travel patterns	2009 (NHTS)
	2013 (ACS)
Pipelines	2014
Rail freight transportation and passenger ridership	2013
Recreational boats, waterways, commercial vessels, locks, facilities, and seaports	2013
Safety	2013
Transit vehicles, person-miles traveled, unlinked passenger trips	2013

KEY: ACS = American Communities Survey, CFS = Commodity Flow Survey, FAF = Freight Analysis Framework, GDP = gross domestic product, NHTS = National Household Travel Survey, PMT = passenger-miles traveled, RPM = revenue passenger-miles, VMT = vehicle-miles traveled.

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 20th edition of the report is based on information collected or compiled by the Bureau of Transportation Statistics (BTS), a Federal statistical agency within the U.S. Department of Transportation.

Over 4 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 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 $7.7 trillion. The public owns 51.3 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 30.6 percent of transportation assets, including railroads, pipelines, trucks, planes, and ships. Personal motor vehicles account for the remaining 18.1 percent.

The average person travels about 13,000 miles per year, and domestic businesses ship and receive 63 tons of freight per year per capita in the United States.

The transportation sector accounted for:

- Nearly $1.4 trillion in purchases and investments in transportation goods and services—or 8.6 percent of U.S. gross domestic product in 2013,
- $125.7 billion in public and private expenditures on transportation construction in 2014,
- 12.3 million jobs in transportation-related industries—or 8.8 percent of the U.S. labor force in 2014,
- about $9,000 in average expenditures for each household—or 17.6 percent of household expenditures in 2013,

- about 34,500 lives lost and roughly 2.3 million nonfatal injuries in 2013,
- 70.5 percent of total petroleum consumption in the United States, and
- about 27 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 required information on:

i. transportation safety across all modes and intermodally—Chapter 6;

ii. the state of good repair of United States transportation infrastructure—Chapters 1 and 4;

iii. the extent, connectivity, and condition of the transportation system, building on the BTS national transportation atlas database—Chapters 1, 2, and 3;

iv. economic efficiency across the entire transportation sector—Chapters 3, 4, and 5;

v. the effects of the transportation system on global and domestic economic competitiveness—Chapters 3, 4, and 5;

vi. demographic, economic, and other variables influencing travel behavior, including choice of transportation mode and goods movement—Chapters 2 and 3;

vii. transportation-related variables that influence the domestic economy and global competitiveness—Chapters 3, 4, and 5;

viii. economic costs and impacts for passenger travel and freight movement—Chapters 2, 3, 4, and 5;

ix. intermodal and multimodal passenger movement—Chapters 1 and 2;

x. intermodal and multimodal freight movement—Chapters 1 and 3; and

xi. 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. See Appendix B for a glossary of terms used throughout this report. See Appendix C for a map of the U.S. transportation system.

This report of the BTS Director to the President and the Congress summarizes the Bureau's findings through 2015.

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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 $7.7 trillion in 2013, an increase of 13.6 percent over 2010 estimates. Publicly owned infrastructure and equipment accounted for over one-half of transportation capital stock.
- Highway lane-miles increased slightly less than 1 percent between 2010 and 2013. Highway person-miles traveled and vehicle-miles traveled increased by 1.5 and 0.7 percent, respectively, over that period.
- The condition of the U.S. transportation infrastructure is improving, but additional work is needed. The percentage of structurally deficient bridges dropped from 12.0 percent in 2010 to 10.5 percent in 2013.
- One impact of bridge deterioration is reduced load limits. In 2013, 11.8 percent of all bridges had reduced load limits, which caused commercial vehicle operators to use smaller trucks 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 2013 period and stood at about 11.4 years in 2013. The average age of commercial trucks is now 14.7 years, up from 12.5 years in 2007.
- The majority of airport runways (commercial service, reliever, and select general aviation) are in good condition; only 2 percent are considered poor.
- Railroad capital expenditures totaled $13.1 billion in 2013, more than double the spending in 2000.
- The average age of inland waterway navigation locks, adjusted for the date of the most recent rehabilitation, is more than 50 years.
- There is a general lack of data on vehicle and traffic control system condition, regardless of mode, and on most aspects of intermodal connections.

The U.S. transportation system serves nearly 319 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 2015, USDOC OTTI]. The system allows almost 75 million foreign visitors to travel to our country, resulting in a sizable contribution to the U.S. economy. The system serves a large and diverse set of users, as highlighted in appendix C and described in box 1-A.

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 $7.7 trillion in 2013, an increase of about $923 billion (13.6 percent) over 2010 estimates.[1] Table 1-1 shows the estimated value of transportation capital stock increased steadily from 2000 to 2013.

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

[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.

BOX 1-A Extent of the U.S. Transportation System

MOTOR VEHICLES AND PUBLIC ROADS: 2000, 2010, and 2013

Public Road and Street Mileage by Functional Type (miles)

	2000	2010	2013
Interstate	46,427	46,900	47,575
Other freeways and expressways	9,140	11,319	11,602
Other principal arterial	152,233	160,493	161,757
Minor arterial	227,364	242,815	243,872
Collectors	793,124	799,226	803,807
Local	2,707,934	2,806,322	2,846,848
TOTAL, mileage	**3,936,222**	**4,067,076**	**4,115,462**
Bridges	587,135	604,460	607,708
Lane-miles	8,224,245	8,581,158	8,656,070

Motor Vehicle Registrations by Type

	2000	2010	2013
Light-duty vehicle, short wheel base	U	190,202,782	184,497,490
Passenger car	133,621,420	U	U
Motorcycle	4,346,068	8,009,503	8,404,687
Light-duty vehicle, long wheel base	U	40,241,658	51,512,740
Other 2-axle 4-tire vehicles	79,084,979	U	U
Truck, single-unit 2-axle 6-tire or more	5,926,030	8,217,189	8,126,007
Truck, combination	2,096,619	2,552,865	2,471,349
Bus	746,125	846,051	864,549
TOTAL, registered vehicles	**225,821,241**	**250,070,048**	**255,876,822**

Person-Miles Traveled (PMT) (millions)

	2000	2010	2013
Light duty vehicle, short wheel base	U	2,814,055	2,882,221
Passenger cars	3,107,729	U	U
Motorcycle	15,463	19,886	21,937
Light duty vehicle, long wheel base	U	831,312	805,997
Other 2-axle 4-tire vehicles	851,762	U	U
Truck, single-unit 2-axle 6-tire or more	100,486	110,674	106,582
Truck, combination	161,238	175,911	168,436
Bus	313,897	292,319	321,544
TOTAL, highway PMT	**4,550,574**	**4,244,157**	**4,306,717**

Vehicle-Miles Traveled (VMT) (millions)

	2000	2010	2013
Light duty vehicle, short wheel-base	U	2,025,745	2,074,458
Passenger cars	1,600,287	U	U
Motorcycle	10,469	18,513	20,366
Light duty vehicle, long wheel-base	U	622,712	603,313
Other 2-axle 4-tire vehicles	923,059	U	U
Truck, single-unit 2-axle 6-tire or more	70,500	110,738	106,582
Truck, combination	135,020	175,789	168,436
Bus	7,590	13,770	15,167
TOTAL, highway VMT	**2,746,925**	**2,967,266**	**2,988,323**

KEY: U = Data are unavailable.

NOTES: 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, Public Roads and Street Mileages, Bridges, Lane-miles, Motor Vehicles, 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 1-5, 1-6, 1-11, 1-28, 1-35, 1-40. Available at http://www.bts.gov/ as of June 2015.

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AIR: 2000, 2010, and 2013

Number of U.S. Airports

	2000	2010	2013
Public use	5,317	5,175	5,155
Private use	13,964	14,353	14,009
Military	U	274	289
TOTAL, airports	**19,281**	**19,802**	**19,453**

Number of U.S. Aircraft

	2000	2010	2013
General aviation aircraft	217,533	223,370	199,927
Commercial aircraft	7,826	7,185	6,733
TOTAL, aircraft	**225,359**	**230,555**	**206,660**
TOTAL pilots	**625,581**	**627,588**	**599,086**

Passenger Enplanements

	2000	2010	2013
Domestic flights	U	629,500,000	645,700,000
International flights of U.S. carriers	U	91,000,000	97,500,000
TOTAL, passenger enplanements	**U**	**720,500,000**	**743,200,000**

Passenger Miles (thousands)

	2000	2010	2013
Domestic, revenue passenger-miles (RPM)	U	552,900,000	577,900,000
International on U.S. carriers, RPM	U	245,200,000	262,500,000
TOTAL, air RPM	**U**	**798,000,000**	**840,400,000**

Ton-Miles (thousands)

	2000	2010	2013
Domestic, enplaned revenue ton-miles	U	12,500,000	12,400,000
International on U.S. carriers, enplaned revenue ton-miles	U	52,500,000	49,500,000
TOTAL, enplaned revenue ton-miles	**U**	**65,000,000**	**62,000,000**

NOTES: General aviation includes air taxis. Commerical aircraft includes mainline and regional aircraft.
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 and 1-11. Available at http://www.bts.gov/ as of June 2015. **Pilots**: USDOT/FAA. FAA Aerospace Forecast, Fiscal Years (multiple issues). Available at www.faa.gov as of June 2015. **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 June 2015. **RPM and Enplaned revenue ton-miles**: USDOT, BTS, OAI, T-100 Segment data. Available at http://www.transtats.bts.gov/ as of June 2015.

TRANSIT: REVENUE YEARS 2000, 2010, and 2013

Number of Transit Vehicles

	2000	2010	2013
Heavy rail cars	10,311	11,510	10,380
Commuter rail cars and locomotives	5,497	6,768	7,150
Light rail cars	1,306	2,096	2,842
TOTAL, rail transit vehicles	17,114	20,374	20,372
Motor bus	59,230	63,679	67,383
Demand response	22,087	33,555	31,433
Ferry boat	98	134	156
Other	7,607	17,932	17,637
TOTAL, non-rail transit vehicles	**89,022**	**115,300**	**116,609**
TOTAL, transit vehicles	**106,136**	**135,674**	**136,981**

Person-Miles (millions)

	2000	2010	2013
Heavy rail	13,844	16,407	18,005
Commuter rail	9,400	10,774	11,736
Light rail	1,339	2,173	2,565
TOTAL, rail transit PMT	24,583	29,353	32,305
Motor bus	18,999	20,739	21,414
Demand response	588	874	898
Ferry boat	298	389	402
Other	632	1,272	1,449
TOTAL, non-rail transit PMT	**20,517**	**23,274**	**24,162**
TOTAL, transit PMT	**45,100**	**52,627**	**56,467**

Unlinked Passenger Trips (billions)

	2000	2010	2013
Heavy rail	2.63	3.55	3.82
Commuter rail	0.41	0.46	0.48
Light rail	0.32	0.46	0.52
TOTAL, rail transit UPT	**3.36**	**4.47**	**4.81**
Motor bus	5.16	5.24	5.33
Demand response	0.07	0.10	0.11
Ferry boat	0.05	0.06	0.06
Other	0.08	0.10	0.09
TOTAL, non-rail transit UPT	**5.36**	**5.49**	**5.60**
TOTAL, transit UPT	**8.72**	**9.96**	**10.41**

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).

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). Table 1-11. Available at http://www.bts.gov/ as of June 2015. **Person-miles traveled**: USDOT/FTA/NTD as cited in USDOT/BTS/NTS. Table 1-40. Available at http://www.bts.gov/ as of June 2015. **Unlinked passenger trips**: USDOT/FTA/NTD, Table 19. Available at http://www.ntdprogram.gov/ as of June 2015.

RAIL: FISCAL YEARS 2000, 2010, and 2013

Equipment and Mileage Operated by Amtrak

	2000	2010	2013
Locomotives	378	282	418
Passenger cars	1,894	1,274	1,447
System mileage	23,000	21,178	U
Stations	515	519	518 (2012)
Passengers (millions)	20.9	28.7	30.9
Passenger-miles traveled (millions)	5,498	6,420	6,810

Equipment and Mileage Operated by Class I

	2000	2010	2013
Locomotives	20,028	23,893	25,033
Freight cars	560,154	397,730	373,838
Car companies and shippers freight cars	688,194	809,544	873,679
System mileage	99,250	95,700	95,235
Ton-miles (trillions)	1.47	1.69	1.74

KEY: FY = Fiscal Year. U = Data are unavailable

NOTE: **Fiscal year** ending in September.

SOURCES: **Amtrak-Locomotives, Railcars, System mileage, Stations and Passenger-miles traveled**: 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 June 2015. **Passengers**: USDOT, Federal Railroad Administration, Office of Safety Analysis, as cited in USDOT, BTS, *Multimodal Transportation Indicators*. Available at www.bts.gov as of June 2015. **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 June 2015. **Ton-miles**: Association of American Railroads, Railroad Facts (Annual issues), as of June 2015.

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WATER: 2000, 2010, and 2013

	2000	2010	2013
U.S.-Flag privately owned merchant fleet (1,000 gross tons or over)	282	221	187
Recreational boats, millions	12.8	12.4	12.0
Lock chambers	276	239	239
Lock sites	230	193	193
Waterway facilities (including cargo handling docks)	9,309	8,060	8,231
Seaports (handling over 250,000 tons)	197	178	182
Miles of navigable waterways	25,000	25,000	25,000

U.S.-Flag Vessels

	2000	2010	2013
Barge/non-self-propelled vessels	33,152	31,412	31,081
Self-propelled vessels	8,202	9,078	8,918
TOTAL, Vessels	**41,354**	**40,512**	**39,999**

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 June 2015. **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 June 2015. **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 June 2015. **Locks, Facilities, and Seaports**: U.S. Army Corps of Engineers. Institute for Water Resources. Navigation Data Center. *The U.S. Waterway System: Transportation Facts and Information* (Annual issues). Available at http://www.navigationdatacenter.us/ as of June 2015.

PIPELINE: 2000, 2010, and 2013

Gas Distribution Systems Mileage

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

Natural Gas Transmission & Gathering Systems Mileage

	2000	2010	2013
Onshore transmission	293,716	299,343	298,290
Offshore transmission	5,241	5,432	4,520
TOTAL, transmission	**298,957**	**304,775**	**302,811**
Onshore gathering	21,879	12,940	11,309
Offshore gathering	5,682	6,699	6,128
TOTAL, gathering	**27,561**	**19,640**	**17,437**
TOTAL, gas transmission & gathering	**326,518**	**324,415**	**320,248**

Hazardous Liquid or Carbon Dioxide Systems Mileage

	2000	2010	2013
Crude oil	U	54,631	60,902
Petroleum / refined products	U	64,787	63,533
Highly volatile liquids	U	57,980	62,742
CO2 or other	U	4,560	5,195
Fuel grade ethanol	U	16	16
TOTAL, hazardous liquid or CO2 systems	**U**	**181,974**	**192,388**

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 June 2015.

total, publicly owned transportation accounted for over one-half of transportation capital stock; public highways and streets accounted for the largest share (42.6 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 components. It accounted for 15.2 percent of transportation capital stock in 2013, most of which was highway related (e.g., truck fleets owned by grocery chains). Railroads, the next largest private sector category, accounted for 5.2 percent of U.S. transportation capital stock, followed by air with 3.0 percent. Motor vehicles owned by households and individuals, some of which are used for business purposes, accounted for 18.1 percent of capital stock.

The total value of public and private transportation construction put in place in 2014 was about $126 billion. Public transportation construction accounted for about $114 billion, or about 90 percent, of spending on transportation infrastructure [USDOC CENSUS 2014]. Approximately three-quarters of government-funded investment was for highways; the remainder supported the construction of transportation facilities and

TABLE 1-1 Estimated Value of Transportation Capital Stock by Mode: 2000 and 2010–2013
Billions of current dollars

	2000	2010	2011	2012	2013
Publicly owned capital stock					
Public highways and streets	1,398	2,880	3,075	3,207	3,284
Other publicly owned transportation	249	574	619	650	673
Privately owned capital stock					
Personal vehicles and parts	1,051	1,288	1,319	1,352	1,393
In-house transportation	820	985	1,040	1,106	1,173
Railroad transportation	288	360	376	391	399
Air transportation	185	220	225	229	234
Pipeline transportation	74	165	185	194	203
Other privately owned transportation	110	123	127	130	133
Commercial truck transportation	71	108	116	123	131
Private transit and ground passenger transportation	37	43	43	43	44
Water transportation	37	41	42	42	44
TOTAL	**4,319**	**6,787**	**7,166**	**7,468**	**7,710**

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. Details may not add to totals due to rounding. *Locks and dams* may be included under *Other publicly owned transportation*. 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 June 2015.

infrastructure such as airport terminals and runways, transit facilities, water transportation facilities, and pedestrian and bicycling infrastructure. In 2014 private transportation construction was about $12 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, and Traffic Control Systems

Roads

Public roads, including interstate highways, other major arterials, and local routes, totaled 4.1 million miles in 2013, changing little from 2010 (as shown in box 1-A). Lane-miles increased slightly less than 1 percent over that period. Local roads are by far the most extensive, amounting to 2.8 million miles (69.2 percent of total system-miles). However, interstate highways, which accounted for about 47,600 miles (1.2 percent of total system miles), handled the highest volumes of traffic as measured by vehicle-miles traveled—24.8 percent in 2013 [USDOT FHWA 2014a]. 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, Delaware, Rhode Island, and Vermont, had the lowest public road and street mileage [USDOT FHWA 2014a]. Figure 1-1 shows the annual average daily traffic on the National Highway System.

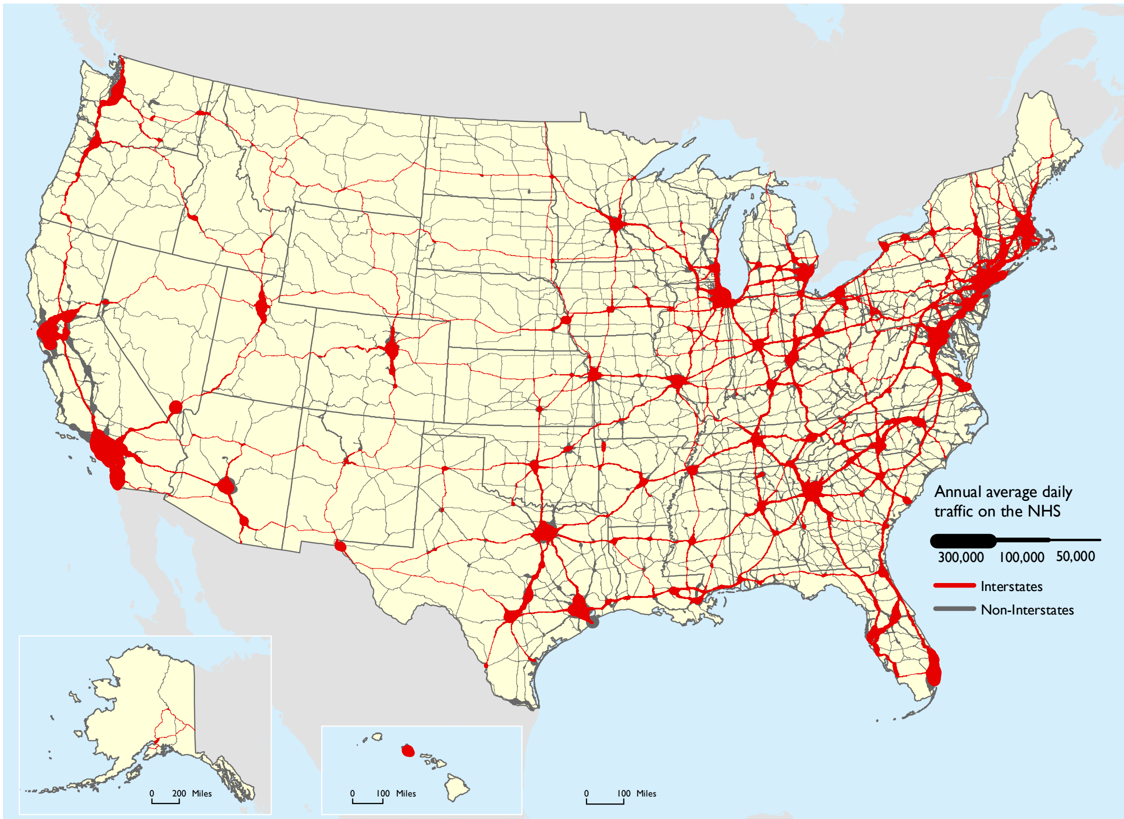
The U.S. Department of Transportation's (USDOT) Federal Highway Administration (FHWA) reports the International Roughness Index (IRI), which measures the smoothness of pavement and is a key indicator of the condition of highways and bridges.[3] Box 1-B provides summary data on the percentage of rough 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.

In urban areas the results are mixed. From 2000 to 2013, interstate highways, other expressways, and other principal arterials had 1.4 to 4.2 percent reductions in the mileage of road surfaces with an IRI above 170. In contrast, over the same period, minor arterial and collector roads showed 4.6 and 1.4 percent increases, respectively, in the mileage of roads with an IRI above 170. The overall condition of all rural roadway categories improved between 2000 and 2011, with collectors showing the greatest improvement (3.5 percent), but all rural functional classes deteriorated over the ensuing 2 years. 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.

[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: 2011



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Average Daily Traffic Volume*, available at http://www.fhwa.dot.gov/ as of April 2015.

Bridges

About 607,700 highway bridges were in use in 2013, ranging in size from rural one-lane bridges crossing creeks to urban multilane and multilevel interstate bridges. Rural local bridges accounted for 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 8.6 percent of the entire U.S. bridge network, followed by Ohio with 4.5 percent and Illinois with 4.4 percent [USDOT FHWA 2014b].

There has been slow but steady improvement in the condition of highway bridges, as shown in box 1-B. 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

Box 1-B Condition of the U.S. Transportation System

AIR: 2000, 2010, and 2013

Runway Condition and Aircraft Age

	2000	2010	2013
Airport runway condition			
All NPIAS Airports, percent			
Good condition	73	79	81
Fair condition	22	18	17
Poor condition	5	3	2
Commercial Service Airports, percent			
Good condition	79	82	83
Fair condition	19	16	15
Poor condition	2	2	2
Average age of aircraft			
Small commercial aircraft	NA	24.0	27.0
Major[a] airline aircraft	NA	14.1	13.3
National[a] airline aircraft	NA	9.1	11.6
Regional airline aircraft	NA	28.2	26.9

HIGHWAYS: 2000, 2010, and 2013

Highway Surface Condition

	2000	2011	2013
Percent of mileage with International Roughness Index[b] over 170			
Rural routes			
Interstates	2.1	1.8	2.4
Other principal arterials	4.0	3.2	4.9
Minor arterials	7.0	6.6	7.2
Collectors	22.1	18.6	19.7
Urban routes			
Interstates	6.5	5.2	5.1
Other freeways and expressways	10.9	7.8	7.2
Other principal arterials	30.0	28.1	25.8
Minor arterials	33.7	37.3	38.2
Collectors	52.3	53.7	53.7

Highway Bridge Condition and Vehicle Age

	2000	2010	2013
Condition of highway bridges, percent			
All structurally deficient bridges	15.2	12.0	10.5
Urban structurally deficient	10.2	8.3	7.0
Rural structurally deficient	16.7	13.3	11.7
All functionally obsolete	15.5	14.2	13.9
Urban functionally obsolete	25.2	24.2	23.8
Rural functionally obsolete	12.7	10.7	10.2

	2000	2010	2013
Average age of vehicles			
Passenger cars	9.1	10.8	11.4
Light trucks	8.4	10.5	11.3
All light vehicles	8.9	10.6	11.4

RAIL: 2000, 2010, and 2013

	2000	2010	2013
New rail and crossties laid			
Rail, thousand tons	690	564	620
Crossties, million	11.5	15.6	16.2
Age of locomotives, percent			
< 5 years old (2000 and 2010), < 9 years old (2013)	23.2	35.2	24.5
6-10 years old (2000 and 2010), 9-13 years old (2013)	13.2	10.0	17.0
11-15 years old (2000 and 2010), 14-18 years old (2013)	8.9	18.7	17.5
16-20 years old (2000 and 2010), 19-23 years old (2013)	12.0	17.9	9.4
> 20 years old (2000 and 2010), > 24 years old (2013)	42.6	18.2	31.6
Capital expenditures, $billion			
Roadway and structures	$4.55	$7.86	$9.32
Equipment	$1.51	$1.91	$3.77
Total	$6.06	$9.77	$13.09
Revenue ton-miles (billion)	1,466	1,691	1,741

TRANSIT (urban): 2000, 2010, and 2013

	2000	2010	2013
Average age of vehicles			
Heavy-rail passenger cars	22.9	18.7	20.2
Commuter-rail passenger coaches	16.9	18.9	20.8
Full-size transit buses	8.1	7.9	8.1
Light-rail vehicles	16.1	16.8	16.4
Transit vans	3.1	3.4	3.5
Ferry boats	25.6	20.5	21.4

WATER: 2000, 2010, and 2013

	2000	2010	2013
Age of locks			
Average age	50.2	59.5	62.5
Age of U.S. flag vessels, percent			
< 6 years old	19.6	18.5	19.3
6 to 10 years old	9.2	11.5	12.1
11 to 15 years old	5.1	17.0	14.3
16 to 20 years old	19.6	8.7	13.6
21 to 25 years old	18.3	4.2	7.7
> 25 years old	27.7	39.3	32.6

[a] Major carriers have annual operating revenue exceeding $1 billion. National carriers have annual operating revenues between $100 million and $1 billion. [b] International Roughness Index values are based on objective measurements of pavement roughness. A low IRI represents a smooth riding roadway.

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

NOTES: Data is taken from multiple sources, thus the number of significant digits may vary. 2010 highway statistics are unavailable, thus 2011 was used.

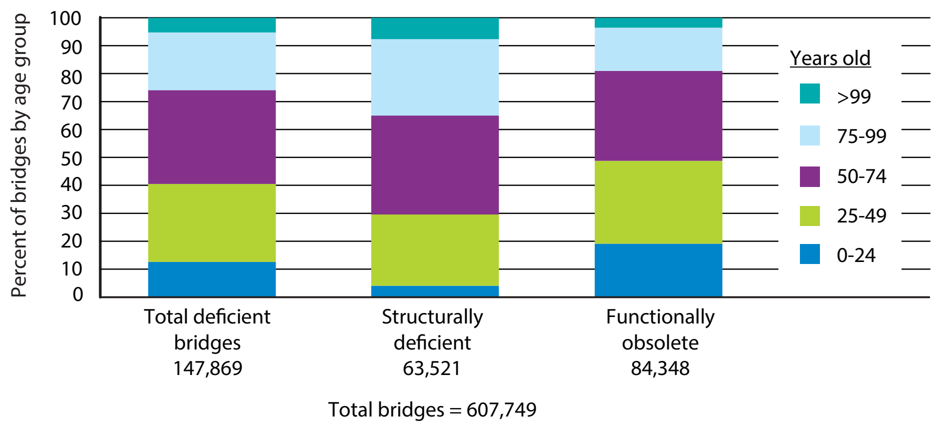
SOURCES: **Air**: U.S. Department of Transportation, Federal Aviation Administration, as cited in U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS), *National Transportation Statistics* (NTS), table 1-25. Available at www.bts.gov as of July 2015. USDOT, BTS, Office of Airline Information, TranStats Database, Form 41, Schedule B-43, special tabulation, July 2015. **Highways**: U.S. Department of Transportation, Federal Highway Administration, as reported in USDOT BTS NTS, op cit., table 1-26 (vehicles), table 1-27 (Highway surface condition), and table 1-28 (Bridges). **Rail**: Association of American Railroads, *Railroad Facts* (Washington, DC: annual issues). **Transit**: U.S. Department of Transportation, Federal Transit Administration, as reported in USDOT BTS NTS, op cit., table 1-29. **Water**: U.S. Army Corps of Engineers, Navigation Data Center, *General Characteristics of Locks and Waterborne Transportation Lines of the United States*. Available at www.ndc.iwr.usace.army.mil as of July 2015.

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 2002 to 2013, with the largest declines recorded for rural bridges. Despite the improvement, 23.8 percent of urban bridges were functionally obsolete in 2013.

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 132-year-old Brooklyn Bridge, due to consistent maintenance and several major rehabilitation projects, 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 bridge will be found deficient increases with the age of the bridge. About 60 percent of deficient bridges are more than 50 years old, and one-half of bridges in place for 75 years or more are rated as deficient.

FIGURE 1-2 Bridge Condition by Age Group: 2013



	Years old (as of 12/31/2013)					
	0–24	**25–49**	**50–74**	**75–99**	**>99**	**All years**
Total bridges	**175,702**	**215,605**	**140,696**	**64,083**	**11,663**	**607,749**
Total deficient bridges						
Number	18,680	41,231	49,646	30,445	7,867	147,869
Percent	10.6	19.1	35.3	47.5	67.5	24.3%
Structurally deficient						
Number	2,576	16,200	22,491	17,388	4,866	63,521
Percent	1.5	7.5	16.0	27.1	41.7	10.5%
Functionally obsolete						
Number	16,104	25,031	27,155	13,057	3,001	84,348
Percent	9.2	11.6	19.3	20.4	25.7	13.9%

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Bridge Inventory*, available at https://www.fhwa.dot.gov/bridge/nbi.cfm as of June 2015.

The more prevalent negative impact of bridge deterioration is the imposition of reduced load limits. In 2013 there were 71,692 bridges in the National Bridge Inventory with some type of load restriction, comprising 11.8 percent of all bridges listed [USDOT FHWA 2014b]. These load limit reductions can cause commercial vehicle operators to either use trucks with smaller payloads or take circuitous routes, both of which increase costs.

Vehicles

Government, businesses, private individuals, and nongovernmental organizations owned and operated about 256 million motor vehicles in 2013, up by 2.3 percent from 2010 levels (box 1-A). Motor vehicle registrations rebounded from the economic recession that began in December 2007 and continued to increase through June 2009 [NBER 2013], but remained slightly below the peak set in 2008.

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. While U.S. vehicle registrations have changed very little since 2005, the same is not true for rapidly industrializing countries. For example, vehicle registrations in China grew from 31 million to 109 million over the 2005 to 2012 period and presently account for about 10 percent of the world total, up from 3.5 percent in 2005 [USDOE ORNL 2014].

Increases in vehicle registrations from 2010 to 2013 varied widely by vehicle type. For example, among passenger vehicles, registrations for light-duty short-wheelbase vehicles[4] decreased by 3 percent, while those for light-duty long-wheelbase vehicles[5] increased by 28 percent. Motorcycle registrations rose by 5 percent, continuing a long-term upward trend.

The numbers of single-unit and combination trucks registrations were down 1.1 and 3.2 percent, respectively, between 2010 and 2013. According to the U.S. Census Bureau's 2012 Economic Census, many of these vehicles were operated by the more than 111,200 trucking establishments[6] in the United States. Between the Census Bureau's 2007 and 2012 Economic Census, a period of time that included the December 2007 through June 2009 recession, the number of trucking establishments decreased by 7.6 percent [USDOC CENSUS 2012].

The number of buses increased by 2.1 percent between 2010 and 2013. Bus registrations grew fairly steadily from 2000 to 2010 and, after a temporary dip, now stand at their highest level over the period shown. Buses owned by schools, churches, and other groups accounted for 83 percent of the registrations in 2013 [USDOT FHWA 2014a]. About 3,500 carriers operated nearly 33,000 motorcoaches (or over-the-road buses) in the United States in 2013 [ABA 2015]. The motor coach industry is discussed further in chapter 2.

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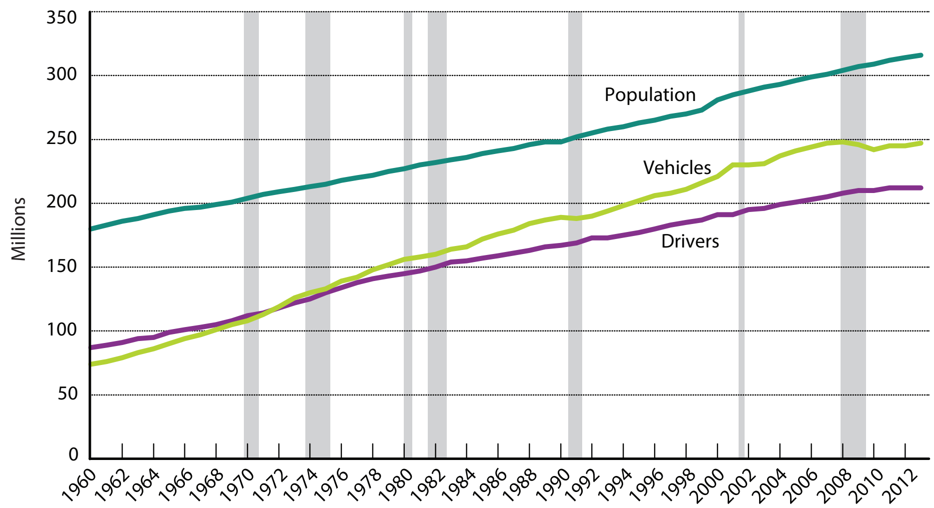
[4] Light duty vehicle, short wheel base includes passenger cars, light trucks, vans, and sport utility vehicles with a wheelbase equal to or less than 121 inches.

[5] Light duty vehicle, long wheel base includes large passenger cars, vans, pickup trucks, and sport/utility vehicles with wheelbases larger than 121 inches.

[6] There are over 500,000 interstate freight carriers registered with the U.S. DOT, which includes many private carriers operated by firms whose primary business classification is not transportation.

FIGURE 1-3 Licensed Drivers, Vehicle Registrations, and Resident Population: 1961–2013



NOTE: Shaded areas indicate economic recessions.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* 2013. Tables DL-1C and MV-1. Available at http://www.fhwa.dot.gov/policyinformation/statistics/2013 as of June 2015.

There is no organized database on the operating condition of vehicles traveling on the Nation's highways. Box 1-B shows that the average age of the light-duty vehicle fleet increased by 28 percent over the 2000 to 2013 period and stood at about 11.4 years in 2013. The commercial truck fleet is even older. The average age of the commercial trucks is now 14.7 years, up from 12.5 years in 2007 [IHS 2015].[7] However, age cannot be used to gauge vehicle condition. Many older vehicles that have been well maintained continue to be in sound condition, while poorly made or maintained newer vehicles may be in poor operating condition.

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

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 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 10.4 billion unlinked trips in 2013, up by 1.7 billion (19.4 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, transit, and trolley bus; subway and light rail; and ferryboat. Buses accounted for nearly half (about 49.2 percent) of the 137,000 transit vehicles in 2013 (box 1-A). In 2013 these transit agencies operated over 5,000 stations, 79 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 NTD 2014]. Box 1-C shows U.S. cities with bike-share systems, which often extend the reach of existing public transit systems (bus, ferry, and rail).

The average age of transit vehicles over the 2000 to 2013 period is shown in box 1-B. Commuter rail passenger coaches aged the most among rail vehicles over that period and are among the oldest of all transit equipment. The heavy-rail car fleet age decreased by 2.7 years between 2000 and 2013, but was still 20.2 years old on average. Light-rail vehicles maintained an average age of about 16 years and transit buses 8 years over the reporting period, indicating that many transit agencies retired and replaced older vehicles on a regular basis. 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 4.2 years, but they remained the oldest part of the transit vehicle population.

There appears to be a direct relationship between public transit system condition and performance and transit ridership (see e.g., Grava 2002 for detailed discussions of the ridership history of each transit mode). Deferred maintenance, outdated equipment and passenger stations, and numerous stops produce an overall transit image that may discourage prospective riders. Conversely, modern, well designed and maintained systems might attract riders who would otherwise travel by other means.

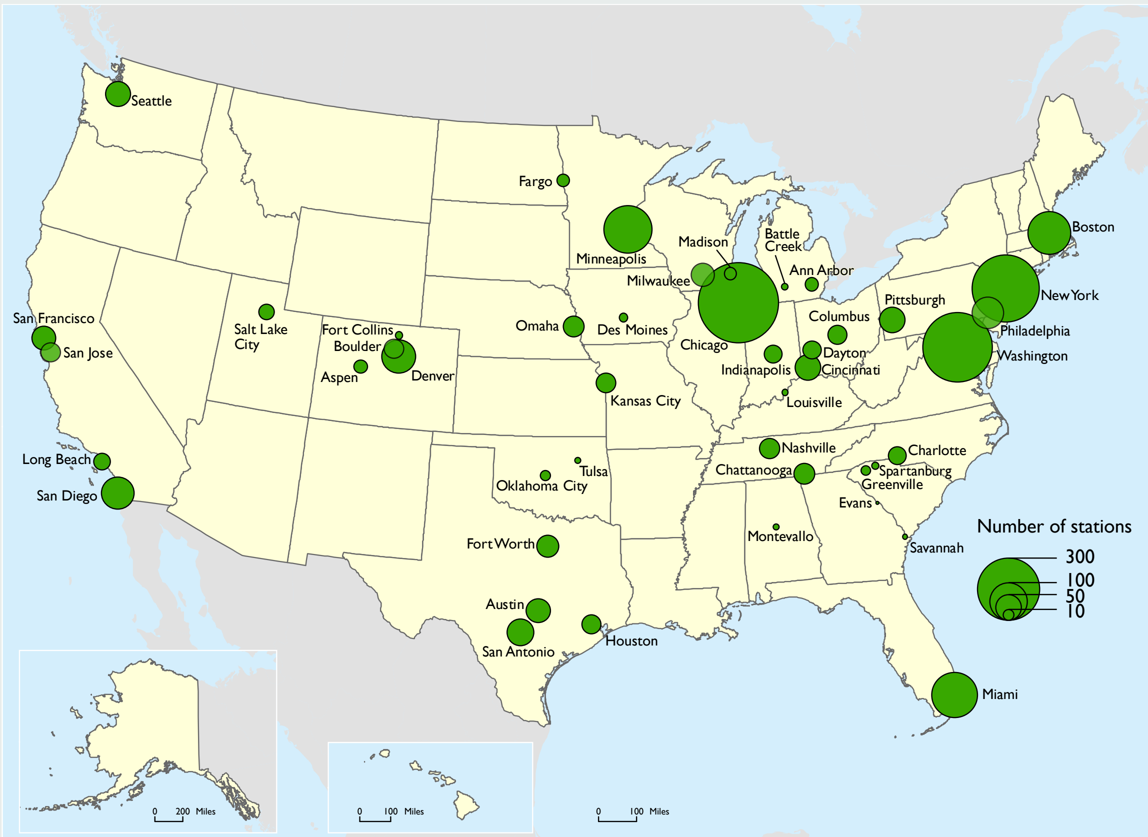
According to USDOT's biennial conditions and performance report, the current total investment across all transit systems is $16.5 billion annually. Bringing all systems to a state of good repair would require an increase to $18.5 billion per year. However, increasing system capacity to accommodate higher 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 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. Box 1-A shows that in 2013 the United States had about 19,500 airports ranging from rural grass landing strips to urban rooftop heliports to large, paved, multiple-runway airports. Many commercial airports now serve aircraft that are larger than those serviced a decade ago as airlines seek to maximize profits by increasing capacity and seating more passengers. The passenger load factor—an indicator of capacity utilization—for U.S. airlines grew from 73.6 percent in 2003 to 82.7 percent in 2014 [USDOT BTS OAI 2015]. Most of the nearly 5,200 public-use facilities are general aviation airports, serving a wide range of users. In addition,

BOX 1-C U.S. Cities with Bike-Share Systems

As of August 2015, there are a total of 2,666 bike-share stations in 68 cities (shown in the map below). Six of these cities operate more than 100 stations: Washington, DC; Chicago; Boston; New York; Minneapolis; and Fort Lauderdale, Lauderdale by the Sea, and Pompano Beach.



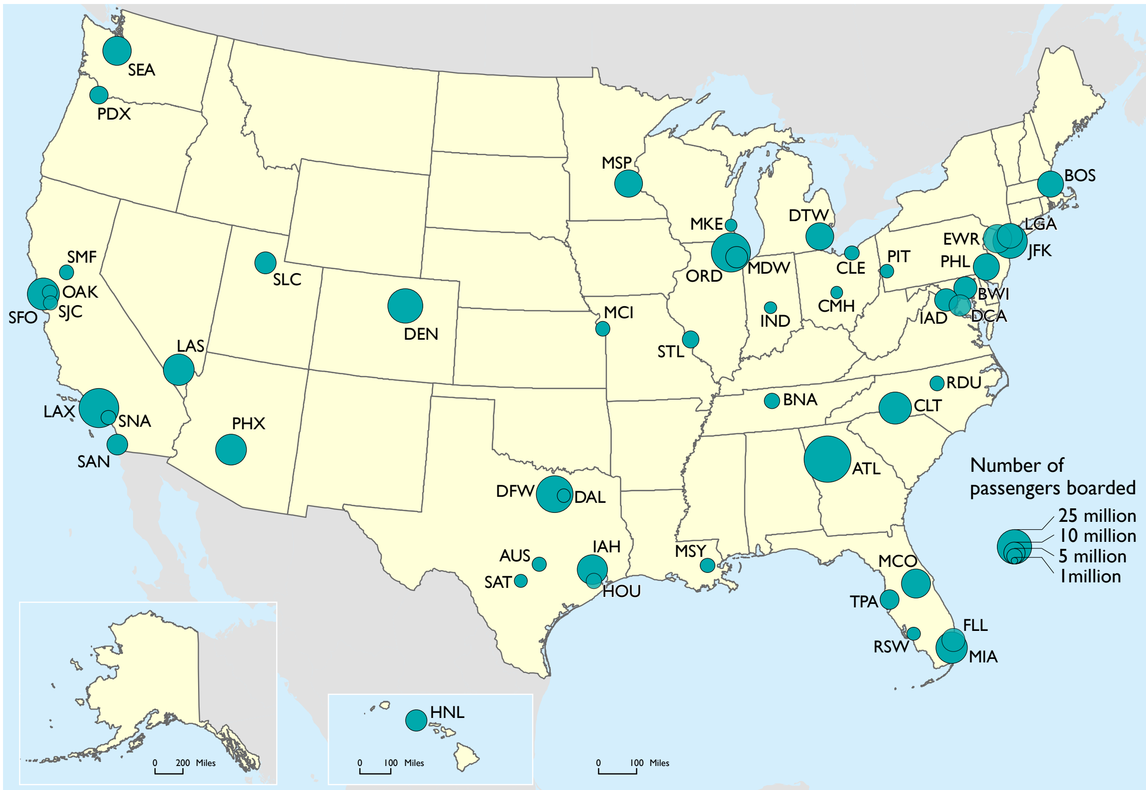
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Intermodal Passenger Connectivity Database*, Available at http://www.bts.gov as of November 2015.

there are about 14,000 private airports, which are relatively small. Figure 1-4 shows the passenger boardings at the top 50 airports in 2014. These airports account for 83.4 percent (about 597 million) of the U.S. passenger enplanements on all domestic flights in 2014 [USDOT BTS OAI 2015].

The Federal Aviation Administration (FAA) compiles data on runway pavement conditions, which are presented in box 1-B. Most airport pavements (commercial service, reliever, and select general aviation) were in good condition between 2000 and 2013, with only 2 percent rated as poor. There are no similar data for other elements of aviation infrastructure.

Box 1-B shows average ages of U.S. commercial aircraft in 2010 and 2013. The aircraft flown by the major national airlines are roughly half the age of the smaller planes used by regional airlines. There are no public

FIGURE 1-4 Passengers Boarded at Top 50 U.S. Airports: 2014



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 2015.

data other than age to indicate the physical condition of the aircraft fleet.

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 line with increasing air traffic demand.

The Airports Council International (ACI) surveyed its U.S. members to ascertain their capital project needs for the 2013 to 2018 period. The survey indicated a total need of $75.7 billion. Age and technological obsolescence are likely the drivers for much of this need, as many airports were built more than 40 years ago. Increasing traffic demand as the U.S. economy has improved, and airline consolidation and increased concentration on hub airports, are cited as other factors.

Large hub airports account for 53 percent of projected investment needs, while medium and small hubs make up another 22 percent. Overall, 48 percent of the funding would be for terminal improvements, and 26.5 percent would be spent on runways, taxiways, and aprons [ACI 2015].

Railroads

The United States had almost 140,000 railroad route-miles in 2013 [AAR 2015], including about 95,200 miles owned and operated by the seven Class I railroads.[8] Amtrak, local, and regional railroads operated the remaining 44,000 miles. Class I railroads owned and operated over 25,000 locomotives and 373,800 freight railcars.

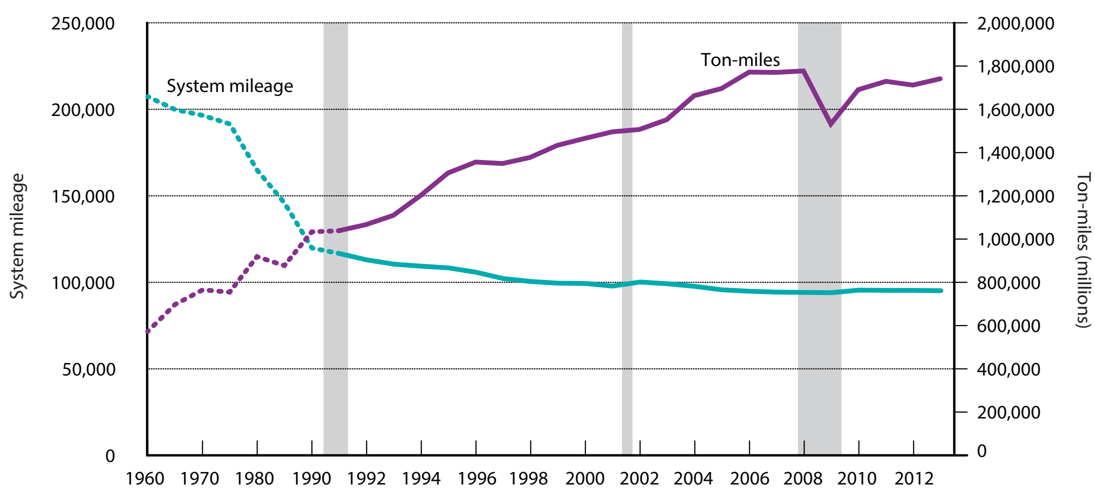
[8] Includes BNSF Railway, CSX Transportation, Grand Trunk Corp., Kansas City Southern, Norfolk Southern, Soo Line (Canadian Pacific operations in the United States), and Union Pacific.

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 2013 was less than one-half the mileage in 1960. However, freight rail ton-miles nearly tripled to 1.7 trillion during the same period (despite a decline during the last recession).

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 2013 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

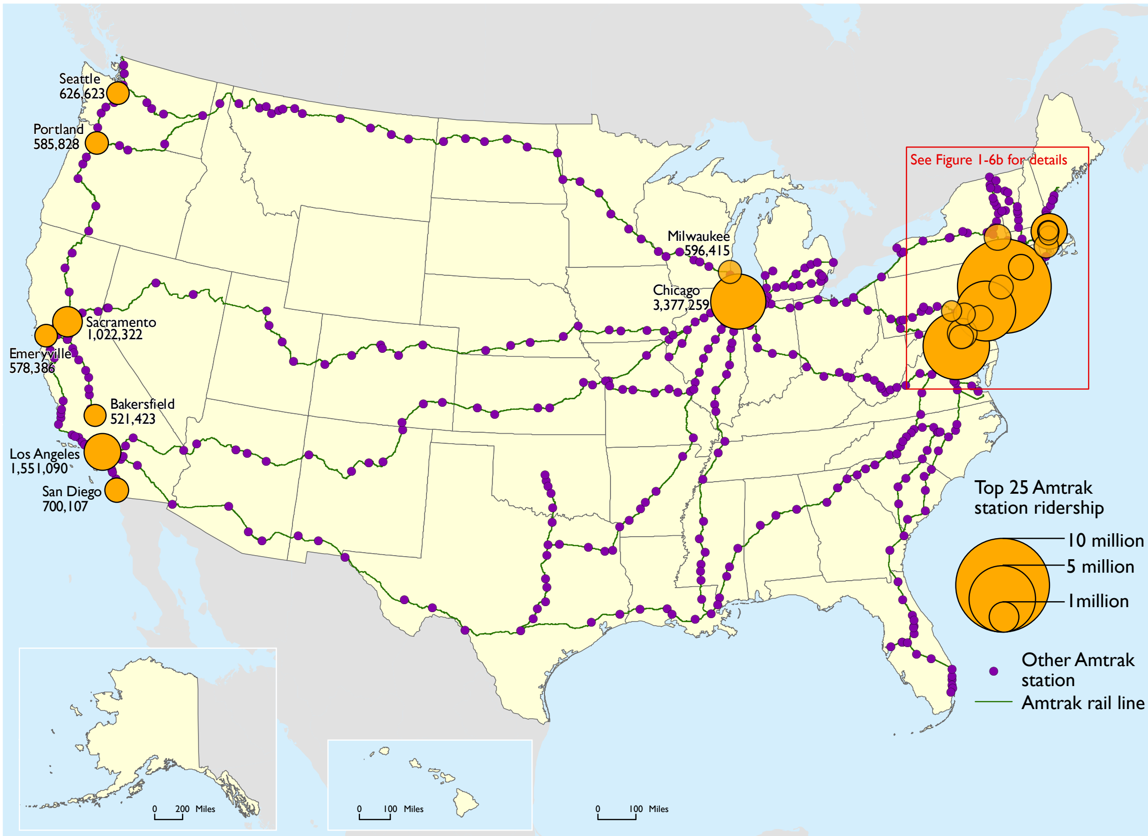
FIGURE 1-5 Class I Railroad System Mileage and Ton-miles of Freight:1960, 1965, 1970–2013



NOTE: Shaded areas indicate economic recessions.

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

FIGURE 1-6a Top 25 Busiest Amtrak Stations: 2014



SOURCE: National Rail Passenger Corporation (AMTRAK), *National Fact Sheet* (January 2014). Available at http://www.amtrak.com as of March 2015.

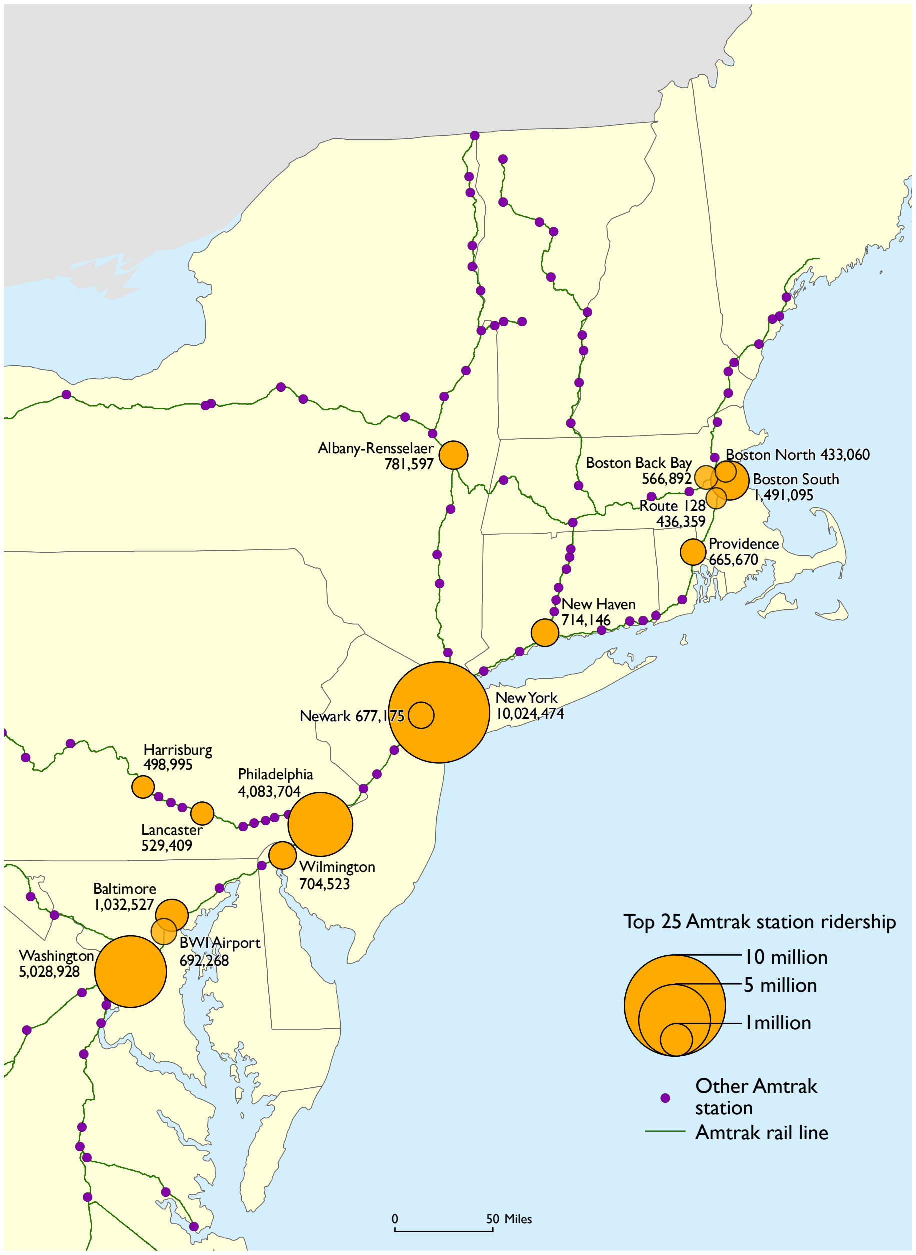
in the Northeast Corridor (NEC). Ridership was also high around Chicago as well as at several locations in California and the Pacific Northwest.

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 2014]. 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 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 are responsible for ensuring track safety, and to that end they regularly inspect their track and perform necessary repairs. The Federal Railroad Administration (FRA) regulations

FIGURE 1-6b Amtrak Stations and Ridership along the Northeast Corridor: 2014



SOURCE: National Rail Passenger Corporation (AMTRAK), *National Fact Sheet* (January 2014). Available at http://www.amtrak.com as of March 2015.

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 to survey tens of thousands of miles of high traffic density and other high priority routes each year. Table 1-2 provides a summary of track inspection results for the years 2004 to 2014. Of the eight track inspection exceptions that are monitored, the incidences of gauge and limited speed have dropped in recent years. The FRA implemented upgrades to the inspection and collection technology in the ATIP fleet in 2013, which allowed for increased sensitivity of exception detection. 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 nearly 620 thousand tons of rail and 16.2 million crossties in 2013, which is more than the annual average of 546 thousand tons of rail and 13.4 million crossties from 2001 to 2005 [AAR 2014].

The AAR also provides data on the age of the seven Class I railroad locomotive fleets (box 1-B). The fleet has become considerably newer since 2000. The percentage of locomotives that were less than 10 years old increased from 36.5 percent in 2000 to 45.2 percent in 2010, and their median age dropped from about 18 to 13 years. The pace of fleet renewal slackened a bit from 2010 to 2013 as the median age increased to about 16 years. No comparable compilation of the age distribution of railcars is available.

Box 1-B shows railroad capital expenditures, which totaled $13.1 billion in 2013, more than doubling the spending in 2000. In contrast, revenue ton-miles increased 18.7 percent over that period [AAR 2014]. 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

More than 8,200 U.S. water transportation facilities, including cargo handling docks, handled 3.2 billion short tons of goods in 2013. 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

TABLE 1-2 Automated Track Inspection Program (ATIP) Exceptions[1] per 100 Miles: 2004–2014

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

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

KEY: ATIP = Automated Track Inspection Program.

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* (June 15, 2015). Available at http://www.fra.dot.gov/ as of July 2015.

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 2015a].

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 62 years[9] (box 1-B). The USACE maintains comprehensive data on lock traffic, lockage time and delay, and lock outages for waterway performance analysis.

Table 1-3 provides data on representative locks throughout the inland waterway system. These

[9] 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.

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 45 and 86 years old, respectively. It had one of the highest average tow delays in the entire inland waterway system, 8.6 hours per tow in 2013.

On the Upper Mississippi River, the Melvin Price Lock has the two newest lock chambers listed in table 1-3. It passes over 40 million tons of freight per year with little delay or downtime. Just 15 miles downstream, Lock 27, with two identical size but much older chambers (61 years), has an average tow delay that exceeds 6 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 91-year-old lock results in an average tow delay of more than 12 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

TABLE 1-3 Selected Inland Waterway Lock Characteristics: 2013

River	River Mile[a]	Lock Chamber Name	Length, feet	Width, feet	Age, years	Tons in 2013, million[b]	Avg. Delay per Tow, hr[b]	Outages in 2013[b] Num.	Hours	Avg. hr. per outage
Ohio	6.2	Emsworth Lock & Dam Aux.	360	56	93					
Ohio	6.2	Emsworth Lock & Dam	600	110	93	19.6	3.02	54	1,048	19.41
Ohio	846	John T. Myers Lock & Dam Aux.	600	110	39					
Ohio	846	John T. Myers Lock & Dam	1,200	110	39	60.7	0.65	99	70	0.71
Ohio	938.9	Lock & Dam 52 Aux.	600	110	86					
Ohio	938.9	Lock & Dam 52	1,200	110	45	84.0	8.61	44	999	22.70
Mississippi	200.8	Melvin Price Lock & Dam Aux.	600	110	20					
Mississippi	200.8	Melvin Price Lock & Dam	1,200	110	24	40.1	0.99	6	14	2.33
Mississippi	185.5	Chain of Rocks L/D 27 Aux.	600	110	61					
Mississippi	185.5	Chain of Rocks L/D 27	1,200	110	61	49.8	6.24	4	73	18.25
GIWW East	7	Inner Harbor Navigation Canal Lock	640	75	91	15.7	12.42	29	93	3.21
Columbia	292	McNary Lock & Dam	675	86	61	6.1	0.17	0	0	N/A

[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; L/D = Lock & Dam; N/A = Not Applicable.

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.

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 items and summary tabulations.

Many of the coastal seaports are served by post-Panamax vessels[10] that continue to increase in size. Containerships calling at U.S. ports had an average capacity of 3,542 TEU 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 Army Corps of Engineers. In 2013 the Corps' and contractor's dredges removed 197 million cubic yards of material, down from 238 million in 2012. In 2013 maintenance dredging accounted for 84.3 percent of the removed material; the average cost per cubic yard increased 11.8 percent to $4.44 [USACE 2015a]. The Corps maintains detailed dredging data, but it does not produce summary tabulations that differentiate the work by deep or shallow draft channels.

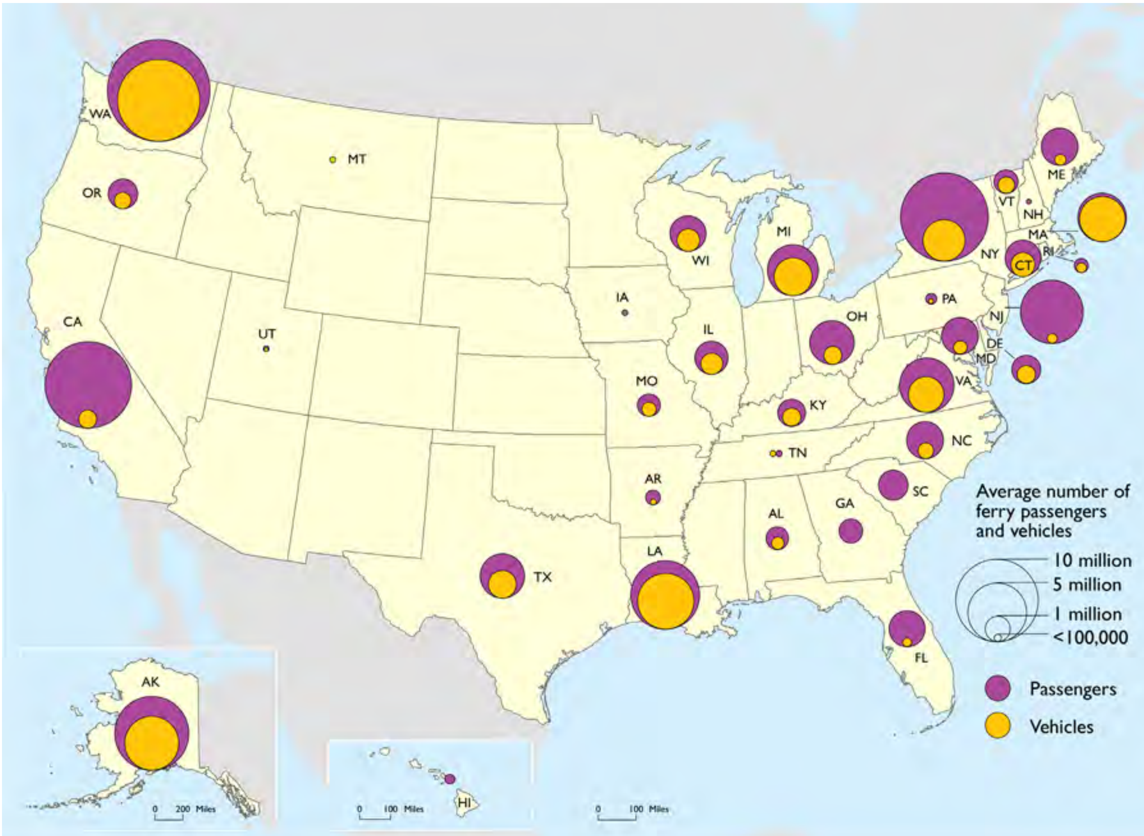
U.S. flag vessels operate on both shallow and deep draft waterways and numerous foreign flag vessels call at deep draft ports. Box 1-B provides age distributions of U.S. flag vessels for the 2000 to 2013 period. The fleet got a bit younger over that period. The percent of vessels younger than 16 years increased from 34 to 46 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; 69 percent are older than 25 years [USACE 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.

U.S. ferries carried an estimated 103 million passengers and just over 37 million vehicles in 2009 [USDOT BTS 2014].[11] Figure 1-7 shows the average number of passengers and vehicles by state. In 2009, 218 ferry operators worked in 37 states, 10 in U.S. territories and 3 between U.S. and non-U.S. locations (e.g., Canada). The U.S. ferry fleet

[10] 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."

[11] These data will be updated in the 2014 National Census of Ferry Operators, which is undergoing imputation.

FIGURE 1-7 Average Number of Ferry Passengers and Vehicles: 2009



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Census of Ferry Operators 2010*, Available at http://www.bts.gov as of January 2014.

was composed of 652 vessels, 622 of which were in active service. California had the most ferry vessels with 62, followed by New York (56), Massachusetts (52), and Washington State (46). Nearly all of the vessels carried passengers (93.4 percent), while less than half (43.6 percent) carried vehicles, and less than a quarter carried freight (22.2 percent).

While there is no definitive list of waterway transportation system investment needs, several recent studies have made estimates. Based on the fact that navigation projects account for one-third of the Corps' 2012 budget, the American Association of State Highway and Transportation Officials (AASHTO) estimated the agency's navigation project backlog totaled $20 billion [AASHTO 2013].

Pipelines

Natural gas was transported via about 320,000 miles of natural gas transmission pipeline and over 2.1 million miles of natural gas distribution main and service pipelines in 2013 (box 1-A). These pipelines connect to 65 million households and 5 million commercial businesses, and to the 1,900 electrical generating units that supply approximately 25 percent of U.S. electricity [AGA 2015]. Over 192,000 miles of crude/refined oil and hazardous liquid pipelines carried over 2.2 billion barrels across the United States [USDOE EIA 2015b].

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].

As with railroads, pipeline companies are private enterprises that are responsible for their own system maintenance, rehabilitation, and expansion. Hence, there are little data or estimates available on systemwide capital investments.

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 11 percent of highway bridges are considered structurally deficient. If these condition issues are not addressed, they could affect system performance in the coming years.

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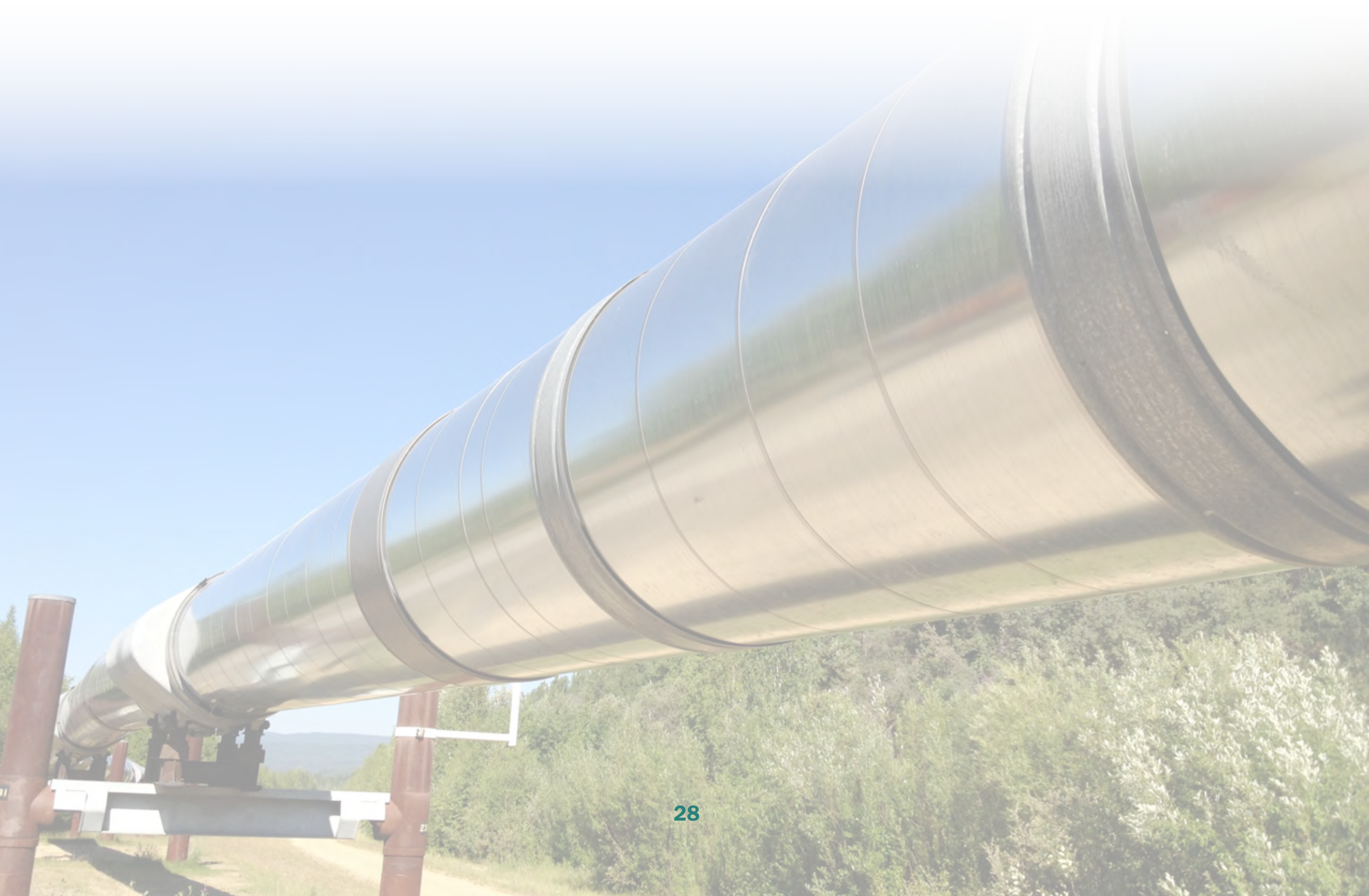


CHAPTER 2

Moving People

Highlights

- In 2013 total domestic person-miles of travel was about 4.7 trillion. Nearly four-fifths of person-miles was in cars or other personal vehicles, while domestic air travel accounted for 11 percent.

- In 2013 person-miles of travel on highways remained below the prerecession peak in 2007; annual data for 2014 are not yet available, but a monthly indicator of highway vehicle-miles of travel evidenced strong growth in 2014. Person-miles and vehicle-miles often rise in tandem.

- In 2014 new peaks were set for the number of commercial airline passengers (about 850 million) and revenue passenger miles (1.2 trillion). In contrast to previous years, U.S. air carrier's international revenue passenger miles exceeded domestic miles in both 2013 and 2014. In 2014, passengers are filling more seats per flight than a decade ago.

- 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.

- Between 1990 and 2013, the number of people who drove alone to work increased by 25 million, while nearly 2 million fewer people carpooled to work.

- About 9 percent of households (about 9.8 million) had no vehicle in 2009. However, only 4 percent of households with a worker were without a vehicle, underscoring the critical role the personal vehicle plays in getting employees to and from work.

- 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

- Transit use for the trip to work has slowly increased since reaching a low point in the mid 1990s. Transit now accounts for 5 percent of work trips, with higher levels in some metropolitan areas (the highest being New York City, San Francisco, CA, and Washington, DC).

- Walking and biking are important components of commuting to work in many cities. Regionally, walking to work is highest in Eastern cities. Over 10 percent of commuters in Boston, MA, Pittsburgh, PA, Washington, DC, and New York City walk to work. Biking to work is highest in the West and Midwest. Over 6 percent of commuters in Portland, OR, bike to work, as do over 5 percent of commuters in Madison, WI, and 4 percent in Minneapolis, MN.
- Working exclusively at home increased by about 82 percent from 1990 to 2013, growing from 3.4 million to 6.2 million.

The Nation's transportation system accommodates a large amount of local and long-distance travel to meet the demands of 319 million U.S. residents and 75 million foreign visitors.[1] In 2013 total domestic person-miles of travel (PMT) was about 4.7 trillion, nearly four-fifths of which was in cars or other personal vehicles, while domestic air travel accounted for 11 percent [USDOT BTS NTS, Table 1-40].[2] Transit, intercity rail, and bus services accounted for the remaining PMT. Walking and biking also accounted for a large number of local trips and travel miles.

The number of commercial air passengers and airline revenue passenger miles reached new highs in 2014, rebounding fully from sharp declines during and after the 2008 and 2009 economic recession. While 2014 highway PMT data had yet to be issued when this report was completed, highway PMT by personal vehicle in 2013 was still below the 2007 peak.

Transit, intercity passenger rail, and intercity bus services continued to grow during and after the recession.

Recent Trends in Local Travel

As illustrated in table 2-1, personal travel is dominated by frequent, repetitive patterns, such as the daily commute to work and weekly shopping trips. Figure 2-1a shows the shares of person trips by trip purpose, and figure 2-1b shows the person-miles of travel for these purposes from the most recent National Household Travel Survey (NHTS) completed by the USDOT Federal Highway Administration in 2009. Social/recreational activities, family/personal errands and shopping combined accounted for nearly 70 percent of household PMT and 60 percent of household trips.

Work 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 2-2).

[1] On an individual basis, data from the National Household Travel Survey indicates that U.S. residents averaged slightly over 13,100 miles per capita in 2009 [USDOT FHWA NHTS 2011].

[2] PMT in 2-axle 6-tire single-unit trucks and in combination trucks have been excluded from this calculation.

TABLE 2-1 Average Annual PMT, Person Trips, and Trip Length by Trip Purpose: 2009 NHTS

Purpose	Total annual trips per household	Average trip length in miles per household	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.

NOTES: 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 June 2015.

Personal vehicles were used for 86 to 88 percent of journeys to work in the 1990 to 2013 period (table 2-3). However, driving alone continued to rise in share and numbers while carpooling declined. About 25 million more people drove alone to work in 2013 than in 1990, while the number of carpoolers fell by nearly two million, as shown in figure 2-2. Transit ridership increased by over one million. Walking dropped in both share and numbers nationwide from 1990 to 2013, while biking increased in both share and numbers nationwide.

The geography of commuting involves two opposing trends:

1. Workers and their places of work have grown farther apart over recent decades. Workers leaving their home county to work in another county more than quadrupled from 9 million to 38 million and almost doubled in share of all workers between 1960 and 2010.
2. An increasing number of workers are working at home. 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 2010, 13.4 million people worked from home at least one day per week, an increase of about 4.2 million people (35.4 percent) from 1997. Home-based workers include those who work exclusively at home as well as those who work at both home and at a job site. Advanced communication and information technologies have increased labor force mobility. Monday and Friday are the most likely days to telework, and Thursday is the least likely [USDOC CENSUS 2013a].

The NHTS survey data show 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,

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

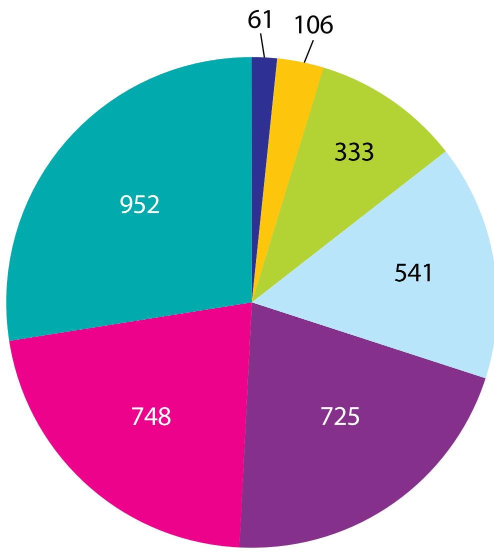
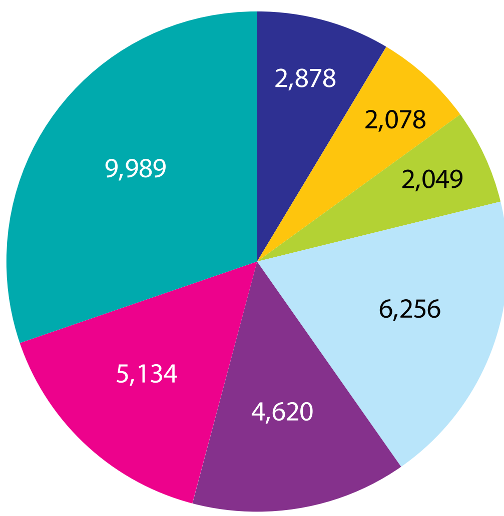


FIGURE 2-1b Average Annual PMT per Household by Trip Purpose: 2009 NHTS



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 June 2015.

TABLE 2-2 Average Annual PMT, Person Trips and Trip Length by Trip Purpose: 1983, 1990, 1995 NPTS, 2001 NHTS and 2009 NHTS

	Average Person Trip (miles)				
	1983	**1990**	**1995**	**2001**	**2009**
All Purposes	**8.7**	**9.5**	**9.1**	**10.0**	**9.7**
To/From Work	8.5	10.7	11.6	12.1	11.8
Work Related Business	21.8	28.2	20.3	28.3	20.0
Shopping	5.4	5.4	6.1	7.0	6.5
Other Family/Personal Errands	7.3	8.6	7.6	7.8	7.0
School/Church	4.9	5.4	6.0	6.0	6.3
Social and Recreational	12.3	13.2	11.3	11.4	10.7
Other	8.2	10.3	22.8	43.1	51.5

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 November 2015.

TABLE 2-3 Commuting by Mode of Transportation: 1990, 2000, 2010, and 2013

Thousands of workers

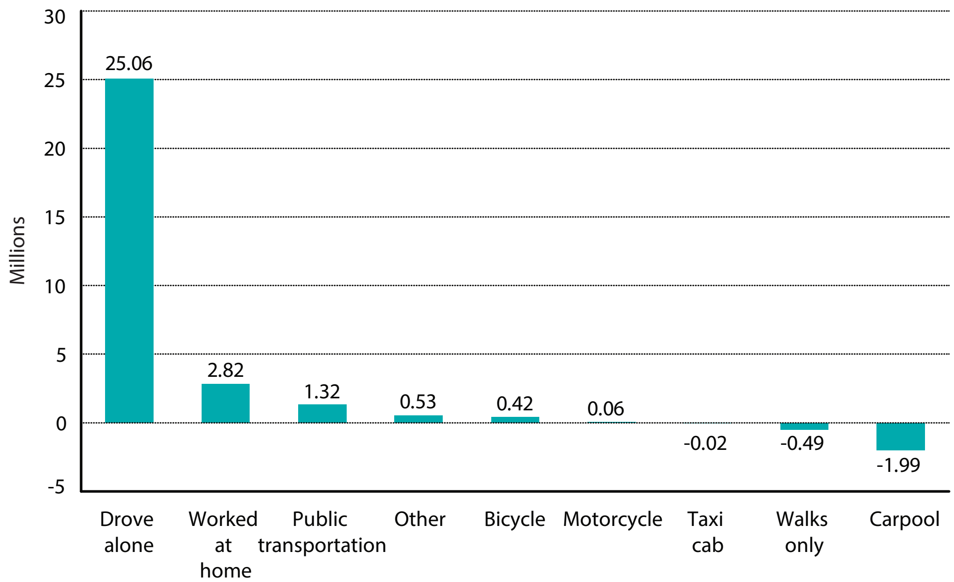
	1990		2000		2010		2013		Change, 1990 to 2013	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Total	**115,070**	**100.0**	**128,279**	**100.0**	**136,941**	**100.0**	**142,962**	**100.0**	**27,892**	**24.2**
Personal vehicle, total	99,593	86.5	112,736	87.9	118,124	86.3	122,664	85.8	23,071	23.2
Drives self	84,215	73.2	97,102	75.7	104,858	76.6	109,277	76.4	25,062	29.8
Carpool, total	15,378	13.4	15,634	12.2	13,266	9.7	13,387	9.4	-1,991	-12.9
2-person	NA	NA	NA	NA	10,294	7.5	10,266	7.2	NA	NA
3-person	NA	NA	NA	NA	1,733	1.3	1,824	1.3	NA	NA
4+ person	NA	NA	NA	NA	1,239	0.9	1,297	0.9	NA	NA
Public transportation	6,070	5.3	6,068	4.7	6,769	4.9	7,393	5.2	1,324	21.8
Taxicab	179	0.2	200	0.2	151	0.1	161	0.1	-18	-10.3
Bicycle	467	0.4	488	0.4	731	0.5	882	0.6	415	89.0
Motorcycle	237	0.2	142	0.1	267	0.2	296	0.2	58	24.6
Walks only	4,489	3.9	3,759	2.9	3,797	2.8	4,000	2.8	-488	-10.9
Other means	809	0.7	901	0.7	1,178	0.9	1,337	0.9	528	65.3
Works at home	3,406	3.0	4,184	3.3	5,924	4.3	6,229	4.4	2,823	82.9

KEY: NA = not available.

NOTES: Principal means of transportation to work refers to the mode of travel used to get from home to work most frequently. If more than one means of transportation was used each day, those surveyed were asked to specify the one used for the longest distance during the trip from home to work. Component values may not add to totals due to rounding.

SOURCES: **1990 and 2000**: U.S. Department of Commerce (USDOC), Census Bureau (CB), Decennial Census. *About Commuting (Journey to Work)*. Available at www.census.gov as of June 2015. **2010 and 2013**: USDOC/CB, *American Community Survey 1-Year Estimates*, as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 1-41. Available at www.bts.gov, June 2015.

FIGURE 2-2 Workers Net Change by Mode of Transportation: 1990 to 2013



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, and includes ferryboats for 2010. *Other* include ferryboats, surface trains, and van service and other means not classified for years 2000, and excludes ferryboats from 2010.

SOURCES: 1990: 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. **2013**: 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 June 2015.

while on the way to and from work [USDOT FHWA NHTS 2011].

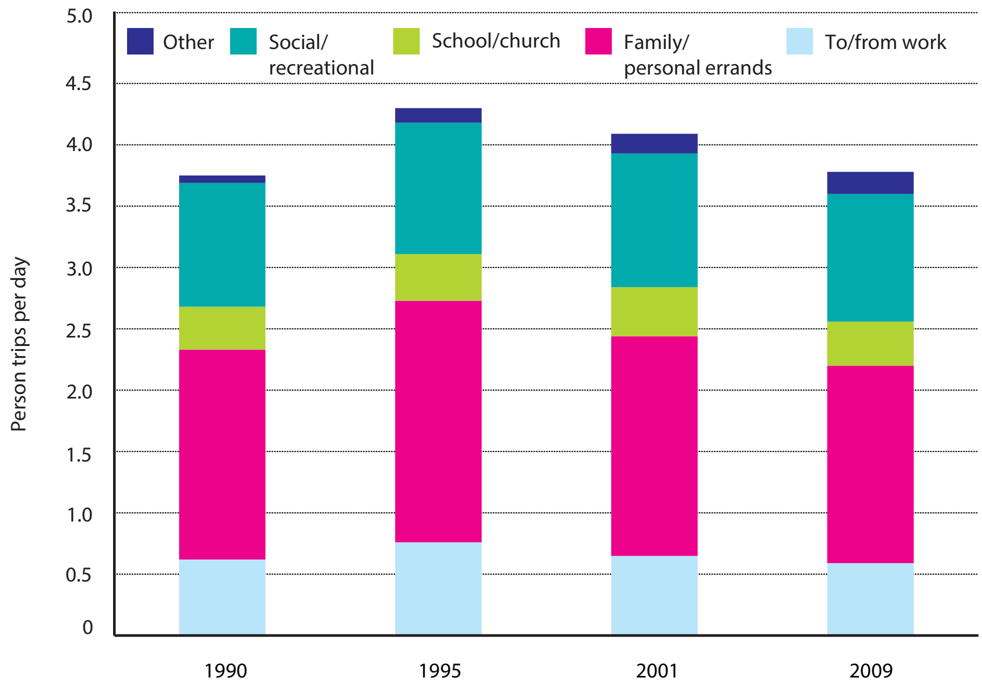
Figure 2-3 traces the number of trips per person per day made for major purposes as reported in the national travel surveys. The number of work trips has been stable, but the share has declined relative to other trips as travel for other trip purposes increased.

The number of trips varies throughout the week (figure 2-4). Friday accounts 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 are taken in 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

FIGURE 2-3 Long-Term Trend in Trips per Day by Purpose: 1977, 1983, 1990, and 1995 NPTS, and 2001 and 2009 NHTS



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.

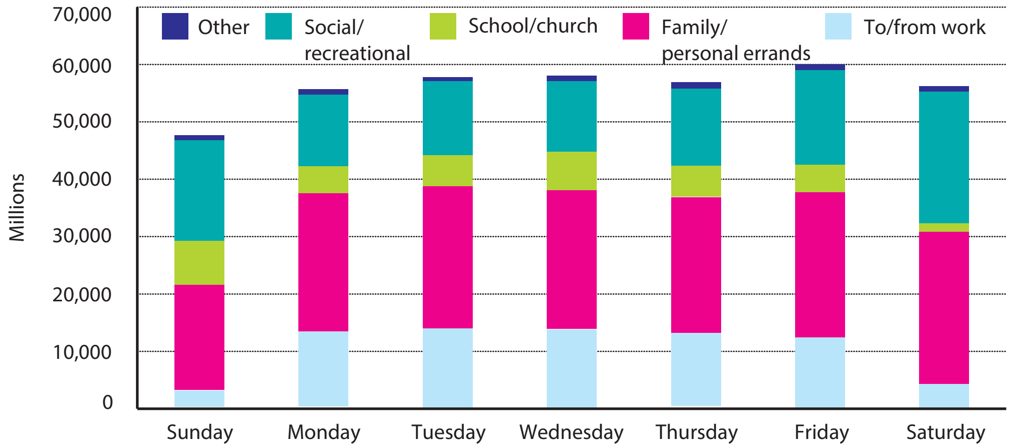
SOURCES: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey, *Summary of Travel Trends*. Table 11. Available at http://nhts.ornl.gov/ as of June 2015.

share of households without a vehicle declined from over 20 percent in 1960 to 8.7 percent in 2007. The most recent data indicate that roughly 10.7 million households, 9.2 percent of all households in 2012, did not have access to a vehicle [USDOC CENSUS 2012]. The number of households without vehicles has stayed about the same, at 10 to 11 million, despite a growing number of households over the past 40 years [AASHTO 2013].

Most households without access to vehicles do not have members in the labor force. Only 4 percent of households with workers have no vehicles. Workers in these households mostly rely on transit, walking, or, to a lesser extent, carpooling to get to work. About 12 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

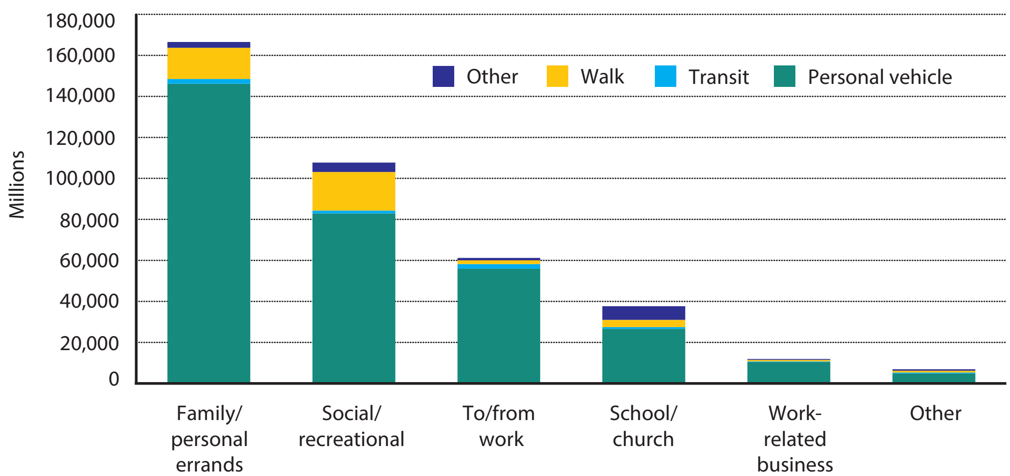
FIGURE 2-4 Annual Number of Person Trips by Purpose and Day of Week: 2009 NHTS



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.

SOURCES: 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 June 2015.

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



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.

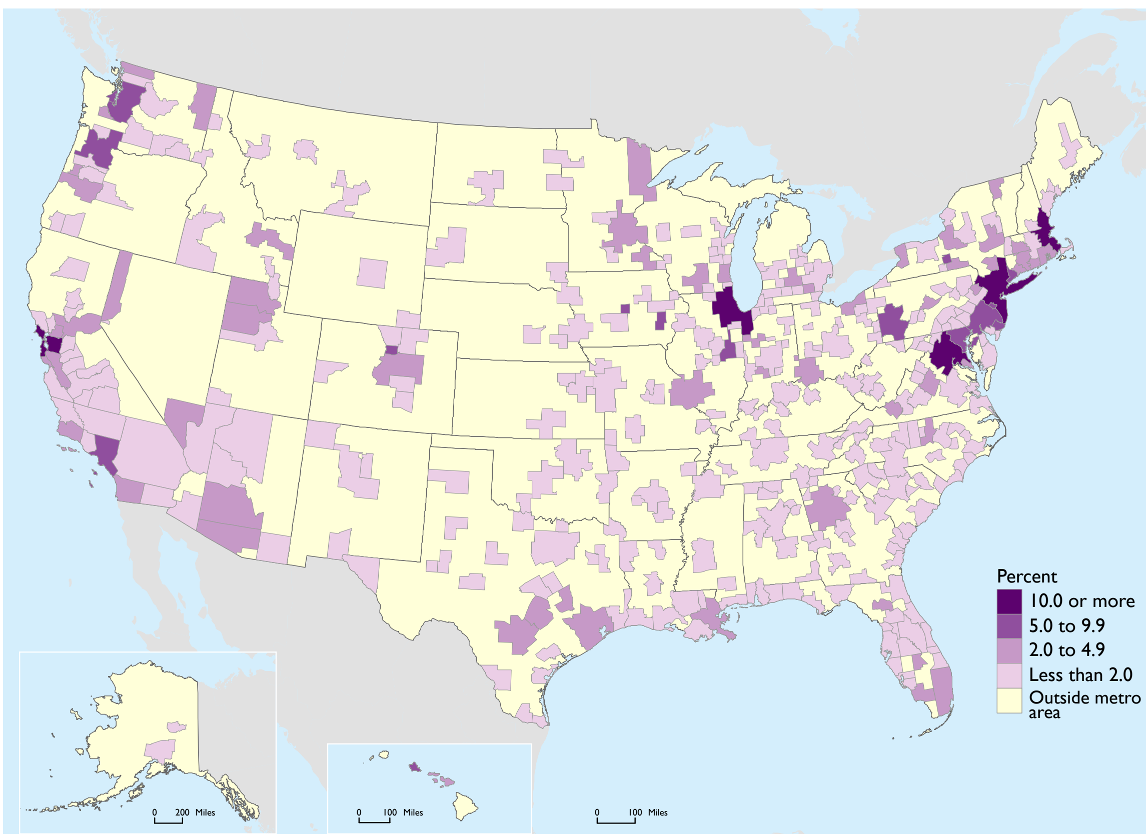
SOURCES: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey (NHTS), *Online Analysis Tool*. Available at http://nhts.ornl.gov as of June 2015.

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). At the highest extreme, 58.7 percent of workers living in the borough of Manhattan in New York City commute by transit and another 20 percent walk [USDOC CENSUS 2012].

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. According to recent Census data, 4.3 percent of workers in the principal cities of metropolitan areas walk to work and another 1.0 percent bike. Over 10 percent of commuters in several large cities (Boston, MA; Washington, DC; Pittsburgh, PA; and New York City) walk to work. Large cities with the highest percentage of commuters by bike are Portland, OR (6.1 percent); Madison, WI (5.1 percent); and Minneapolis, MN (4.1 percent). These cities have also invested in

FIGURE 2-6 Percentage Commuting by Public Transit: 2013 ACS



SOURCES: U.S. Department of Commerce, Census Bureau, *2009-2013 American Community Survey 5-Year Estimates*, available at http://www.census.gov/acs as of March 2015.

infrastructure to facilitate biking. Some small cities have higher rates of walking and biking, especially university towns.

Among regions, the Northeast has the highest rate of walking, 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.

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 [MCKENZIE 2014]. 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].

Recent Trends in Long-Distance Travel

When defined as trips to a place over 50 miles away, long-distance travel is primarily served by personal vehicles or air carriers. There is no longer a comprehensive data source for long-distance travel. 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 personal vehicles, 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 measured, but passenger lists have not been compiled into trips since June 2012.

Long-distance travel includes approximately 74.8 million international visitors to the United States, as shown in figure 2-7a, in 2014, an increase of 15 million from 2010. Figure 2-7b shows the fluctuation in international visits since 2000, reflecting the impacts on international travel after the 2001 terrorist attacks and the influence of the global recession in the first half of 2009 [USDOC OTTI 2015]. U.S. and foreign airlines carried nearly 850 million passengers on domestic flights and international flights to and from the United States in 2014. Passenger enplanements were up by about 26 million from 2013, surpassing their previous peak in 2007. In 2014 domestic enplanements accounted for 78.0 percent of passengers, while international enplanements on U.S. and foreign airlines accounted for 22.0 percent [USDOT BTS OAI 2015]. U.S. airlines carried 55.0 percent of passengers traveling between the United States and international points. As shown in table 2-4, planes have become more crowded since

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

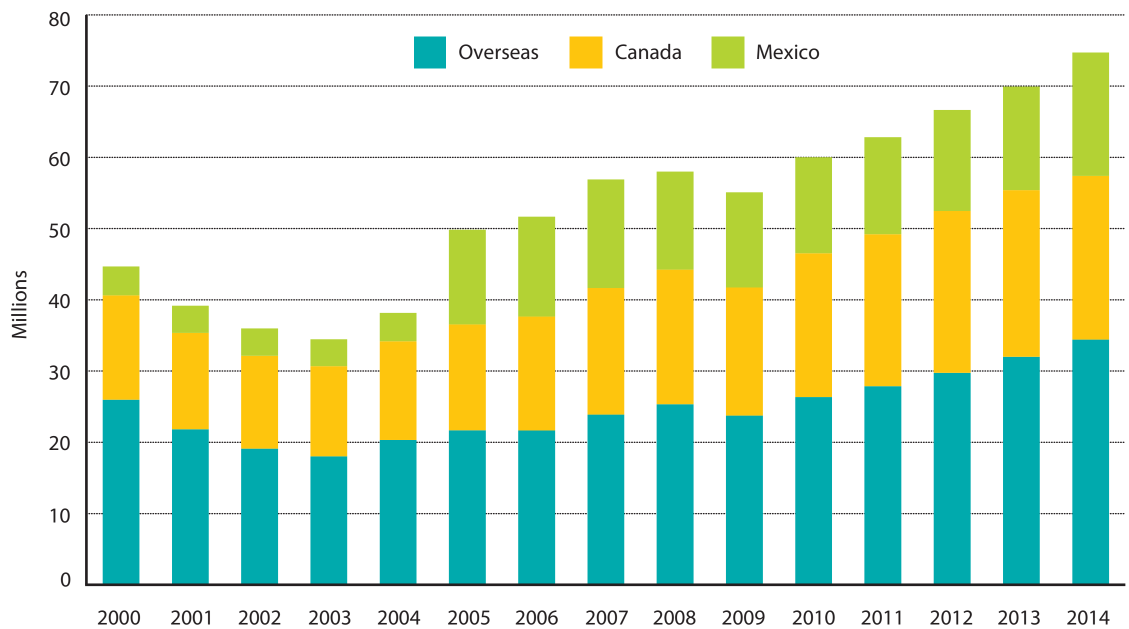
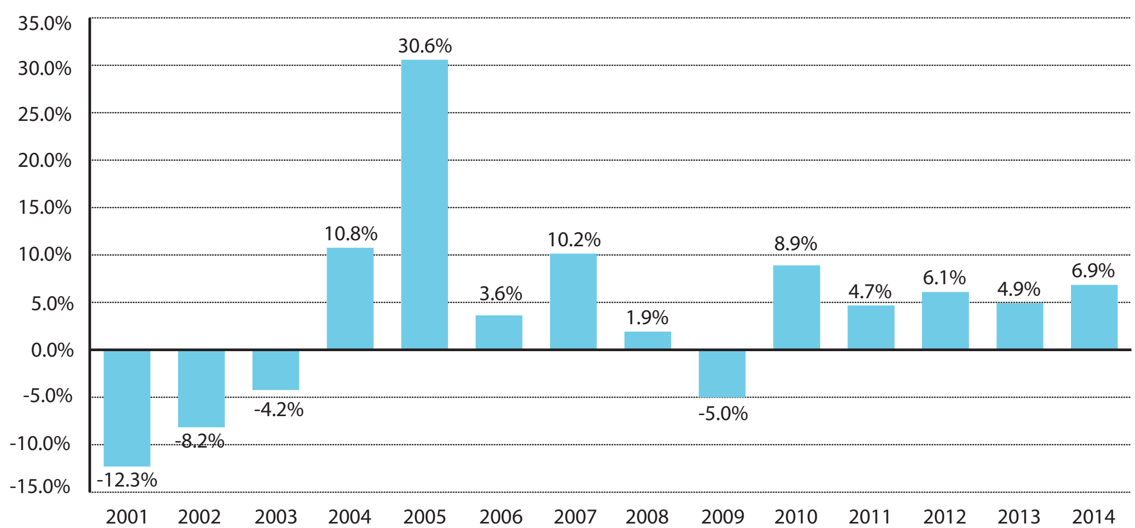


FIGURE 2-7b Percent Change from Previous Year in Total Foreign Visits: 2001–2014



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

2005 as measured by load factors. Domestic flights were, in general, more crowded than international flights.

The number of domestic and international flights (9.5 million in 2014) has been trending downward since the peak of over 11.3 million flights in 2005, but these flights are carrying more passengers and have a higher load factor than a decade ago. Domestic flights in 2014 accounted for 85.2 percent of total U.S. flights, while international flights of U.S. and foreign carriers accounted for 14.8 percent [USDOT BTS OAI 2015].

Between January 2003 and January 2015, U.S. airlines' total (domestic and international) passenger enplanements rose 18.1 percent. Enplanements of 64.4 million in January 2015 were the highest since the recession ended in June 2009 and the fourth highest of all-time. During this period, growth of international enplanements (52.3 percent) outpaced domestic enplanements (14.3 percent). While domestic and total enplanements remain below prerecession levels, passengers are traveling longer distances. Passengers traveled 72.8 billion revenue passenger-miles in January 2015, the second highest of all-time, and 0.7 percent less than the all-time record set in the previous month (figure 2-8).

Long-distance railroad travel in the United States is primarily on Amtrak (also known as the National Rail Passenger Corp.). Amtrak ridership has been growing for many years, rising from 19.7 million annual person trips in its fiscal year 1997 to 30.9 million riders in 2014 [AMTRAK 2014]. On a second, smaller railroad, the Alaska Railroad, annual ridership peaked in 2007 at more than one-half million trips, but had not regained this level as of 2014. Customers traveling aboard railcars owned by cruise lines and pulled by the Alaska Railroad

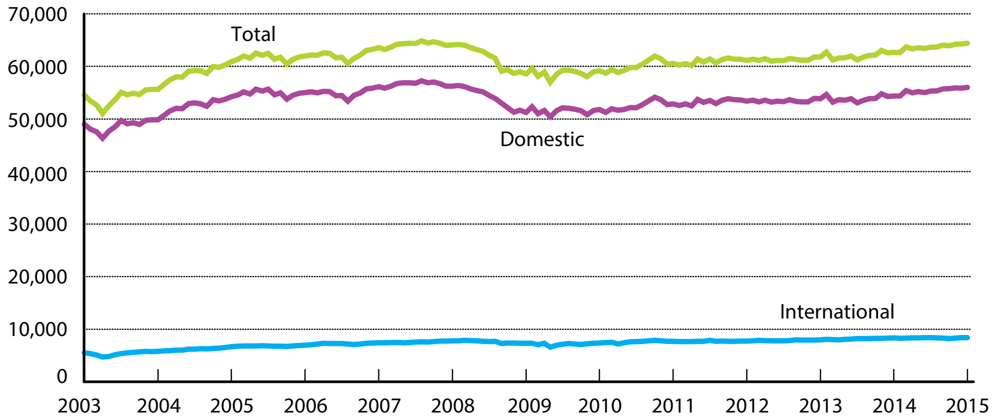
TABLE 2-4 Annual Airline (U.S. and Foreign Carriers) Passenger Enplanements: 2005–2014
Scheduled flights only

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

FIGURE 2-8 U.S. Airline Passenger Enplanements: Jan 2003–Jan 2015



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

SOURCES: 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 2015.

accounted for about half of the 2014 Alaska Railroad passengers [ARRC 2015].

Long-distance travel by motorcoach is summarized in table 2-5. In 2013 the motorcoach industry provided 605 million person trips in the United States and Canada, covering about 63 billion miles for an average trip length of about 104 miles. In 2013 the 19 large carriers, with more than 100 buses each, accounted for less than 1 percent of operators, but provided 38.5 percent of person trips. Small carriers, with less than 10 buses each, accounted for 82.0 percent of operators, but provided only 21.9 percent of trips. The remaining carriers, with between 10 and 99 buses, provided 39.6 percent of person trips. Roughly half of all bus passengers are either students or senior citizens [ABA 2015]. About 48.4 percent of motorcoach mileage was in

TABLE 2-5 Motorcoach Carriers, Coaches, Trips, and Passenger Miles: 2010–2013

	2010	2011	2012	2013
Carriers	4,011	3,984	3,954	3,801
Coaches	40,709	40,141	39,607	36,903
Passenger trips (millions)	601	627	637	605
Passenger trips per coach	14,800	15,600	16,100	16,400
Passenger miles (billions)	69	76	76	63
Passenger miles per coach	1,703,200	1,897,400	1,912,500	1,710,000

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 June 2015.

charter service; scheduled service accounted for another 33.9 percent. The remaining miles were for such services as commuting, packaged tours, and transport to and from airports.

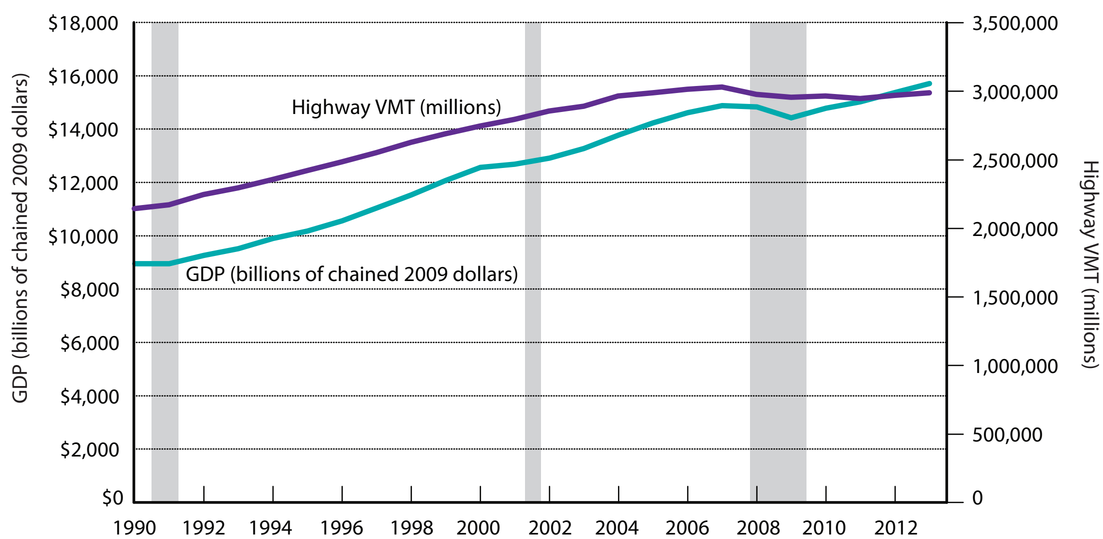
Forces of Change in Travel

After decades of growth, person-miles of travel (PMT) by the dominant mode of personal vehicles recovered slowly after 2008, but personal vehicles still account for about 80 percent of PMT. As described earlier, air travel declined during the recession, but has subsequently rebounded to reach new highs in 2014. The increases in travel by other modes (e.g., transit and intercity passenger rail) are far too small in numbers to offset the decline in highway PMT on total travel [USDOT BTS NTS 2015].

Economics and Recession

The 2008–2009 recession clearly impacted recent travel trends. Vehicle-miles traveled (VMT) peaked in 2007, just as the recession began, before dropping 1.8 percent in 2008, 0.7 percent in 2009, and 0.7 percent in 2011, followed by modest growth in 2010 and 2012. U.S. gross domestic product (GDP) grew at approximately 4 percent per year in the 1990s and 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 onwards through at least the end of 2014. Figure 2-9 shows the interrelationship between GDP and VMT. Annual series data are not yet available for 2013 and 2014, but monthly estimates indicate further VMT growth in these years as the

FIGURE 2-9 U.S. Gross Domestic Product (GDP) and Highway Vehicle-Miles Traveled (VMT): 1990–2013



NOTE: Shaded areas indicate economic recessions.

SOURCES: 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 June 2015. **VMT**: DOT, Federal Highway Administration as cited in DOT, BTS. *National Transportation Statistics*, Table 1-35. Available www.bts.gov as of June 2015.

economy continued to grow [USDOT FHWA 2015].

While the number of passengers on international 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. Only urban transit and intercity rail passenger volumes grew during and after the recession (with the previously mentioned exception of the Alaska Railroad). The probable degree to which increases in gas prices may encourage people to take transit rather than drive is discussed in box 2-A. As shown in figure 2-10, person-miles of travel increase with household income. With the last national personal travel survey completed in 2009, at the end of the recession, it remains to be seen what the next survey now underway will show about the trip-making propensities of the public.

Demographic and Geographic Shifts

Demographic factors are the driving force behind long term travel demand. Between 1990 and 2014, the U.S. population grew by 70 million people, reaching 319 million, placing additional travel demands on the transportation system [USDOC CENSUS

BOX 2-A Impact of Gas Prices on Transit Ridership

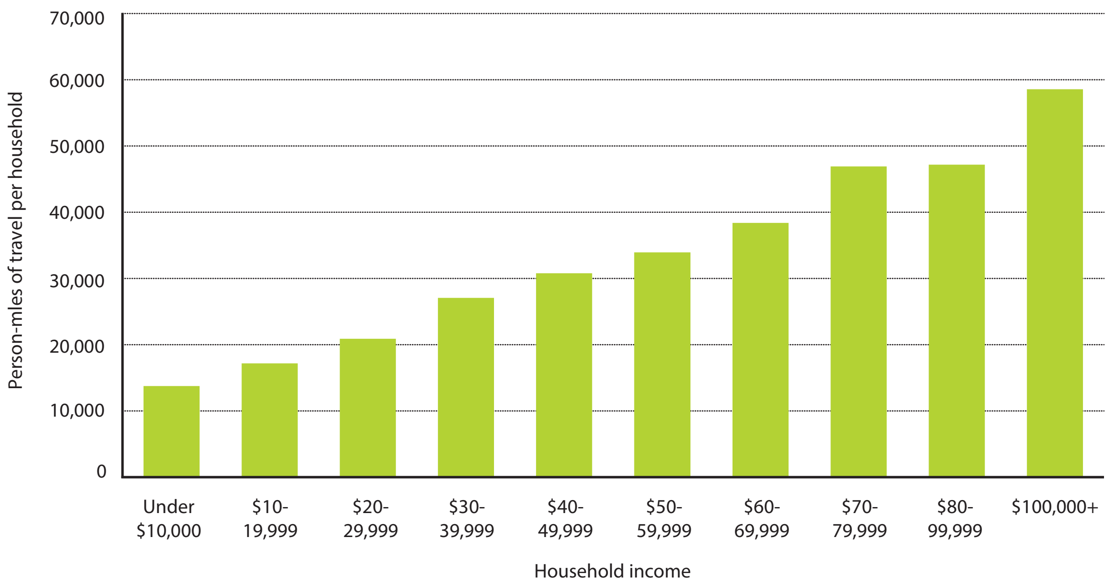
Transit ridership has increased dramatically over the past few years. Gas prices paid by drivers also increased dramatically until recently. The USDOT Office of the Assistant Secretary for Research and Technology (formerly known as RITA) and the California DOT cosponsored a study to examine the relationship between increases in gas prices and transit ridership in 10 U.S. urbanized areas (mostly densely populated urban cores).

The study, *Net Effects of Gasoline Price Changes on Transit Ridership in U.S. Urban Areas*, released in December 2014, hypothesized what might happen with transit ridership if gasoline prices rose 10 percent between 2002 levels and 2011 in the 10 urbanized areas. It also examined transit ridership changes when gasoline prices reached a $3 threshold and a $4 per gallon threshold [ISEKI; ALI 2014].

The study examined bus, light rail, heavy rail, and commuter rail modes, as well as total transit system ridership. Effects varied by transit mode and other conditions. While only the bus mode (and aggregate ridership) had strongly positive short-term effects when there was a 10 percent increase in gasoline prices, all modes showed ridership increases when the gas price increase was long-term during the 10-year study period. When gas prices were over $3 per gallon, the study noted a "positive threshold boost effect" for commuter and heavy rails, resulting in a "substantially higher rate of ridership increase." The rate of increase in bus ridership was 1.67 percent; the rate of increase for commuter rail was 2.05 percent, and the rate of increase for aggregate ridership rose 1.80 percent for the same level of gasoline price changes. When gasoline prices rose over $4 a gallon, the rate of increase in ridership for heavy rail rose to 9.34 percent.

The study suggested that transit agencies could prepare for such "potential" increases in peak-period ridership from high gasoline prices through measures such as pricing strategies, general financing, capacity management, and operations planning of transit services.

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



SOURCES: U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey, Online Analysis Tool. Available at http://nhts.ornl.gov/ as of June 2015.

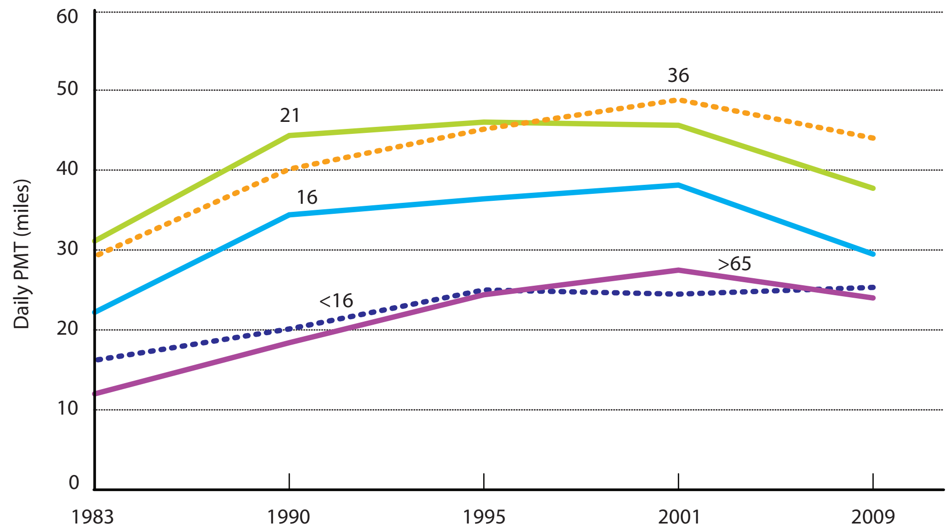
2015]. All regions added population, but growth is not even across the country. More than 80 percent of the 1990 to 2010 population gain was in the South and West, continuing a decades-long trend [USDOC CENSUS 2001 and 2011]. Although two-thirds of the Nation's counties and 85 percent of metropolitan counties gained population from 2000 to 2010, 175 metropolitan counties and 920 non-metropolitan counties lost a total of 2 million residents [AASHTO 2013]. These regional and metropolitan population changes affect transportation infrastructure needs and travel patterns.[3]

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 becomes available for spending on discretionary travel. The number of workers increased by over 25 million, growing from about 119 million in 1990 to 146 million in 2014 [USDOL BLS 2015].

Figure 2-11 illustrates the effect of age on travel. 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) travel the least compared to other age groups. The other three age groups shown in the figure account for the majority of person-miles traveled (PMT),

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

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



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.

SOURCES: 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.

particularly those between 26 and 65 years of age. This is a harbinger of future trends as older members of the labor force move toward the 65-year-age threshold, when many people move into retirement. 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 recession and its aftermath, while the working age groups were most affected, particularly the youngest segment [NBER 2013]. Whether this is cyclical or a fundamental change in travel behavior is not clear.

The baby boom generation, born between 1945 and 1965, has been the driving force for travel activity at the local and intercity level for many decades. Today, as the trailing edge of the baby boom generation approaches 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].

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 are 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 for youth than with shifting preferences of the 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].

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 generation, 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.

Time Spent Traveling

On weekdays in 2013, the average person spent 81.6 minutes per day traveling for a variety of activities. Examining only people who engaged in travel for work, the average person spent 46.1 minutes per day traveling, the most time for all selected activities.

On weekends and holidays, people spent an average of 86.1 minutes per day engaged in various travel activities, 4.5 minutes more than on weekdays. Out of all selected activities, the average person spent the most time (45.6 minutes) traveling for activities related to socializing, relaxing, and leisure, about 11.0 minutes per day more than on weekdays. Travel related to eating and drinking on weekends and holidays accounted for 35.9 minutes—about 10 minutes more than on weekdays [USDOL BLS 2013].

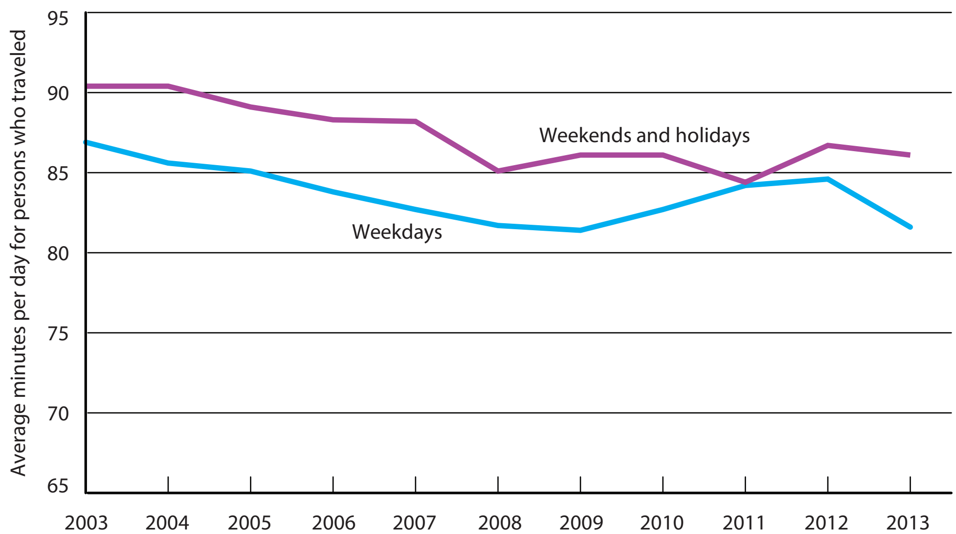
People spent less time traveling in 2013 than 2003. On weekdays in 2013, people spent 5.2 fewer minutes traveling per day, a decrease of 6.0 percent from 2003. On weekends and holidays, people spent 4.3 fewer minutes traveling per day, a 4.7 percent decrease (figure 2-12).

Time spent traveling reached a low in 2008 in the midst of 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 groups in society who have the most difficulty traveling. This section begins

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



NOTE: 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.

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

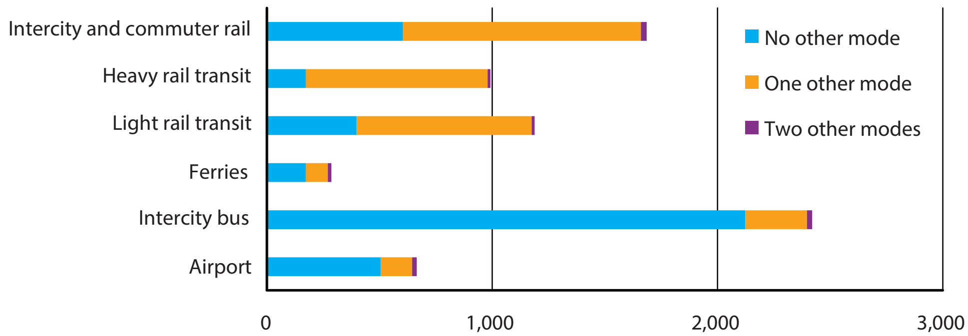
with a discussion of the degree of connectivity[4] between public transportation modes, using data from the Bureau of Transportation Statistics' (BTS') Intermodal Passenger Connectivity Database. Other challenges discussed include access to transportation for people without a personal vehicle and transportation options for the elderly and for people with disabilities. The section concludes with health issues related to transportation.

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 inventories the connectivity of passenger transportation facilities (e.g., air, long-distance bus and ferry, and intercity rail service) and certain transit facilities (e.g., local ferry and heavy, light, and commuter rail). There are over 7,200 intercity passenger travel facilities (figure 2-13), of which 54.9 percent do not offer connections to other transportation modes, 43.5 percent connect to one other mode, and 1.5 percent

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

FIGURE 2-13 Intermodal Passenger Facilities by Mode: September 2013



Number of Connections by Facility Type

Number of facilities:	No other mode	One other mode	Two other modes	Grand total
Airport	506	138	22	666
Intercity bus	2,123	274	24	2,421
Ferries	173	98	16	287
Light rail transit	398	779	12	1,189
Heavy rail transit	173	808	11	992
Intercity and commuter rail	604	1,055	26	1,685
	3,977	3,152	111	7,240

NOTES: *Types of connections* include: Ferry (transit and intercity), Bus (intercity, transit, code share, and supplemental), Rail (intercity, light, heavy, and commuter), and Air. *Type of facilities* include: Ferry (transit and intercity, Intercity bus, Rail (intercity, light, heavy, and commuter), and Air.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, *Intermodal Passenger Connectivity Database* (as of 07/13/2013). Available at www.bts.gov as of June 2015.

connect to two other modes of transportation (e.g., bus, air, rail, or ferry) [USDOT BTS 2013].

Specifically, 83 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 options, followed by light-rail transit (with 66.5 percent), and Amtrak/intercity and commuter rail (with 64.2 percent). About a quarter (24.0 percent) of airports with schedule passenger service connect with other transportation modes. Only 12.3 percent of intercity bus facilities have connections to other modes [USDOT BTS 2013].

Access to Transportation for People Without a Vehicle

Many people without access to a personal vehicle, especially the poor, have difficulty reaching stores, services, and workplaces outside of their immediate neighborhoods. As previously discussed, roughly 9 percent of households (about 9.8 million) in 2009 did 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 15.8 percent between 2000 and 2013 as the number of poverty stricken persons increased from 33.3 million to 48.8 million[5] [USDOC CENSUS 2013b, 2014]. 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, 63.6 percent drive to work compared to 76.4 percent of workers overall in 2012. Compared to commuters as a whole, people below the poverty level are more likely to take public transportation, walk, or use other transportation modes (compare figures 2-14a to 2-14b).

Transportation Access for Elderly and Disabled Passengers

Accessibility to transportation options also is a challenge for the elderly and 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 had taken 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 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. In 2012 the percentage of accessible buses with 35 seats reached 99 percent, compared to about 94 percent in 2003 [USDOT FTA 2013]. Also during this period, accessible portions of the commuter rail fleet doubled to 85 percent, and accessibility on the light rail and heavy rail fleets reached 88 and 99 percent, respectively. The trolleybus fleet grew from 47 to 100 percent accessible. Demand-response transit fleets also have become more accessible, increasing from 84 to 89 percent.

Box 2-B examines the interactions between transportation and public health.

[5] There is no statistically significant difference in the poverty rate between 2011 and 2013, while the poverty rate increased each year in the four years prior to 2011.

FIGURE 2-14a How Workers Below the Poverty Level Get To Work: 2012

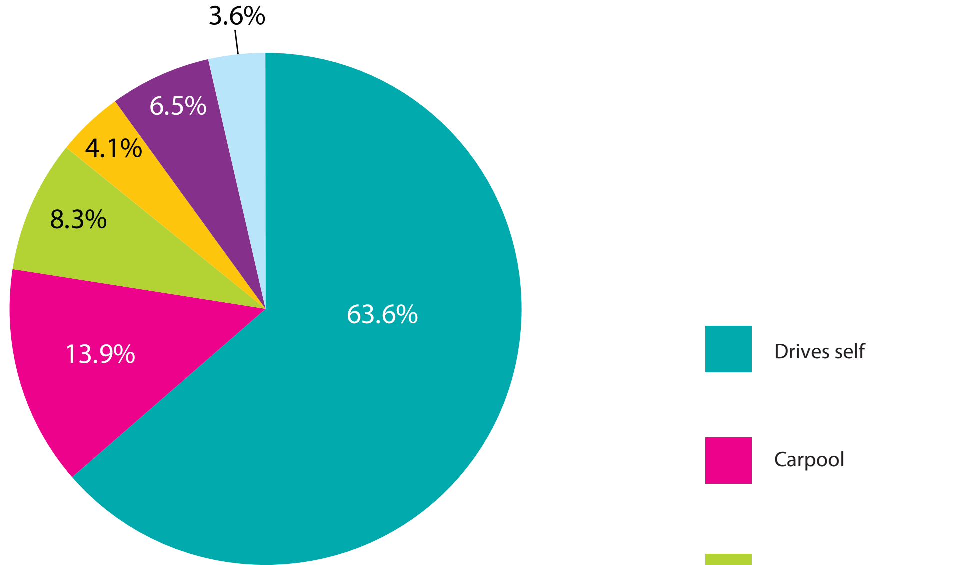
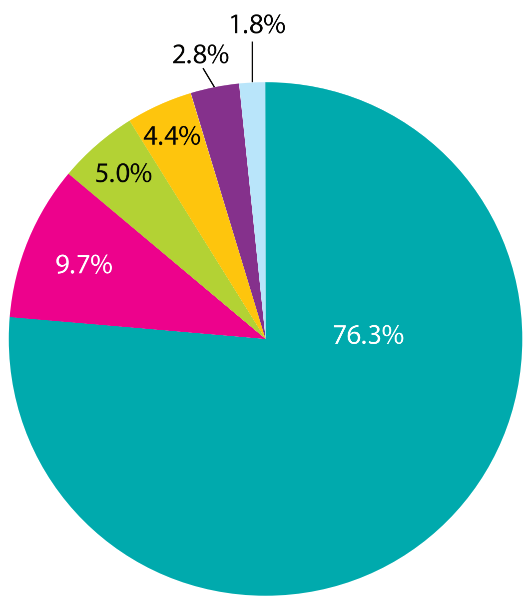


FIGURE 2-14b How Workers Get To Work: 2012



[a] *Public transportation* category includes workers who used a bus or trolley bus, streetcar or trolley car, subway or elevated, railroad, or ferryboat. [b] *Other means* includes ferryboats, surface trains, and van service and other means not classified.

NOTES: Percents may not add to 100 due to rounding. For additional information, please refer to the *American Community Survey's 2012 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.

SOURCES: *Below Poverty Level*: U.S. Department of Commerce, Census Bureau, 2012 American Community Survey, 1-year estimates, table B08122. Available at http://www.census.gov/acs/www/index.html as of June 2015. *Total*: U.S. Department of Commerce, Census Bureau, 2012 American Community Survey, 1-year estimates, table B08006. Available at http://www.census.gov/acs/www/index.html as of June 2015.

Box 2-B Health and Transportation

Transportation and public health interact in several ways, such as in the areas of public safety and exposure of the public to air pollution. In this regard, there has been improvement in some critical indicators of transportation's health impacts over the last several decades.

As is discussed in chapter 6, transportation fatalities and injuries have declined in recent decades, yet every day, on average, about 95 people die and 6,400 people are injured in transportation accidents—primarily on the highway. Air pollution from transportation also is an indicator of health effects, as is discussed in chapter 7. Here, too, there has been a reduction in transportation emissions over the last few decades, resulting in benefits to public health.

Perhaps the most dramatic change has been the virtual elimination of lead from gasoline. 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].

But air quality health impacts from transportation emissions from other air pollutants remain a concern. According to the US EPA, living, working or attending school near major roads has been associated with greater incidence or severity of such health effects as asthma, cardiovascular disease, reduced lung function, childhood leukemia, and premature death. Besides air pollution, noise exposure may also play a role in roadway-related health problems [USEPA].

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, the time people spend each day walking and bicycling to workplaces or other places has declined, while the time spent sitting in vehicles has increased [AJPH 2011]. Census Bureau reports show that in 1960, 10.3 percent of people walked to work, compared to 2.8 percent in 2013. People also are less likely today than in the 1960s to use public transit, which generally involves walking to and from a bus stop or transit station.

The NHTS found that people averaged 1 hour a day in their vehicles as a passenger or a driver in 2009. This was less time than in 2001 but more time than in 1990 [USDOT FHWA 2011]. The amount of time spent in a vehicle varied by age group, from somewhat more than 40 minutes a day for children under the age of 18 (those less than 5 were not tallied) to over 70 minutes per day for those between 35 and 54 years of age. The 2009 NHTS survey found that walking accounted for 10 percent of daily trips—an increase from 8.6 percent in 2001.

The complex interactions between transportation and public health are increasingly recognized as an aspect of transportation planning. Several states and communities are explicitly addressing these connections in their statewide transportation plans. At the federal level, several USDOT agencies participate in a health in transportation working group. The working group also participates with other groups, such as the U.S. Department of Health and Human Services' Centers for Disease Control and the Transportation Research Board in sponsoring workshops and other activities designed to bring health issues to the fore in transportation planning.

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CHAPTER 3

Moving Goods

Highlights

- The U.S. freight transportation system moved 55.0 million tons of goods valued at more than $49.3 billion each day in 2013—about 63.4 tons of freight per capita per year. This was an increase of 2.0 percent from 2012.

- In 2013 freight tonnage and value rose by 6.3 and 8.0 percent, respectively, over 2007 levels, fully rebounding from declines during the 2008–2009 recession.

- This trend continued with trucks carrying the largest shares by value, tons, and ton-miles for shipments moved 750 or fewer miles. Rail is the dominant mode by tons and ton-miles of shipments ranging from 750 to 2,000 miles, while air, multiple, and other/unknown modes accounted for a majority of the value of shipments moved more than 2,000 miles, according to the latest available FAF data.

- The value of U.S.-international trade increased from $2.6 trillion in 2000 to nearly $4.0 trillion in 2014 (adjusted for inflation using the Consumer Price Index), a 44.5 percent increase. Trade with Canada and Mexico increased by 32.8 percent over the same period. Trade growth 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 2013, but the top 25 gateways handled nearly $2,406 billion (62.3 percent) of total U.S.-international trade.

- Shifts in oil production have affected transportation patterns of energy commodity movements in recent years. Class I railroads carried almost 500 thousand carloads of crude oil in 2014, a 50-fold increase from 9,500 carloads in 2008.

The U.S. freight transportation system moved nearly 20.1 billion tons of goods valued at $18.0 trillion in 2013, according to estimates derived from the Freight Analysis Framework (FAF) (table 3-1). This total means the freight transportation system carried, on average, about 55.0 million tons of goods worth more than $49.3 billion each day, or about 63 tons of freight per capita per year in the United States in 2013, an 11 percent increase from 57 tons in 2011. See box 3-A for information about the FAF and the Commodity Flow Survey (CFS).

In 2013 freight tonnage rose to 6.3 percent over 2007 levels, fully rebounding from declines during the recession of 2008 and 2009. FAF paints a similar picture for the value of freight shipments. Table 3-1 shows that the total weight and value of freight in 2013 surpassed prerecession levels in all categories (except import tonnage). FAF forecasts over the long term that freight weight will grow 1.3 percent annually between 2013 and 2040. The value of goods moved, in real dollars, is expected to increase faster than tonnage

TABLE 3-1 Weight and Value of Shipments by Transportation Mode: 2007, 2013, and 2040

Weight

	2007				2013				2040			
Millions of tons	**Total**	**Domestic**	**Exports[2]**	**Imports[2]**	**Total**	**Domestic**	**Exports[2]**	**Imports[2]**	**Total**	**Domestic**	**Exports[2]**	**Imports[2]**
Truck	12,778	12,587	95	97	13,955	13,732	120	103	18,786	18,083	368	335
Rail	1,900	1,745	61	93	1,858	1,681	82	94	2,770	2,182	388	201
Water	950	504	65	381	808	410	89	309	1,070	559	164	347
Air, air & truck	13	3	4	6	15	3	5	7	53	6	20	27
Multiple modes & mail[1]	1,429	433	389	606	1,554	459	559	536	3,575	645	1,546	1,383
Pipeline[1]	1,493	1,314	4	175	1,539	1,391	11	137	1,740	1,257	17	467
Other & unknown	316	266	36	14	333	274	47	13	526	362	130	34
Total	**18,879**	**16,851**	**655**	**1,372**	**20,063**	**17,950**	**914**	**1,199**	**28,520**	**23,095**	**2,632**	**2,794**

Value

	2007				2013				2040			
Billions of 2007 dollars	**Total**	**Domestic**	**Exports[2]**	**Imports[2]**	**Total**	**Domestic**	**Exports[2]**	**Imports[2]**	**Total**	**Domestic**	**Exports[2]**	**Imports[2]**
Truck	10,780	10,225	267	287	11,444	10,841	312	291	21,465	19,315	985	1,166
Rail	512	374	45	93	577	424	54	99	898	555	148	195
Water	340	158	15	167	284	131	20	133	337	138	46	153
Air, air & truck	1,077	151	422	505	1,167	134	425	609	5,043	834	1,997	2,212
Multiple modes & mail[1]	2,884	1,646	394	844	3,065	1,695	500	870	9,925	5,203	1,911	2,811
Pipeline[1]	716	651	4	61	1,083	1,003	15	65	776	605	17	154
Other & unknown	341	252	48	41	363	270	53	40	821	482	199	139
Total	**16,651**	**13,457**	**1,196**	**1,997**	**17,983**	**14,496**	**1,380**	**2,107**	**39,265**	**27,131**	**5,303**	**6,831**

[1] 2007 total and domestic numbers for multiple modes and mail and the pipline categories were revised as a result of Freight Analysis Framework database improvements.

[2] 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 2013 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. As a consequence, rail and water 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, Office of Freight Management and Operations, Freight Analysis Framework, version 3.5, 2015.

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

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

The FAF supplements CFS results with data from a variety of other sources to include imports and shipments from domestic establishments not in scope of the CFS. FAF provides tonnage and value information 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 30 year forecast to provide a picture of current and projected freight truck volumes.

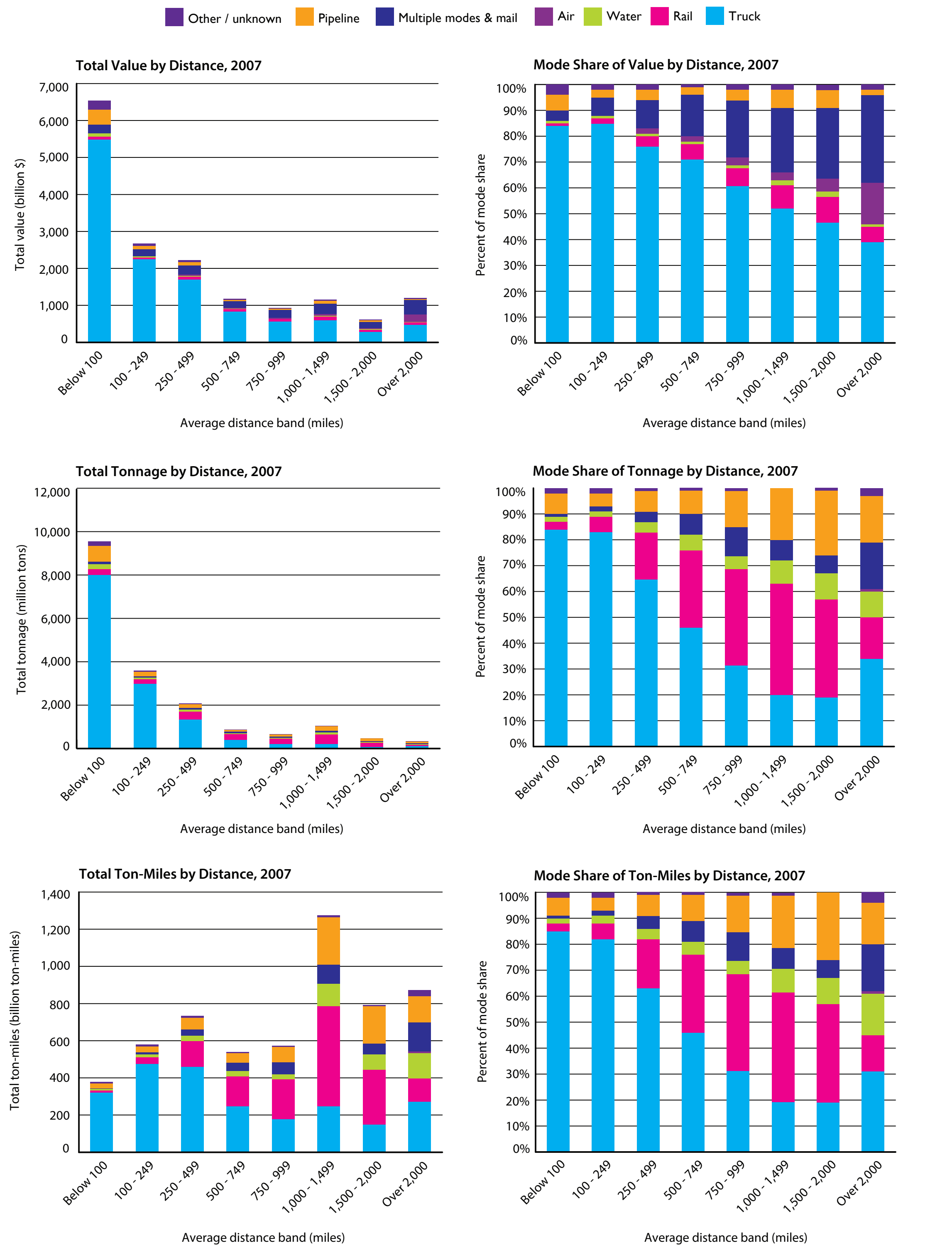
While the FAF is more complete, the CFS provides greater commodity detail and additional shipment characteristics, such as hazardous materials class. BTS released final 2012 CFS estimates in December 2014, which are available at https://www.census.gov/econ/cfs/.

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.

and nearly double during this time span as higher value goods are moved [USDOT BTS and FHWA 2015]. U.S. exports and imports accounted for 4.5 and 6.0 percent of the weight and 7.6 and 11.8 percent of the value of freight transported in 2013, respectively. FAF forecasts that U.S. exports and imports will account for an even greater share of freight movements in 2040, reaching 19.0 percent of the weight and 30.9 percent of the value of goods shipped throughout the country [USDOT BTS and FHWA 2015].

Population growth and economic activity are 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 2009 and 2014, the U.S. population increased by 3.9 percent [USDOC CENSUS], and U.S. gross domestic product grew by 20.8 percent in terms of current dollars over the depressed post-recession level [USDOC BEA 2015]. In addition, changes in the composition of goods demanded and shifts of economic centers of gravity 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

FIGURE 3-1 Value, Tons, and Ton-Miles of Freight by Distance: 2007



SOURCES: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics, and USDOT, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 3.5, 2015.

the past recession. According to the Bureau of Transportation Statistics' (BTS's) freight Transportation Services Index, the level of freight shipments in April 2015 was 27.2 percent above the April 2009 low recorded during the most recent recession [USDOT BTS 2015c].

How Domestic Freight Moves

The freight transportation industry moved 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 (see figure 3-1).

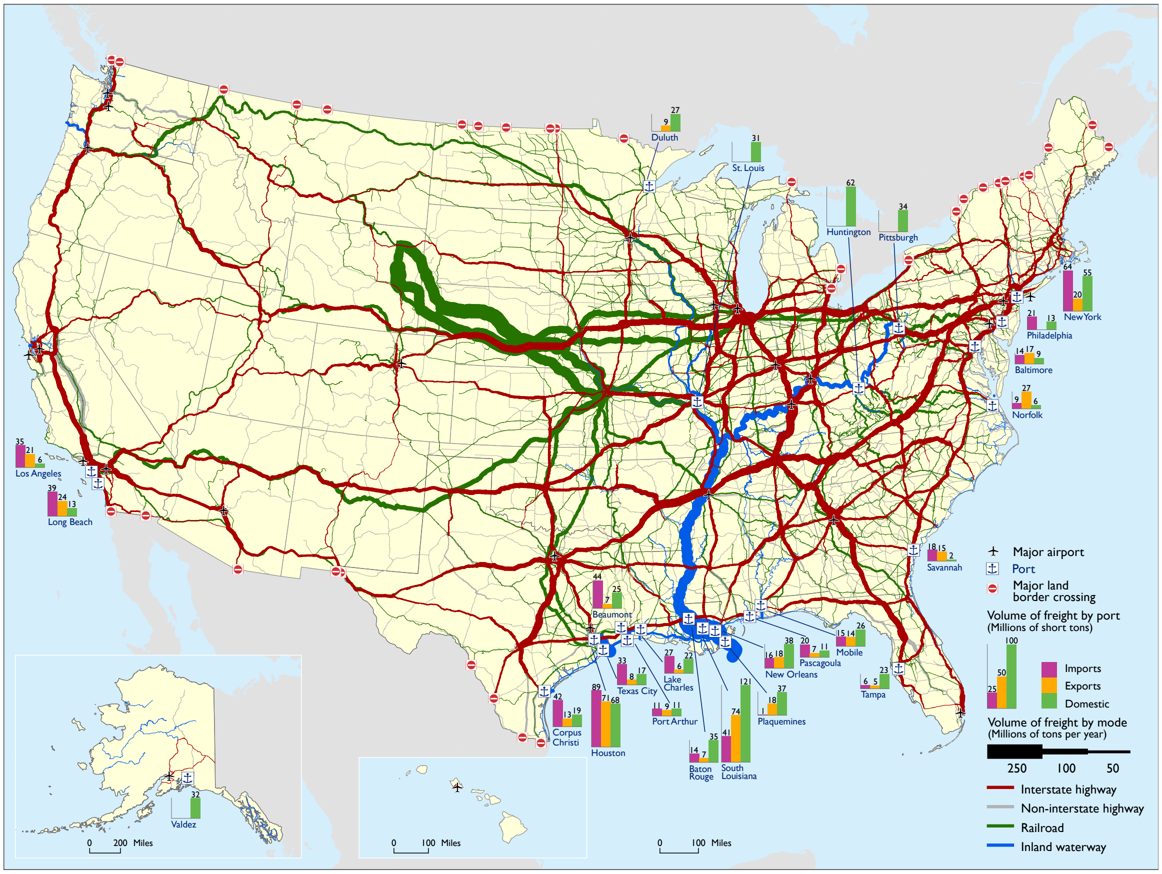
Most goods are moved short distances (less than 250 miles), and accounted for 55.7 percent of the value, 70.7 percent of the weight, and 16.7 percent of the ton-miles for all shipments within the United States in 2007. Although accounting for less than 30 percent of the total weight of all shipments in 2007, shipments of more than 250 miles constituted the bulk of ton-miles logged—83.3 percent. Modal shares of freight vary considerably by distance. While trucks carry the largest shares by value, tons, and ton-miles for shipments moving 750 miles or less; rail is the dominant mode by tons and ton-miles of shipments ranging from 750 to 2,000 miles; and air, multiple, and other/unknown modes account for 51.8 percent of the value of shipments moving more than 2,000 miles [USDOT BTS and FHWA 2015].

Overall, trucks carry the highest percentage of the weight and value of goods in the United States. However, figure 3-2 shows that railroads and inland waterways carry large volumes and tonnages of commodities, like coal and petroleum products, over long distances. Rail and water combined accounted for 13.2 percent of the total tonnage and 4.8 percent of the total value of freight moved in the United States in 2013. 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 $77,800 per ton. In comparison, the overall value-to-weight ratio of cargo carried by all modes combined is less than $900 per ton. In 2013 pipelines moved 1.5 billion tons of goods valued at nearly $1.1 trillion ($577 per ton), while rail moved more tonnage of lesser value—1.9 billion tons valued at $551 billion ($275 per ton). Rail represented 9.3 percent of the total tonnage and 3.2 percent of the total value of shipments in 2013. Rail shipments by tonnage are projected to increase by 49.1 percent between 2013 and 2040 [USDOT BTS and FHWA 2015].

The water mode typically carries low-value, bulk products similar to rail.[1] In 2013 the water transportation industry moved 808 million tons worth $284 billion ($285 per ton), representing 4.0 percent of the tonnage and 1.6 percent of the value of all freight shipments [USDOT BTS and FHWA 2015]. In 2013 approximately 566.7 million short tons of cargo were moved by vessel along the inland waterways,

[1] Many shipments arriving in the United States by rail and 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 than those in other published sources.

FIGURE 3-2 Freight Flows by Highway, Railroad, and Waterway: 2011



SOURCES: *Highways*: U.S. Department of Transportation, Federal Highway Administration, Freight Analysis Framework, Version 3.5, 2015; *Rail*: Based on Surface Transportation Board, Annual Carload Waybill Sample and rail freight flow assignments done by Oak Ridge National Laboratory; *Inland Waterways*: U.S. Army Corps of Engineers, Institute or Water Resources, Annual Vessel Operating Activity and Lock Performance Monitoring System data, September 2015.

including the Mississippi River—the Nation's busiest waterway [USACE NDC 2013].

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 2013 to 2040, growing by 332.1 percent [USDOT BTS and FHWA 2015]. In 2013 U.S. airlines[2] carried a total of 34,804 million international and domestic revenue freight and mail cargo revenue ton-miles, of which 12,428 million were domestic [USDOT BTS 2015b].

Over the last 20 years, the U.S. transportation system has become increasingly interconnected. Although multimodal services accounted for a relatively small share (7.7

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

percent) of freight tonnage, they moved 17.0 percent of the value of the goods in 2013. FAF forecasts the value of multimodal shipments will increase significantly between 2013 and 2040 [USDOT BTS and FHWA 2015].[3]

The growth in intermodal freight movement is driven, in part, by global supply chain requirements. Between 1990 and 2013, the railroad industry reported a 106.7 percent increase in trailer and container traffic [AAR 2014a]. The Association of American Railroads reports that rail intermodal traffic accounted for 12.9 percent of U.S. Class I railroad revenue in 2012. Only coal along with chemicals and allied products accounted for a larger share of revenue [AAR 2013]. With the growth in container trade and improvements in information and logistics technologies, the stage is set for increased reliance on intermodal transportation to move goods from manufacturers to consumers.

[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.

Commodities Moved Domestically

Table 3-2 shows that heavy, low-value bulk products, such as gravel, cereal grains; coal, non-metallic mineral products; waste/scrap; and natural gas, coke, and asphalt comprised a large share of the tonnage moved in 2013, but accounted for a small share of the Nation's freight value. In fact, in 2013 the top 10 commodities by weight accounted for 64.6 percent of total tonnage but only 16 percent of the value of goods. Rounding out the top 10 by weight were coal, gasoline, crude petroleum, fuel oils, and natural sands [USDOT BTS and FHWA 2015].

The picture changes considerably when looking at the value of goods shipped. The highest value goods were those that are time-sensitive, including machinery, electronics, motorized vehicles, mixed freight, and pharmaceuticals. Other top commodities by value are gasoline; miscellaneous manufactured products; textiles/leather; natural gas, coke, asphalt; and plastics/rubber. In 2013 the top 10 commodities by value accounted

TABLE 3-2 Top Commodities by Weight and Value: 2013

Weight	Millions of tons	Value	Billions of 2007 dollars
Gravel	2,427	Machinery	$1,877
Cereal grains	1,665	Electronics	$1,485
Non-metallic mineral products	1,514	Motorized vehicles	$1,484
Waste/scrap	1,441	Mixed freight	$1,110
Natural gas, coke, asphalt[1]	1,403	Pharmaceuticals	$914
Coal	1,263	Gasoline	$796
Gasoline	1,029	Miscellaneous manufactured products	$740
Crude petroleum	839	Textiles/leather	$736
Fuel oils	757	Natural gas, coke, asphalt1	$650
Natural sands	620	Plastics/rubber	$618
Total, all commodities	**20,063**	**Total, all commodities**	**$17,983**

[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, Office of Freight Management and Operations, Freight Analysis Framework, version 3.5, 2015.

for 58.0 percent of total value but only 18.8 percent of total tonnage [USDOT and FHWA 2015].

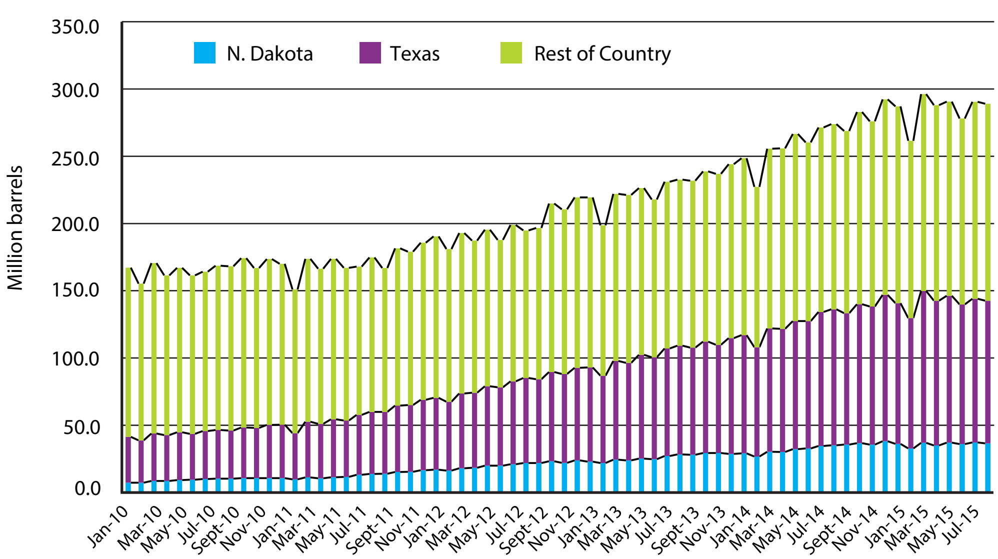
Energy Commodities Transportation

The transportation of four major energy commodities/resources is discussed here: crude oil and refined petroleum products, natural gas, coal, and ethanol. The delivery of these energy commodities involve various modes, depending on the characteristics of the commodity, the distance 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.

Crude Oil and Petroleum Refined Products

Pipelines are the predominant mode for transporting crude oil and petroleum products in the United States. Historically, pipelines delivered crude oil from the Gulf of Mexico to refineries located near U.S. coastlines. However, 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, barge, and truck to move oil from the wellhead to refineries. Moreover, pipelines that previously delivered crude oil from the Gulf of Mexico to refineries now also deliver domestic and Canadian oil to the Gulf of Mexico to be refined and/or exported [USDOE 2015]. U.S. crude oil production increased by 72.9 percent from 167 billion barrels in January 2010 to 289 billion barrels in August 2015 (figure 3-3). Texas and North Dakota accounted for about half of U.S. crude oil production in August 2015.

FIGURE 3-3 Field Production of Crude Oil (thousand barrels): January 2010–July 2015



SOURCES: U.S. Department of Energy, Energy Information Administration, *Field Production of Crude Oil*. Available at http://www.eia.gov as of November 2015.

The recent growth in oil shipments by rail is demonstrated by the increase in the number of railcars carrying crude oil. According to the American Association of Railroads (AAR), U.S. Class I railroads (including U.S. Class I subsidiaries of Canadian railroads) carried 493,146 carloads of crude oil in 2014, a 50-fold increase from 9,500 carloads in 2008 [AAR 2015]. The U.S. Department of Energy, Energy Information Administration estimates that rail moved more than 1 million barrels of crude oil per day in 2014 [USDOE EIA 2015c]. The Bakken region has accounted for the majority of new rail shipments. The North Dakota Pipeline Authority estimates that about 700,000 barrels of crude oil per day were moving out of the state by rail as of early 2015, which is equivalent to roughly 60 percent of the State's total crude oil production [NDPA 2015]. Railroads own less than one percent of the tank cars that transport crude oil. Nearly all of them are owned by companies served by the railroads and by leasing companies [AAR 2015a].

Shifts in oil production also have spurred growth in the waterborne transport of oil. According to the U.S. Army Corps of Engineers, U.S. ports and inland waterways handled nearly 7 billion barrels of crude and petroleum products in 2013, the latest year for which data are available [USACE NDC 2015]. This is about half of the total volume of oil transported by transmission pipelines in 2013 [AOP]. Of the total moved by the water mode, 2.5 billion barrels were transported by barges on U.S. inland waterways from port to port along the coast or on the Great Lakes [USDOE 2015]. The use of barges for oil transport has risen in recent years, as shown by the increase in refinery receipts by barge from 61.6 million barrels of domestic crude in 2009 to nearly 244.3 million barrels in 2014. Over the same period, barge deliveries of foreign crude have risen by little more than 2.2 percent, due in part to a decrease in oil imports [USDOE EIA 2014c]. Presently, all oil transport is intermodal, where oil may be transported by pipeline or rail to a terminal and then be 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 outstripped the construction of pipeline gathering systems in the Bakken area, trucks deliver about 40 percent of Bakken oil to pipeline and rail terminals. Trucks also are used to move crude oil over short distances to refineries. The demand for truck transport is illustrated by the doubling of refinery receipts of crude oil by truck, from 67.8 million barrels in 2009 to 152.5 million barrels in 2013 [USDOE EIA 2014c].

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.

Natural Gas

A complex network of pipelines transports natural gas from the wellhead to the final customer. Pipeline gathering systems, which consist of low-pressure, small-diameter pipelines, move raw natural gas from the wellhead to the processing plant where impurities and other hydrocarbons are removed. Gathering pipelines also may transport the gas directly to the mainline transmission grid, depending on the quality of the wellhead gas. After processing, the gas is then transported by interstate and intrastate pipeline to consumers or is put into underground storage for future use to meet customer requirements during peak-usage periods. In 2014 U.S. natural gas production reached 27.3 trillion cubic feet (tcf) [USDOE EIA 2015b]. Pipelines deliver about one-third of natural gas production to power plants to produce electricity, and about one-fifth is delivered to homes for heating [USDOE EIA 2014a].

Coal

The way in which coal is transported to where it will be used depends on the distance that needs to be covered. Trucks are used for short distances, and trains and barges are used for longer distances. Alternatively, coal can be crushed and mixed with water to form a slurry and transported through a pipeline.

According to FAF, rail moved the greatest share of domestic coal shipments in 2012, accounting for 69.0 percent (619 million short tons) of the total 1.3 billion short tons. Trucks are the second largest mover of domestic coal shipments, hauling 16.9 percent (nearly 224 million tons) (figures 3-4 and 3-5). The Association of American Railroads reports that coal represents 39.5 percent of total tonnage moved by rail and 19.9 percent of total industry revenues and is viewed by many in the industry as its most important single commodity [AAR 2014b].

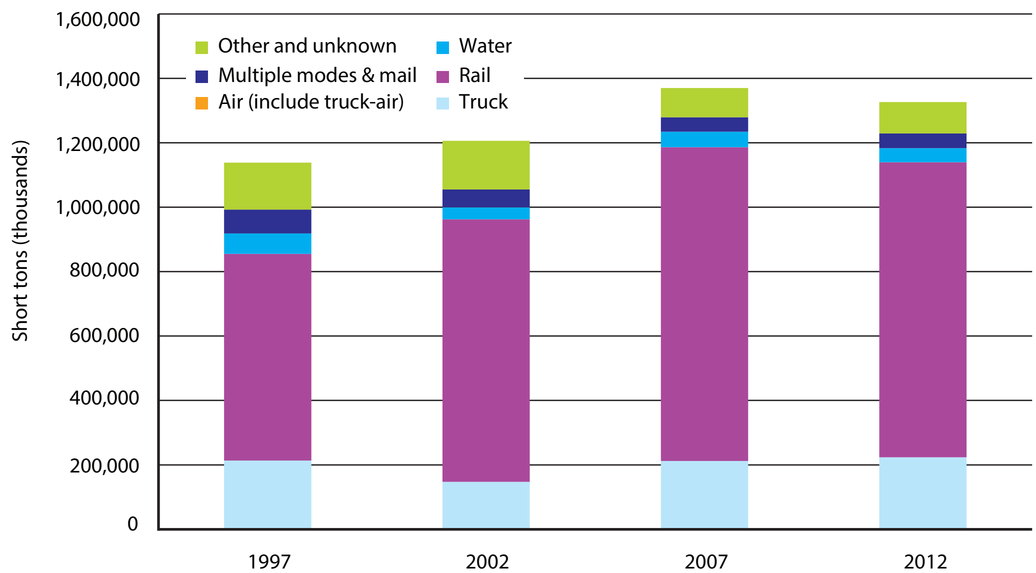
More than two-thirds of coal used to generate electricity is delivered to power plants by rail. Approximately, two-fifths of all U.S. coal is produced in Wyoming's Powder River Basin. The vast majority of Wyoming's coal is sent to power plants in 34 states, almost all of which is moved by rail [USDOE EIA 2014b].

Inland waterways are an important transportation option for coal shipments. 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. Coal used at an electric power plant that is located near a mine can be moved by trucks. Slurry pipelines also are used to deliver coal to power plants.

Ethanol

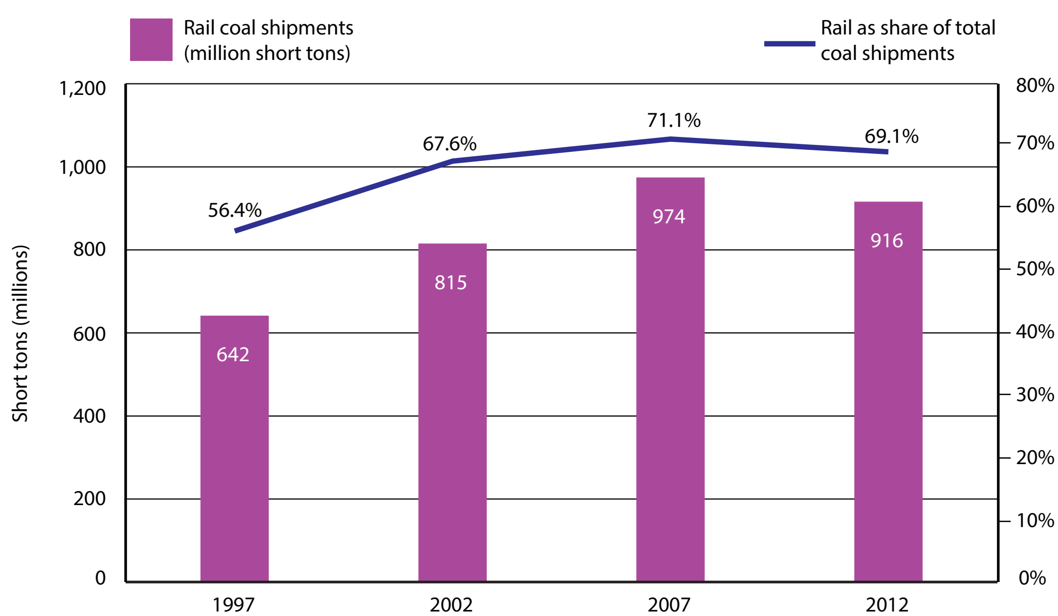
U.S. ethanol production has grown steadily from 17.8 million barrels in 1990 to 341.4 million barrels in 2014 [USDOE EIA 2015b]. Ethanol now displaces approximately 10 percent of U.S. gasoline demand by volume. Ethanol production is primarily located in the Midwest where most of the corn feedstocks are grown, while the blending of ethanol with gasoline takes place at petroleum product distribution terminals across the country. Typically, rail moves ethanol from production plants to distribution terminals, which accounts for around 70 percent of ethanol shipments. More than 306,000 carloads of ethanol were transported by railroads in 2012 (latest year for which data are available). Most ethanol carried by railroads moves in 30,000-gallon tank cars.

FIGURE 3-4 Domestic Coal Shipments by Mode: 1997, 2002, 2007, 2012



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight Analysis Framework, Version 3.4, November 2015.

FIGURE 3-5 Rail Coal Shipments: 1997, 2002, 2007, 2012



SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight Analysis Framework, Version 3.4, November 2015.

Almost all of these cars are owned by shippers or leasing companies, not by railroads [AAR 2014c]. The final product is delivered by truck to retail outlets.

Hazardous Materials

According to the CFS, more than 22.6 billion tons of hazardous materials were moved in 2012, an increase of 15.6 percent over 2007 tonnage. The value of hazardous materials rose by 61.2 percent between 2007 and 2012, fueled by increases in the price of refined petroleum products [USDOT BTS and USDOC Census 2015]. Flammable liquids accounted for the largest share of hazardous materials shipped by value (80.8 percent) and by tons (78.6 percent), followed by gases, a distant second (table 3-3).

Trucks moved more than half of all hazardous materials shipments, calculated both by weight and value. Pipelines handled about 24.3 percent of the tonnage, followed by waterways (6.7 percent) and rail (5.6 percent). Trucks accounted for approximately 31.4 percent of all hazardous materials ton-miles because of the relatively short distances these products are transported. Rail accounted for 27.6 percent of the hazardous materials ton-miles (table 3-4). The average distance of hazardous material shipments is 114 miles across all modes [USDOT BTS and USDOC Census 2015].

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

	Value		Tons		Ton-miles[1]		Miles
Transportation mode	**$ Billions**	**Percent**	**Millions**	**Percent**	**Billions**	**Percent**	**Average distance per shipment**
All modes, total	**2,334.4**	**100.0**	**2,580.2**	**100.0**	**307.5**	**100.0**	**114**
Single modes, total	**2,304.7**	**98.7**	**2,552.9**	**98.9**	**275.6**	**89.6**	**68**
Truck[2]	1466.0	62.8	1,531.4	59.4	96.6	31.4	56
For-hire	870.9	37.3	882.3	34.2	62.0	20.2	150
Private	595.1	25.5	649.1	25.2	34.5	11.2	33
Rail	79.2	3.4	111.0	4.3	844.9	27.6	808
Water	217.8	9.3	283.6	11.0	54.9	17.9	212
Air	4.4	0.2	0.3	Z	0.3	0.1	1,120
Pipeline[3]	537.3	23.0	626.7	24.3	S	S	S
Multiple modes, total	**29.7**	**1.3**	**27.3**	**1.1**	**31.9**	**10.4**	**654**
Truck and rail	13.3	0.6	17.0	0.7	16.6	5.4	954
Truck and water	S	S	S	S	S	S	1,181
Rail and water	2.5	0.1	4.6	0.2	1.4	0.4	S
Parcel, U.S. Postal Service, or Courier	10.3	0.4	0.3	Z	0.2	0.1	650
Other multiple modes	0.0	0.0	0.0	0.0	0.0	0.0	0
Other modes	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**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 1a. Available at www.census.gov/econ/cfs/2012/ec12tcf-us-hm.pdf as of June 2015.

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

		Value		Tons		Ton-miles[1]		Miles
Hazard class	Description	$ Billions	Percent	Millions	Percent	Billions	Percent	Average distance per shipment
Class 1	Explosives	18.4	0.8	4.0	0.2	1.0	0.3	840
Class 2	Gases	125.1	5.4	164.8	6.4	33.2	10.8	57
Class 3	Flammable liquids	2,016.7	86.4	2,203.5	85.4	204.6	66.5	93
Class 4	Flammable solids	5.4	0.2	11.3	0.4	5.8	1.9	565
Class 5	Oxidizers and organic peroxides	7.6	0.3	12.0	0.5	5.5	1.8	437
Class 6	Toxic (poison)	15.2	0.7	7.6	0.3	3.6	1.2	513
Class 7	Radioactive materials	12.3	0.5	S	S	0.4	Z	34
Class 8	Corrosive materials	75.9	3.2	125.3	4.9	37.8	12.3	264
Class 9	Miscellaneous dangerous goods	58.0	2.5	51.0	2.0	16.1	5.2	530
Total		**2,334.4**	**100.0**	**2,580.2**	**100.0**	**307.5**	**100.0**	**114**

[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 2a. Available at www.census.gov/econ/cfs/2012/ec12tcf-us-hm.pdf as of June 2015.

Safety and environmental issues associated with the transportation of hazardous materials are discussed in chapters 6 and 7, respectively.

International Trade

The value of total U.S.-international merchandise trade increased from $2.6 trillion in 2000 to nearly $4.0 trillion in 2014—a 44.5 percent inflation-adjusted increase[4] [USITC]. Six of the top 15 U.S. trading partners were Asian countries in 2014. Trade with China grew the fastest, from 5.8 percent of the total value of U.S. merchandise trade in 2000 to 14.9 percent in 2014. In 2000 China ranked 10th among U.S. trading partners. Today it is second only to Canada, while Mexico, Japan, and Germany, respectively, round out the top five [USDOC ITA 2015].

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 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.

Freight with Canada and Mexico

The U.S. North American Free Trade Agreement partners—Canada and Mexico—accounted for 30.1 percent ($1.19 trillion) of the value of U.S. merchandise trade in 2014.

[4] The 2000 U.S. International Trade Commission trade data was adjusted to current dollars using the Bureau of Labor Statistics' Consumer Price Index (CPI) Inflation Calculator.

[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.

Over the 2000 to 2014 period, combined trade adjusted for inflation with Canada and Mexico increased 32.8 percent[6] [USITC].

Trucks carried 26.8 percent of the tonnage and 59.9 percent of the value of U.S. merchandise trade with Canada and Mexico, while rail carried 19.5 percent of the tonnage and 14.9 percent of the value in 2014 (table 3-5). U.S. freight with Canada and Mexico reached nearly $1.2 trillion in 2014, an increase of 4.5 percent from 2013 and 67.6 percent since 2004. Mineral fuels and oils transported by the pipeline and water modes accounted for 25.8 percent of the increase in freight value between 2004 and 2014. In 2014 U.S. imports from Canada and Mexico exceeded exports in terms of total merchandise trade value. In 2014 mineral fuels and oil were the top commodity category transported between the United States and Canada. Vehicle and vehicle parts (other than railway vehicles and parts) was the next highest commodity category transported by the truck and rail modes [USDOT BTS 2015d].

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

A sharp drop in oil prices that began in 2014 has contributed to a decrease in the value of freight moved between the United States and Canada in 2015. The value of trade totaled $48.0 billion in August 2015, down 13.6 percent from August 2014. Mineral fuels transported by pipeline and vessel declined 35.1 and 40.2 percent, respectively, in August 2015 from the previous year [USDOT BTS 2015e]. The Canadian economy was officially declared to be in a recession, after contracting 0.8 percent in first quarter and 0.5 percent in the second quarter 2015, which has been widely attributed to the drop in oil price [COMTE 2015].

TABLE 3-5 Value and Tonnage of U.S. Merchandise Trade with Canada and Mexico: 2000, 2010, 2013, and 2014

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

	2000		2010		2013		2014	
Mode	**Value**	**Weight**	**Value**	**Weight**	**Value**	**Weight**	**Value**	**Weight**
Truck[1]	429	NA	560	176	684	196	715	206
Rail[1]	94	NA	131	114	175	143	178	150
Air	45	<1	45	<1	43	<1	44	<1
Water	33	194	81	210	103	198	104	212
Pipeline[1]	24	NA	65	107	84	140	94	160
Other[1]	29	NA	37	8	51	33	58	40
Total[1]	**653**	**NA**	**920**	**614**	**1,140**	**709**	**1,193**	**767**

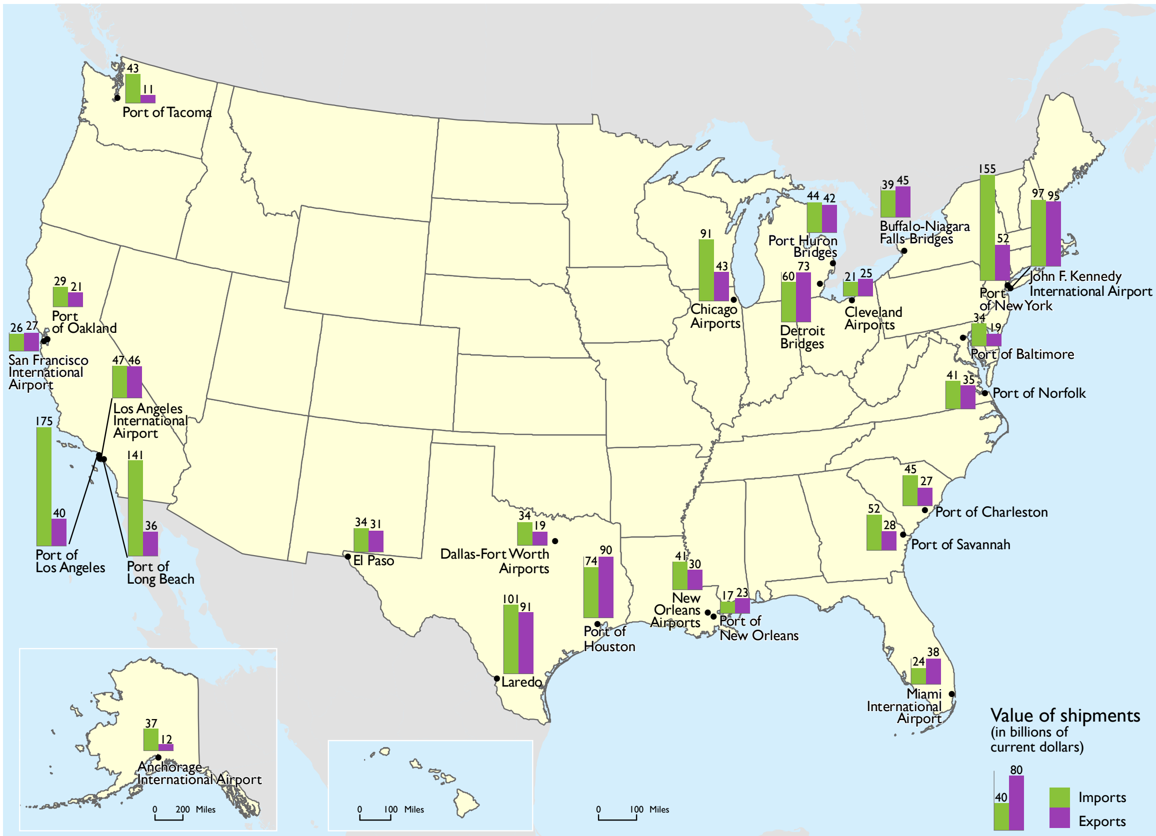
KEY: NA = not available.

[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: 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. Numbers may not add to totals due to rounding. 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 June 2015; **Air and Water**: U.S. Department of Commerce, Census Bureau, Foreign Trade Division, *FT920 - U.S. Merchandise Trade: Selected Highlights* (Washington, DC: annual issues).

FIGURE 3-6 Top 25 U.S. International Trade Freight Gateways by Value: 2014



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

Michigan, which accounts for 13.0 percent of the U.S.-Canada border mileage, was the leading state for trade with Canada. 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 2015d].

Electrical machinery was the top commodity transported between the United States and Mexico. 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 2015d]. In total, there are 87 ports-of-entry along the U.S.-Canada border and 25 on the U.S.-Mexico border.

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 3-6). More than 400 gateways, including airports, border crossings, and seaports handled international cargo in 2013 [USDHS CBP 2014], but the top 25 gateways in terms of value handled the greatest share of trade—$2,406 billion or 62.3 percent of the nearly $3,863 billion total U.S.-international trade in goods. Sixteen of the top 25 gateways handled more imports than exports.

In 2014 the Port of Los Angeles was the top 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, handling $206.5 billion. Laredo, the top land-border crossing, handled $192.1 billion in trade across the U.S.-Mexico border. John F. Kennedy International Airport was the leading air gateway, handling $191.8 billion in exports and imports.

Water is the leading transportation mode for U.S.-international trade both in terms of weight and value. Ships accounted for more than 71.6 percent of trade weight and 44.2 percent of trade value in 2014. Air handles less than 1 percent of trade weight but 24.8 percent of trade value, due to its focus on high-value, time-sensitive, and perishable commodities. In 2013 the top U.S.-international air gateways by value were John F. Kennedy International, NY; Chicago area airports; and Los Angeles International, CA [USDOT BTS 2015a]. Memphis International, TN; Ted Stevens Anchorage International, AK; and Louisville International, KY were the top U.S.-international air gateways by weight in 2013, the latest year for which data are available [USDOT FAA 2014]. Trucks, which haul a large share of imports and exports between U.S. international gateways and inland locations, carried 18.0 percent of the value of total U.S.-international trade (figure 3-7a) and 10.4 percent of the tonnage in 2014 (figure 3-7b).

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 2007 and 2012, vessel calls at U.S. seaports increased by 3.9 percent. The average displacement of container vessels increased 10.2 percent, from 47,732 deadweight tons (dwt) in 2007 to 52,589 dwt in 2012 [USDOT MARAD 2014]. In 2013 tankers accounted for 38.7 percent of the vessel calls, followed by containerships with 23.6 percent of the more than 74,000 vessel calls [USDOT MARAD 2015]. The new Post-Panamax containerships also increased in average capacity by 12.7 percent, as measured in twenty-foot equivalent units (TEU), from 2006 to 2012, the latest year for which data are available [USDOT MARAD 2014].

In 2014 U.S. seaports handled 31.7 million TEU of containerized cargo, which is 6 percent more than reported in 2007 and an increase of 23.9 percent from 25.6 million TEU in 2009, following the last recession. The ports of Los Angeles and Long Beach on the Pacific coast and the port of New York and New Jersey on

FIGURE 3-7a U.S. International Merchandise Trade by Value: 2014

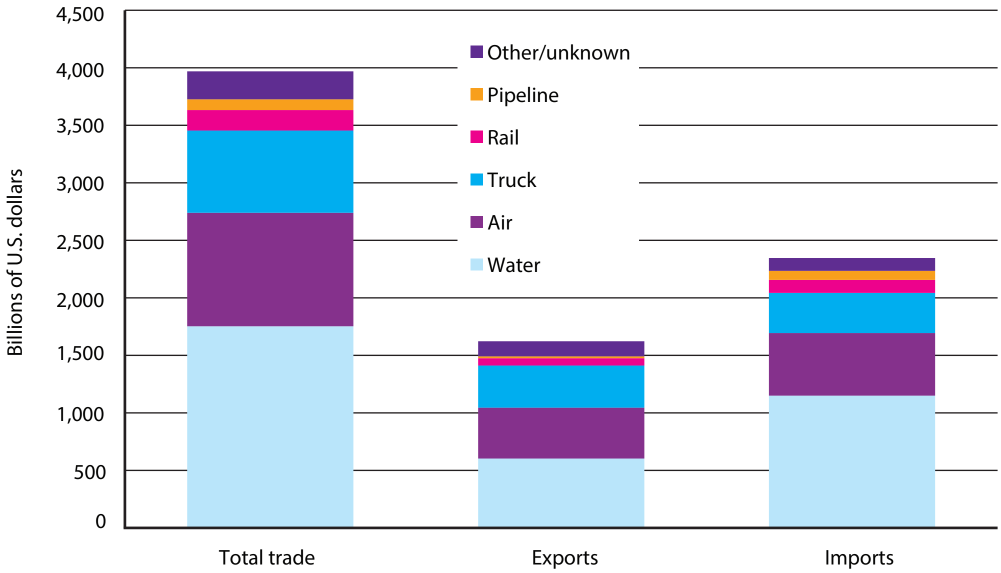
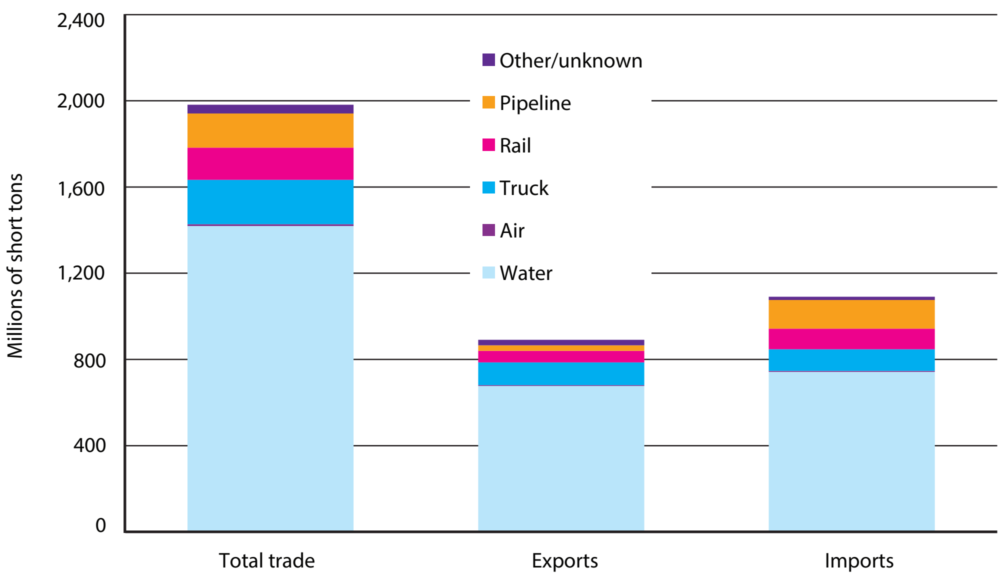


FIGURE 3-7b U.S. International Merchandise Trade by Weight: 2014



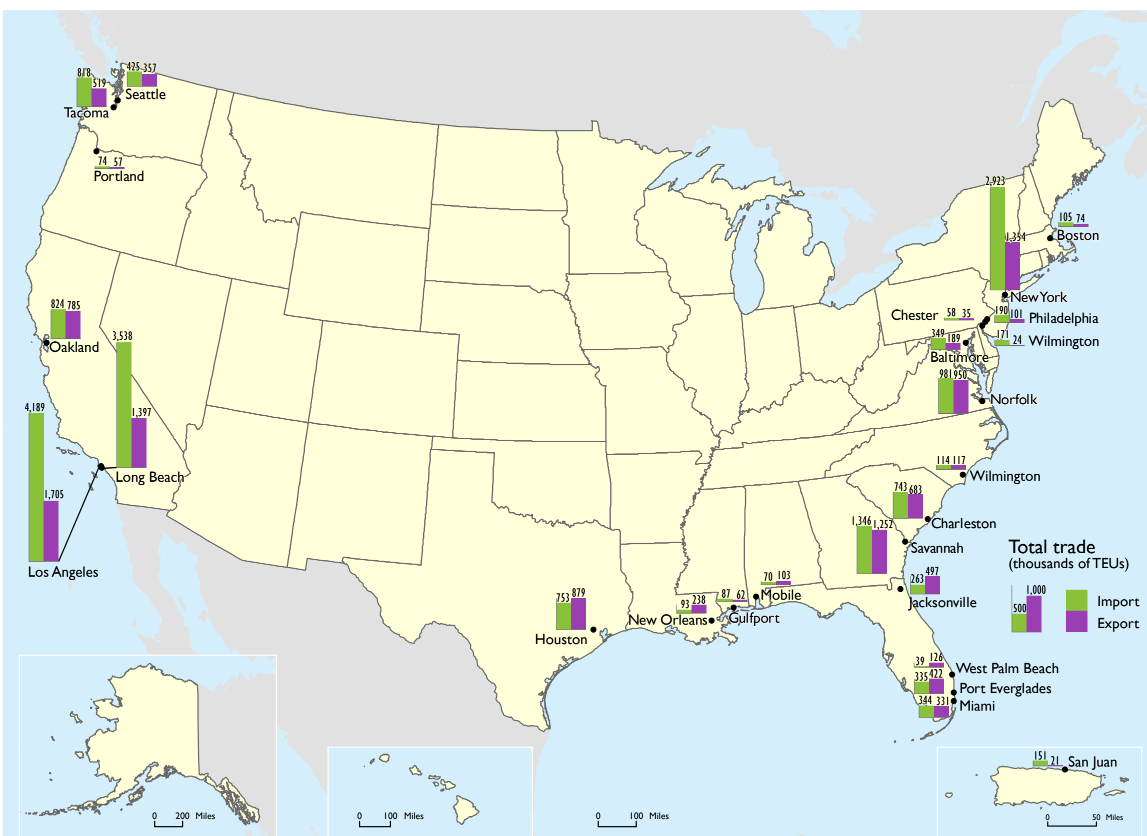
NOTES: 1 short ton = 2,000 pounds. The U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics estimated 2012 weight data for truck, rail, pipeline, and other and unknown modes using value-to-weight ratios derived from imported commodities. Totals for the most recent year differ slightly from the USDOT, Federal Highway Administration, Office of Freight Management and Operations, 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 2015). *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 June 2015.

the Atlantic coast are the leading container ports [USDOT MARAD 2015]. As shown in figure 3-8, 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 3-2). In 2012 the Atlantic coast, including Puerto Rico, accounted for 37.8 percent of all types of vessel calls, followed by the gulf coast with 37.5 percent, and then the Pacific coast with 24.8 percent [USDOT MARAD 2015].

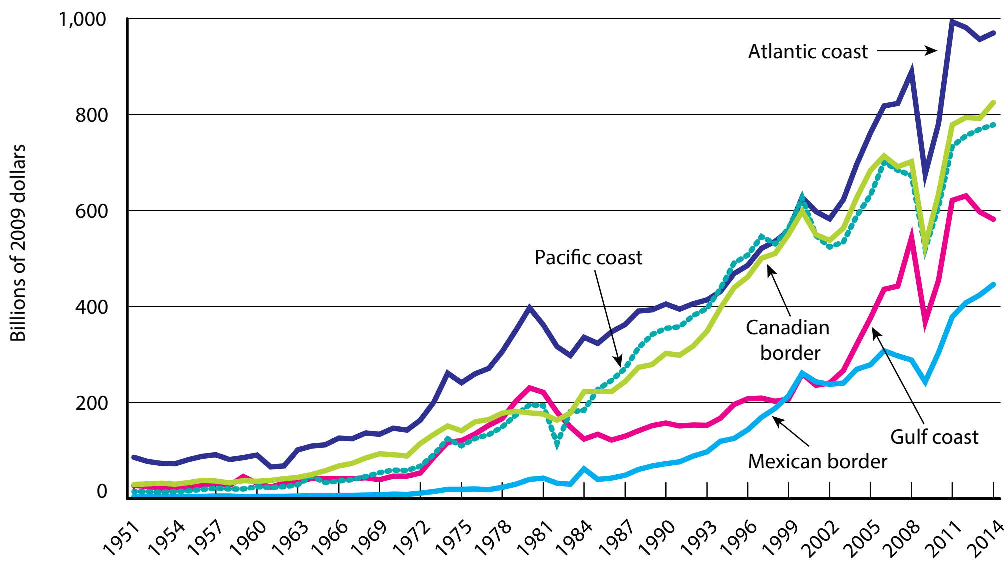
The major increase in trade with China has resulted in a large share of trade moving through Pacific coast ports (figure 3-9). The trend toward larger containerships has led to a concentration of liner service at ports with ample overhead clearance and water draft, intermodal connections such as double stack rail, and room to grow. This trend is expected to continue, especially when the expanded Panama Canal locks open. The Panama Canal's existing locks allow Panamax vessels, carrying up to 5,000 TEU, to transit

FIGURE 3-8 Top 25 Water Ports by Containerized Cargo: 2014



SOURCES: 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 June 2015.

FIGURE 3-9 Value of U.S. International Merchandise Trade by Coasts and Borders: 1951–2014



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 June 2015.

between the Atlantic and Pacific Oceans. A third set of locks is scheduled to open in 2016, which will handle Post-Panamax vessels up to 13,000 TEUs. The Panama Canal expansion will increase the potential for direct all-water access to South Atlantic and gulf coast ports, especially for U.S. imports from Asia [USDOT MARAD 2013].

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CHAPTER 4

Transportation System Performance

Highlights

- The average annual delay per commuter rose from 26 hours in 1990 to 42 hours in 2014—a 62 percent increase. The total number of hours of delay experienced by all commuters across the Nation reached 6.9 billion hours in 2014—more than twice the 1990 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, drivers had to allow 241 percent more travel time to arrive on time 95 percent of the time.
- Amtrak's on-time performance increased from 70 percent in 2005 to a record high 83 percent in 2012. On-time improvement was more prominent on long distance routes.
- Barge tows on the inland waterways experienced an average delay of 2 hours navigating a lock in 2014, the largest delay on record and nearly double the delay in 2000.
- At inland waterway locks in 2014, scheduled maintenance and unexpected stoppages due to weather and operational issues resulted in more than 135,000 hours of lock shutdowns to traffic, almost 80 percent higher than the level in 2000.
- Over 21 percent of domestic scheduled airline flights (or 1.2 million flights) arrived at the gate at least 15 minutes late in 2014. Almost 10 percent (or 576 thousand) arrived at the gate more than 2 hours late.

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.

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 and carriers to reach key destinations, such as hospitals, job sites, schools, factories, airports, ports, and community centers. The use of accessibility as a performance measure may need to be modified to take into account the impact of modern telecommunication systems. In today's world one can accomplish many objectives without ever traveling, such as electronic banking, shopping, and communications. This substitution effect for trip-making has in some cases reduced the number of trips made, but it might increase the number of trips in other categories, such as the number of truck deliveries resulting from internet shopping.

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 transportation system accessibility to jobs. 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.

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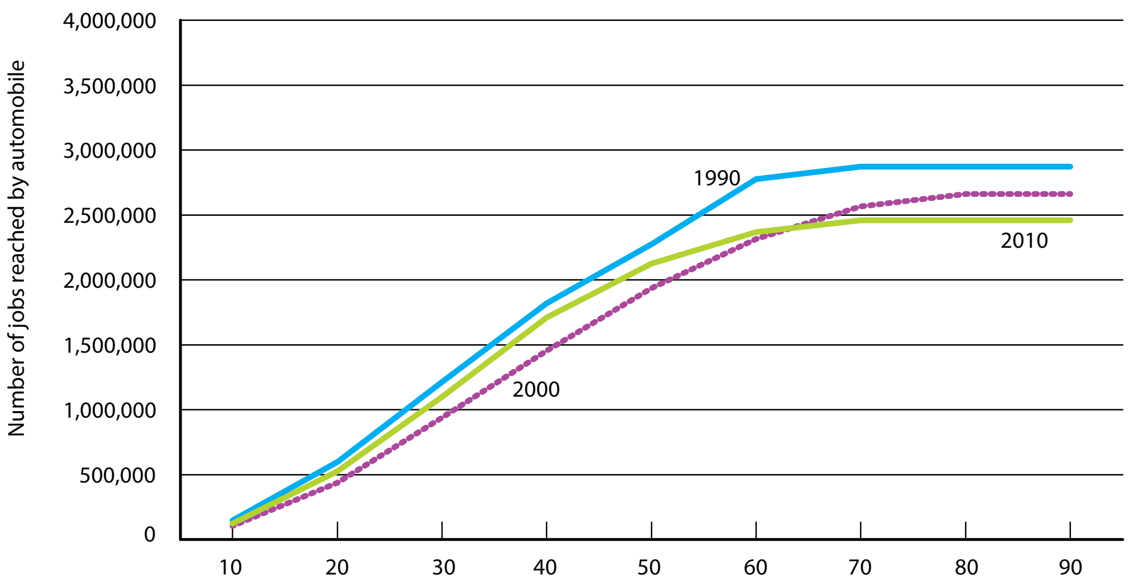
[1] The *Moving Ahead for Progress in the 21st Century Act* (MAP-21) requires the U.S. Department of Transportation to establish performance measures and standards for several program/policy areas. MAP-21 also requires statewide and metropolitan transportation planning agencies to establish and use performance-based approaches for transportation decision-making.

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



SOURCES: Levinson, D. 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.

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, 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 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, respectively, 20,000 and 176,000 jobs. 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. Box 4-A describes how system performance measures, such as travel time and congestion, are viewed from two different perspectives—the user's versus the operator's.

BOX 4-A System Performance User's v. Operator's Perspectives

From the user's standpoint, system performance is based on an individual trip. Travel time to work refers to the total number of minutes it normally takes a person to get from home to work each day, including time spent waiting for public transportation, picking up passengers in carpools, and on other activities related to getting to work [USDOC CENSUS 2015b]. In 2000 average travel time as measured by the decennial census was 25.5 minutes, which was an increase of 3.8 minutes (17.5 percent) from 21.7 minutes in 1980, and an increase of 3.1 minutes (13.8 percent) from 22.4 minutes in 1990 [USDOC CENSUS 2015b]. In 2014, based on the American Communities Survey, the average travel time stood at 26.0 minutes [USDOC CENSUS 2015a].

From the operator's perspective, congestion can also be measured by the yearly hours of delay. Table 4-1 shows that annual delay per commuter has increased by 16 hours (61.5 percent) from 26 hours in 1990 to 42 hours in 2014). This is extra time spent traveling at congested speeds rather than free-flow speeds by private vehicle drivers and passengers who typically travel in the peak periods [TAMU TTI 2015]. The Travel Time Index (TTI) is another important indicator for system operators and is discussed in detail in this chapter.

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 a biannual *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 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 21.0 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 1990. 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 $65 billion in 1990 (2014 dollars). The average yearly delay per commuter rose from 26 hours in 1990 to 42 hours in 2014, a 62 percent increase, and the total national hours of delay in 2014 reached 6.9 billion hours—more than twice the 1990 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;

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

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

TABLE 4-1 Annual Congestion Delay and Costs: 1990, 1995, 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)
1990	1.13	26	3.0	1.3	$65
1995	1.16	31	4.0	1.5	$87
2000	1.19	37	5.2	2.1	$114
2005	1.21	41	6.3	2.7	$143
2006	1.21	42	6.4	2.8	$149
2007	1.21	42	6.6	2.8	$154
2008	1.21	42	6.6	2.4	$152
2009	1.20	40	6.3	2.4	$147
2010	1.20	40	6.4	2.5	$149
2011	1.21	41	6.6	2.5	$152
2012	1.21	41	6.7	3.0	$154
2013	1.21	42	6.8	3.1	$156
2014	1.22	42	6.9	3.1	$160

NOTES: 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://tti.tamu.edu/ as of August 2015.

- 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 noncongested conditions to arrive at their destination ontime 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 (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 has continued to increase through 2014 [USDOT FHWA 2015]. The average duration of daily congestion[5] increased from 4 hours and 30 minutes in 2013 to 5 hours and 16 minutes in 2014, and the Travel Time Index (TTI) increased from 1.32 to 1.36.

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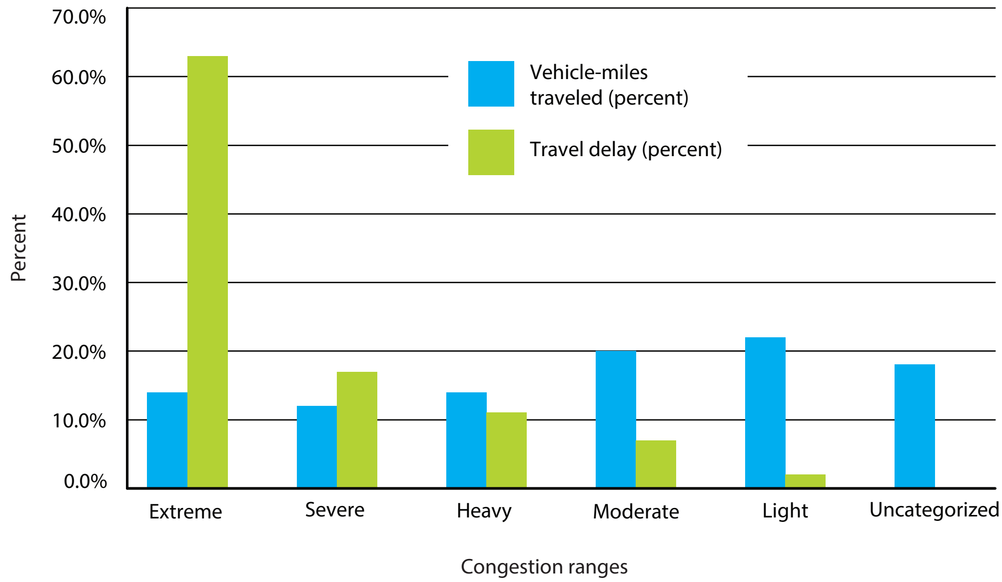
[4] Vehicle probe data are based on real-time vehicle positions, typically obtained from the vehicle's GPS receiver or the operator's mobile phone.

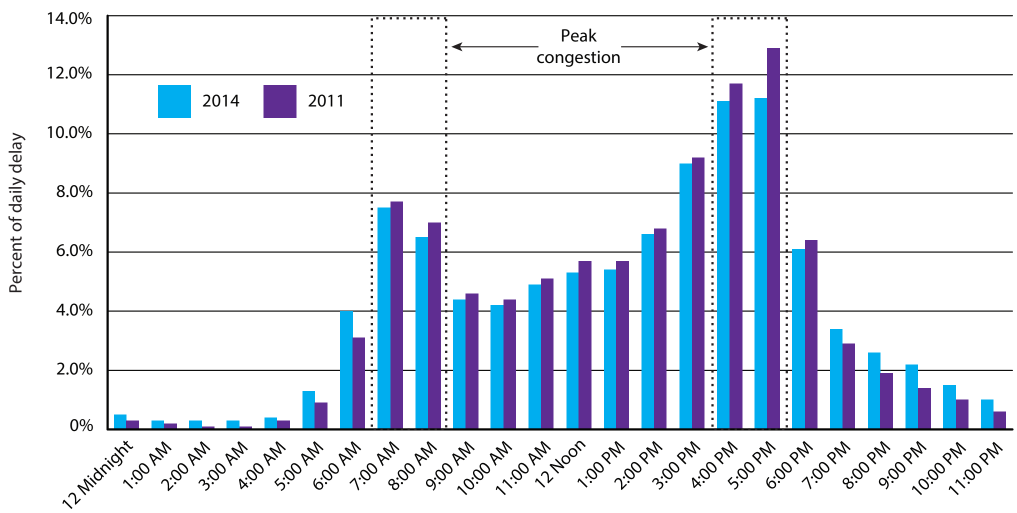
[5] Hours of congestion is defined as the amount of time when highways operate at less than 90 percent of free-flow speeds.

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



SOURCES: 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 August 2015.

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



SOURCES: 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 October 2015.

Congestion and delay are not limited to roadways. The average length of flight delays has been over 50 minutes in every year since 2004 and reached 57 minutes in 2014, even though the number of arriving domestic flights operated by the large U.S. airlines decreased by 22.5 percent over that period (table 4-2). Mainline carrier's domestic aircraft size increased in 2014 by 1.2 seats—from 153.9 to 155.1 seats. 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 inefficient aircraft and shifting to wide-body and larger narrow-body aircraft [USDOT FAA 2015], 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. For instance, if the separation between aircraft using the runway is increased to 5 nautical miles, then capacity would be cut by a third [NASA 2003].

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 nonextreme weather conditions, airport operations, heavy traffic volume, and air traffic control

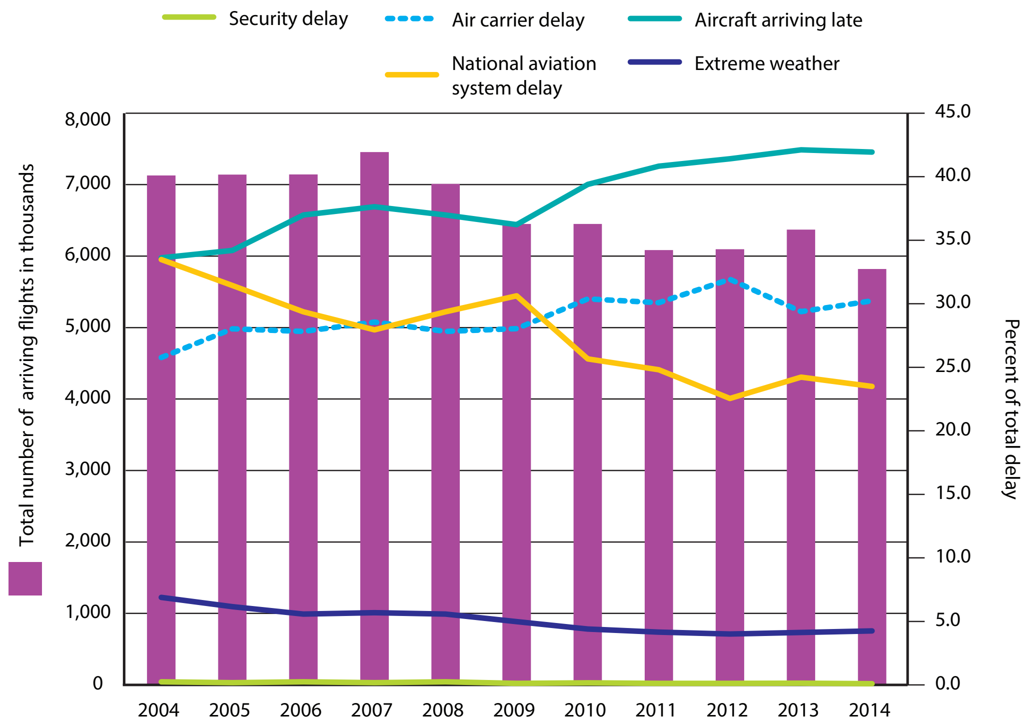
TABLE 4-2 Percentage of All Delayed Flights by Length of Time Delayed: 2004–2014

	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

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. The average length of flight delays has been over 50 minutes in every year since 2004 and reached 57 minutes in 2014, even though the number of arriving domestic flights operstedoperated by the large U.S. airlines flights decreased by 22.5 percent over that period.

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 June 2015.

FIGURE 4-4 National Flight Delays by Cause, Percent of Total Delay Minutes: 2004–2014



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.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, Transtats Database, *Airline On-Time Performance*, available at http://www.transtats.bts.gov/ as of June 2015.

contributed to 23.5 percent of delays in 2014, a 10 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 41.9 percent of delays for scheduled flights in 2014.

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 23.1 mph peak period average speed and a 42.6 mph nonpeak period average speed in Austin, TX, yields a ratio of 1.84. Some of the most congested truck bottlenecks on freight-heavy highways in 2012 could be found in Austin, TX (1.84); Chicago, IL (1.81); Houston, TX (1.46); and Atlanta, GA (1.46) [USDOT FHWA and BTS 2013].

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 2014 barge tows experienced an average delay of 2 hours navigating a lock (table 4-3), the largest delay on record and nearly double the delay in 2000 [USACE 2015]. Furthermore, the percent of vessels that experienced any delays increased from 35 to 49 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 62 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

[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.

TABLE 4-3 Lock Characteristics and Delays on Rivers with 5,000 or More Lockages: 2000, 2010, and 2014

	Total lockages (2014)	Average age of locks (2014)	Percent commercial vessels (2014)	Average delay in minutes			Percent of vessels delayed		
				2000	2010	2014	2000	2010	2014
All Waterways	**611,125**	**59**	**61**	**64**	**80**	**121**	**35**	**36**	**49**
Ohio River	111,734	52	88	52	97	95	31	34	43
Mississippi River	91,622	73	52	90	81	163	20	19	45
Gulf Intracoastal Waterway	39,015	52	99	58	65	110	78	84	90
Illinois Waterway	25,854	80	88	127	53	166	41	29	62
Monongahela River	23,079	70	78	12	11	24	16	18	27
Arkansas River	22,830	46	81	11	13	13	35	23	23
Tennessee River	20,719	68	67	209	122	277	24	24	43
Tennessee Tombigbee Waterway	18,636	32	46	9	3	11	38	10	14
Chicago River	10,959	77	34	5	5	13	1	1	83
Allegheny River	8,380	84	24	8	4	47	7	3	11
Columbia River	8,075	47	92	32	30	22	85	90	84
Red River	6,570	25	36	8	1	18	49	23	24
St. Mary's River	6,051	79	88	27	16	31	26	19	41
Cumberland River	5,536	54	59	16	18	113	13	12	30

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 October 2015.

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 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. Based on PTI data collected from 52 cities between 2013 and 2015, travelers would have to plan a minimum of about 150 percent more travel time to arrive "on-time" for 19 out of 20 trips (figure 4-5b). Figure 4-5c shows the potential impact of weather on travel as the congested hours were generally higher in winter than in summer months. Also average congested hours per day in 2015 likely fell below their 2014 levels.

For nonhighway 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 improvement in on-time performance with a record 83.0 percent on-time performance in

[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.

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

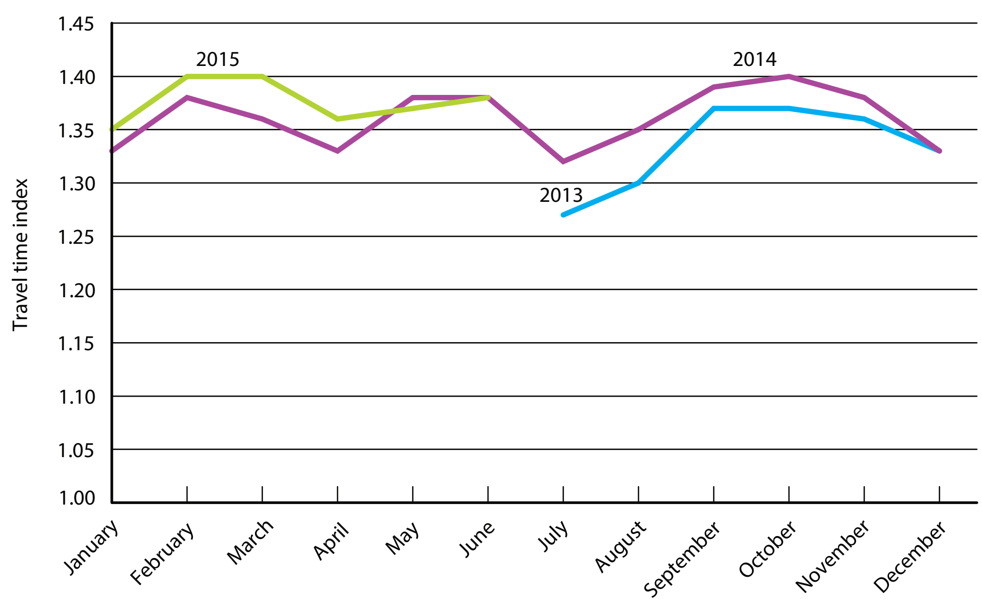


FIGURE 4-5b Planning Time Index (PTI): July 2013–June 2015

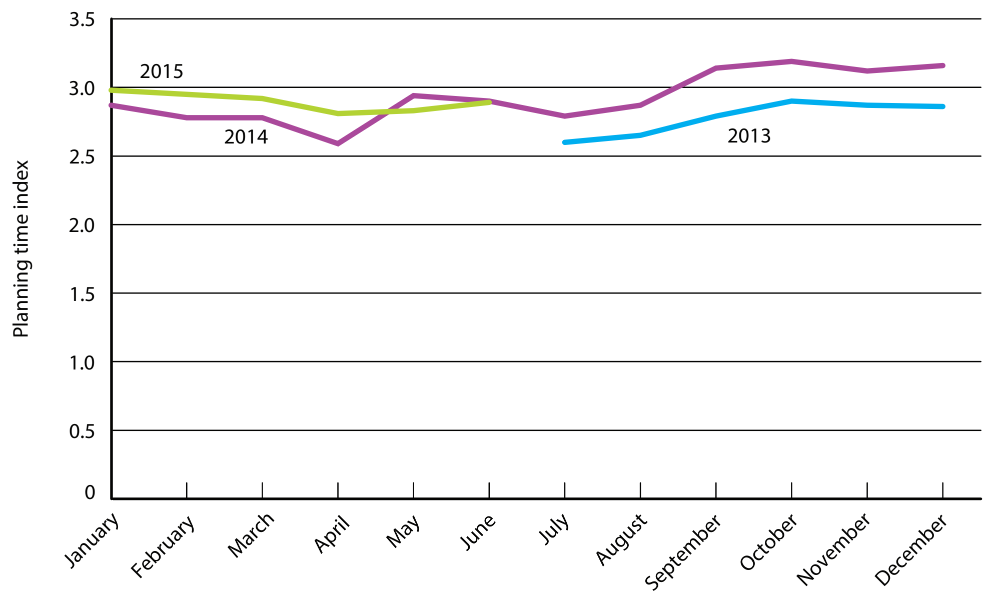
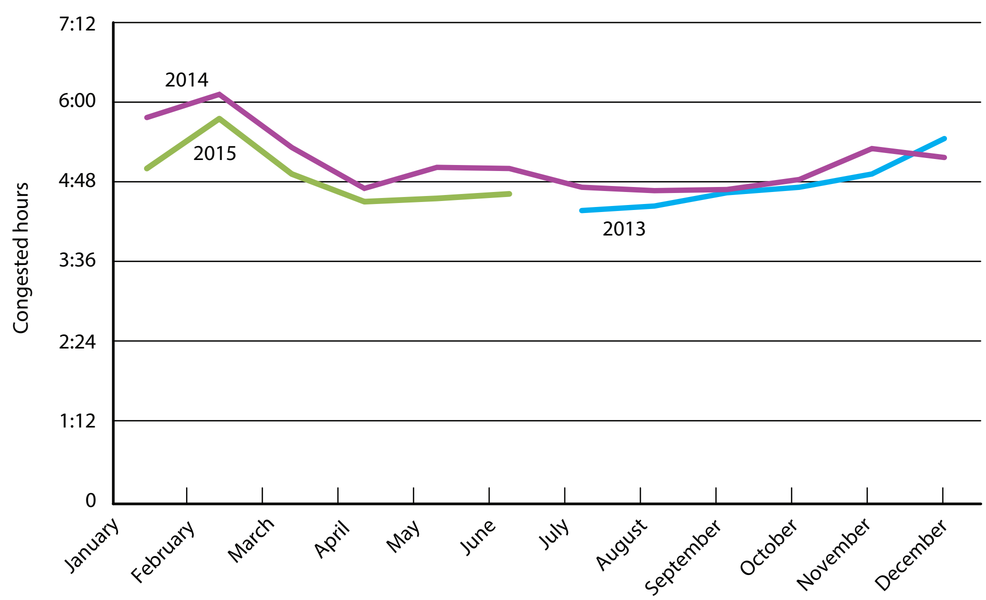


FIGURE 4-5c Congested Hours: July 2013–June 2015



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.

SOURCES: U.S. Department of Transportation, Federal Highway Administration, National Performance Management Research Data Set. Available at http://www.ops.fhwa.dot.gov/ as of November 2015.

TABLE 4-4 Amtrak On-Time Performance Trends and Hours of Delay by Cause: 2000, 2005, and 2010–2012

	2000	2005	2010	2011	2012
On-time performance, total percent (weighted)	78.2	69.8	79.7	78.1	83.0
Short distance (<400 miles), percent	82.0	73.6	80.3	79.8	84.5
Long distance (>=400 miles), percent	55.0	42.1	74.7	63.6	70.7
Hours of delay by cause, total[a]	**70,396**	**95,259**	**79,976**	**86,021**	**79,235**
Amtrak[b]	23,337	25,549	23,404	26,121	21,384
Host railroad[c]	43,881	64,097	44,090	48,707	46,564
Other[d]	3,176	5,613	12,482	11,192	11,286

[a] Amtrak changed its method for reporting delays in 2000. Therefore, the data for 2000 and following years are not comparable with prior years. [b] 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. [c] 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. [d] 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):
- 0–250
- 251–350
- 351–450
- 451–550
- > 551

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics. *National Transportation Statistics*, Table 1-73. Available at http://www.bts.gov/ as of June 2015.

2012, up from 69.8 percent in 2005 (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 70.7 percent in 2012. 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.

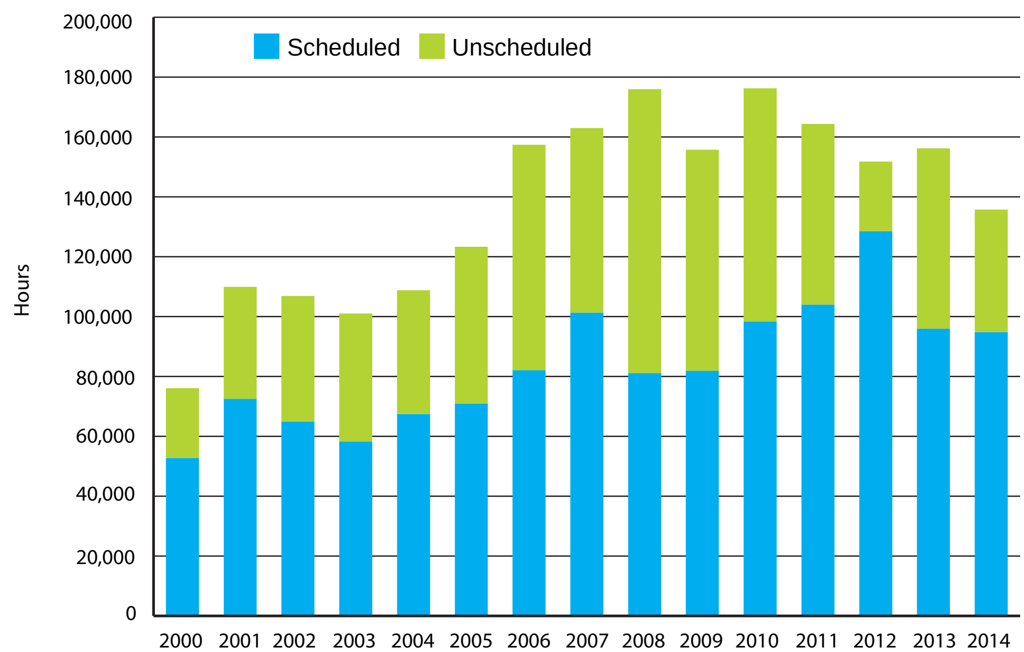
U.S. airlines reported that over 21 percent of domestic scheduled flights, or more than 1.2 million flights, arrived at the gate at least 15 minutes late in 2014. The average length of delay for late arriving flights was almost an hour. Almost 10 percent, or nearly 580,000 flights, arrived at the gate more than 2 hours late (table 4-2). Between 2005 and 2014, late arrivals increased from 20.5 to 21.3 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 2014 was almost 136,000, nearly 80 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 70 percent of total down time in 2014, which was exceeded only by the 85 percent recorded for 2012. 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 46,000 hours per year. A recent study by the Transportation Research Board (TRB) examined data on lost transportation time, due to both delay and unavailability, at all locks over the period 2000 to 2013, and found no overall correlation between lock age (adjusted for the date of the most recent rehabilitation) and lost time [TRB 2015], although there are notable exceptions as discussed in Chapter 1.

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 so that it can withstand severe blows, respond appropriately to threats, and mitigate the

FIGURE 4-6 Total Number of Hours of Lock Closures: 2000–2014



SOURCE: U.S. Army Corps of Engineers, *Navigation Data Center, Lock Performance Monitoring System. Locks by Waterway, Locks Unavailability, Calendar Years 1993-2014* (May 22, 2015). Available at http://www.navigationdatacenter.us/ as of June 2015.

consequences of threats through response and recovery operations [USDOT VOLPE 2013]. A resilient transportation system is one that can "take a punch" and recover in a timely way to provide the mobility and accessibility that are critical to the economy and to the quality of life of the Nation's citizens.

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 has experienced 178 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]. 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 2014 there were 8 such events (figure 4-7), causing 53 deaths and damages of $17 billion.

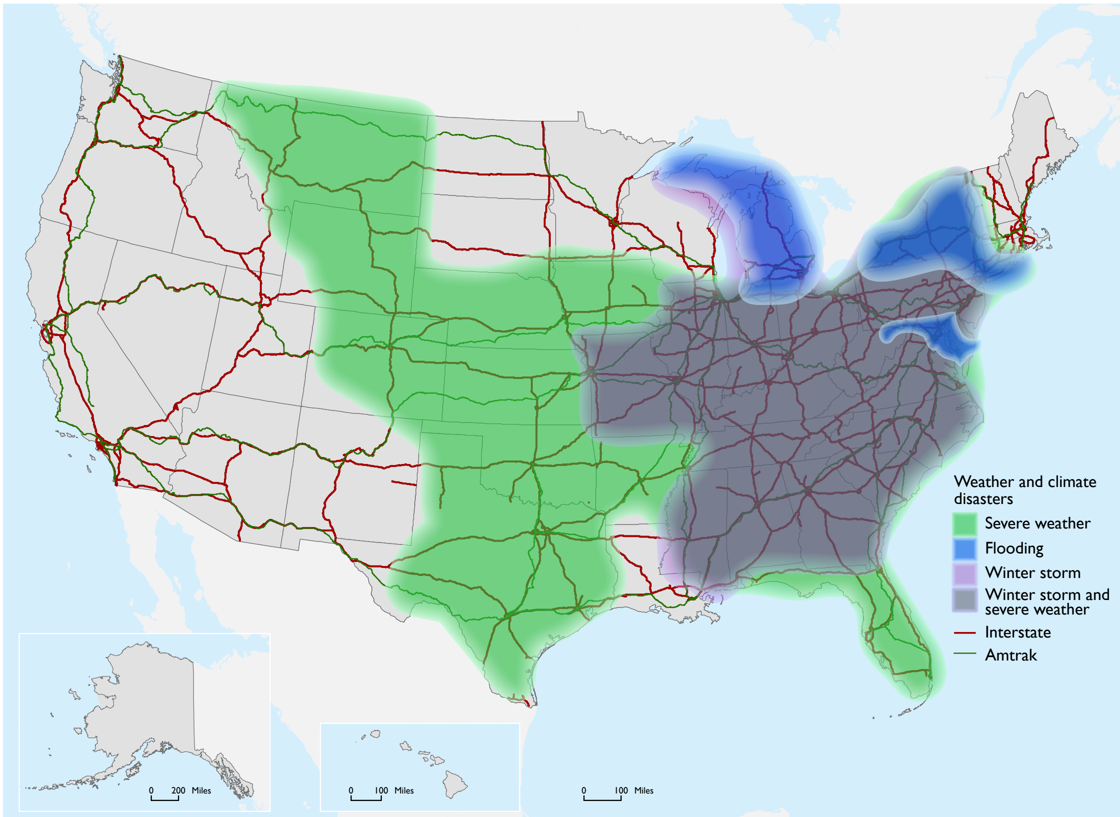
System Disruptions from Extreme Weather

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. This extreme snow accumulation was accompanied by sustained subfreezing temperatures.[8] The transportation system in the region was severely disrupted. Over those 30 days the Massachusetts Bay Transportation Authority (MBTA), which is the country's fifth largest public transportation system, was forced to completely shut down revenue service on three separate occasions. MBTA 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

[8] The mean temperature for Boston over this period was 19.0 degrees Fahrenheit, which was the second-coldest on record.

FIGURE 4-7 Billion-Dollar Weather and Climate Disasters: 2014



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics based upon U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center (NCDC), *2014 Billion-Dollar Weather and Climate Disasters*, available at https://www.ncdc.noaa.gov/billions/ as of November 2015.

and Boston on January 27th, and canceled two or more trains on 10 additional days. The Massachusetts Department of Transportation implemented 171 lane or road closures of significant duration. The extreme snow accumulation produced dangerously high snowbanks along roadways and pedestrian routes, creating significant safety hazards for motorists and pedestrians attempting to traverse the narrowed streets and nonexistent sidewalks. [MEMA 2015]

Although the New Jersey/New York/Connecticut and New England 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 New Jersey/New York/

Connecticut and New England transportation network provided travel options for both person and freight trips seeking to avoid travel blockages. In both 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.

There are economic and other costs associated with such major disruptions, including those resulting from extreme weather events, infrastructure repair, 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], 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[9] [IHS 2015].

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 2014 alone, the TSA prevented more than 2,200 firearms from being brought onto passenger aircraft [USDHS TSA 2015].

International piracy incidents and armed robberies at sea are another security concern affecting U.S. citizens traveling overseas, particularly in the waters surrounding the horn of Africa. This area has been monitored closely, especially after the hijacking of the U.S.-flagged *Maersk Alabama* on April 8, 2009. While, reported piracy activity at the horn of Africa was at a low in 2014, with no hijackings or boardings and only two attempted boardings, piracy activity was more prevalent in other waters in 2014, with 99 total events in West Africa (Gulf of Guinea) and 200 events in Southeast Asia [USN ONI 2015].

Economic Benefits of Improved System Performance

The following discussion focuses on the economic costs associated with poor transportation system performance, costs associated with system disruptions, and expected benefits from strategies that will improve system performance.

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 foregone given transit service) is thus

[9] 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.

considered the benefit of transit investment. For 2011 the benefit includes 865 million hours of delay eliminated and 450 million gallons of fuel saved, 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.

With respect to businesses, three critical aspects of operations can be affected directly by congestion:

- direct travel (user) cost, comprising vehicle operating costs and value of time (including reliability-related buffer time[10]) for drivers and passengers, for all business-related travel;
- logistics and scheduling costs, including costs of stocking, perishability, and just-in-time processing, and buffer times included in all of these; and
- market accessibility and scale, including loss of market-scale economies and reduced access to specialized labor and materials because of congestion.

Eliminating or reducing these costs through improved system performance would produce large economic benefits, but comprehensive estimates beyond those given in this chapter are not available.

With a new emphasis on performance-based decision making in the Federal *Moving Ahead for Progress in the 21st Century Act* (MAP-21) legislation, it is likely that state transportation planning agencies throughout the Nation will be collecting more data on system performance. This data, and the information it produces, could be useful to decision makers in identifying targeted opportunities for improving transportation system performance, with its attendant economic and quality of life benefits.

[10] Buffer time is the amount of time built into a trip to reduce the risk of being late.

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CHAPTER 5

Transportation Economics

Highlights

- Total spending on transportation fell in 2008 after the onset of the 2007–2009 economic recession, returning in 2014 to the pre-recession level.
- In total, the public and private sectors spent $125.7 billion on transportation construction in 2014.
- The transportation revenues of federal, state, and local governments totaled $180.2 billion in 2012, while government transportation expenditures totaled $319.8 billion—a deficit of $139.6 billion, down from $152.3 billion in 2009.
- Personal, business, and government purchases of transportation goods and services accounted for 8.9 percent of U.S. gross domestic product in 2014.
- All freight traffic and passenger travel, as measured by the Transportation Services Index (TSI), declined during the 2007–2009 economic recession but rebounded in 2014. The passenger TSI lagged the freight TSI in recovery.
- Transportation and related sectors employed over 12.3 million workers in 2014, representing 8.8 percent of the Nation's labor force.
- The highest wage transportation-related occupations employ relatively few workers, while the lower wage occupations employ millions. Air traffic controllers, airline pilots, and aerospace engineers had an annual median wage of more than $100,000 in 2014 and employed 167,000, while the largest transportation-related occupation, heavy and tractor-trailer truck drivers, had an annual median wage of $39,520 and employed over 1.6 million.
- American households spent, on average, about $9,000 per year on transportation in 2014, representing 17.0 percent of household expenditures. Transportation expenditure is the second largest household spending category, next to housing.
- Annual household expenditures on transportation differ in dollar amount by

income quintile, with the highest income quintile spending on average 4.7 times as much ($16,788) as the lowest income quintile ($3,555). However, as a percent of average annual total household expenditures transportation spending was similar across income quintiles.

Transportation Economics

The Nation's transportation system makes possible the efficient movement of both people and goods throughout the country and internationally. As discussed in chapter 1, transportation assets, totaling $7.7 trillion in 2013, are a major underpinning of the Nation's wealth and prosperity. Besides facilitating activity in all segments of the economy, the for-hire transportation sector (services for which one pays a fee or buys a ticket) directly employed over 4.6 million people in 2014, generating revenues from taxes and user fees through payments for fuel, and invested in infrastructure and equipment needed to move people and goods. Beyond its contribution to the U.S. gross domestic product (GDP), transportation is also an important element in both household and government budgets. The average household spends about $9,000 per year on transportation, while the government spends about $1,000 per capita on transportation expenditures.

TABLE 5-1 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%**
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 August 2015.

Transportation's Role and Contribution to the Economy

The demand for transportation included $1,422 billion in personal consumption (e.g., vehicle and motor fuel purchases), private domestic investment in transportation structures and equipment, government purchases, and exports related to transportation goods and services in 2014 (as measured in chained 2009 dollars). Transportation, as a share of the Nation's total demand for goods and services, accounted for 8.9 percent of U.S. GDP in 2014 (table 5-1). GDP is an economic measure of all goods and services produced and consumed in the country.

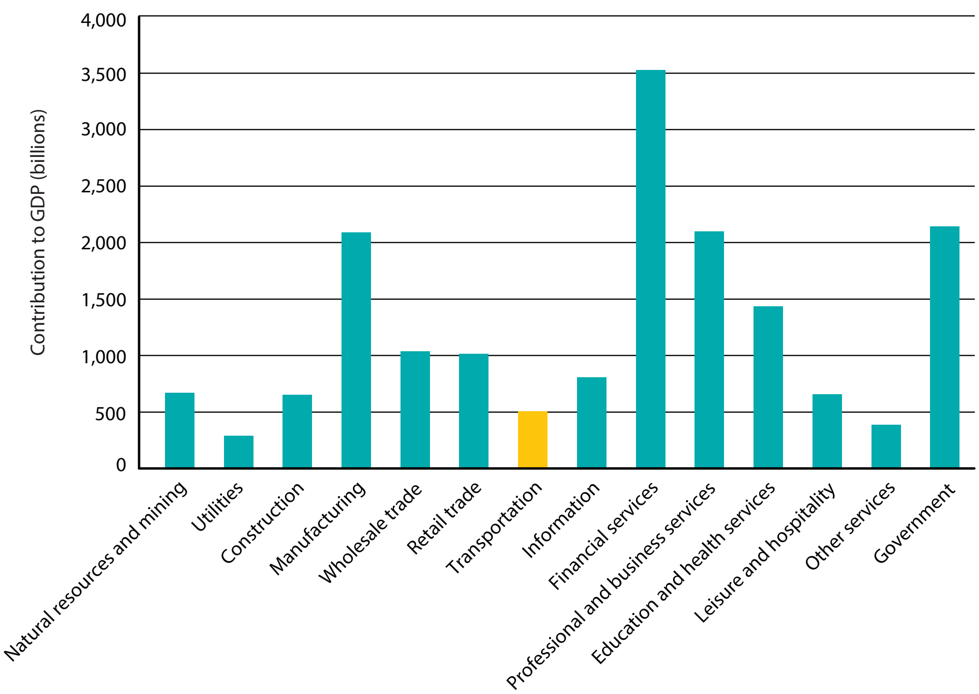
The contribution of transportation to the economy can also be found by looking at transportation's role in production. The transportation services used to move wheat from farms to mills, flour from mills to bakers, and bread from bakers to grocery stores, exemplifies how transportation enables the production and sale of nearly everything made and consumed in the United States. The U.S. Input-Output (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 2014 for-hire transportation contributed $506.2 billion (2.9 percent) to U.S. GDP (current dollars). While for-hire transportation contributes less to the economy than other industries, for-hire transportation delivers the raw materials other industries need to produce finished products and delivers finished products to consumers (figure 5-1). The Transportation Satellite Accounts (TSAs), produced by the Bureau of Transportation Statistics, expand on the I-O accounts to show the full role of transportation in production (see box 5-A). The TSAs use the same structure as the I-O accounts and quantify transportation's role and impact from four perspectives.

1. the value of transportation services each transportation industry *makes*,
2. the amount of transportation *used* by each industry and sector in the economy and the contribution of each industry and sector to the economy,
3. the amount of transportation *required* to produce one dollar of each product, and
4. the inputs *required* to produce one dollar of transportation.

The TSAs provide data for the years 2002 through 2012. In the 2012 TSAs, for-hire transportation contributed 2.9 percent to the U.S. GDP of $16.5 trillion. Transportation services (air, rail, truck, and water) provided by nontransportation industries for their own use, called in-house transportation, contributed an additional 1.2 percent ($203.2 billion) to U.S. GDP. The contribution of in-house truck transportation to GDP ($172.1 billion) exceeded the contribution of for-hire truck transportation ($123.0 billion) due to the extensive operation of trucks by nontransportation industries for their own purposes (figure 5-2).

Similarly, one can consider households as producers of transportation. Households produce transportation services by purchasing goods and services, such as cars and motor vehicle fuel, so they can travel by their own motor vehicle. The household production of

FIGURE 5-1 Industry Contribution to Gross Domestic Product: 2014



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts, available at http://bea.gov as of September 2015.

Box 5-A Transportation Satellite Accounts

The Transportation Satellite Accounts (TSAs) belong to the group of satellite industry accounts that supplement national income and product accounts and input-output accounts by focusing on a particular aspect of economic activity. The TSAs seek to capture transportation services provided by both for-hire transportation industries and by nontransportation industries for their own use, and transportation by households through the use of personal vehicles.

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 to industries and the public on a fee-basis, such as railroads, transit agencies, common carrier trucking companies, and pipelines.

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.

Household transportation covers transportation provided by households for their own use through the use of a motor vehicle. Air passenger travel is included in for-hire air transportation.

transportation services contributed $295.6 billion (1.8 percent) to U.S. GDP in 2012 (figure 5-2).

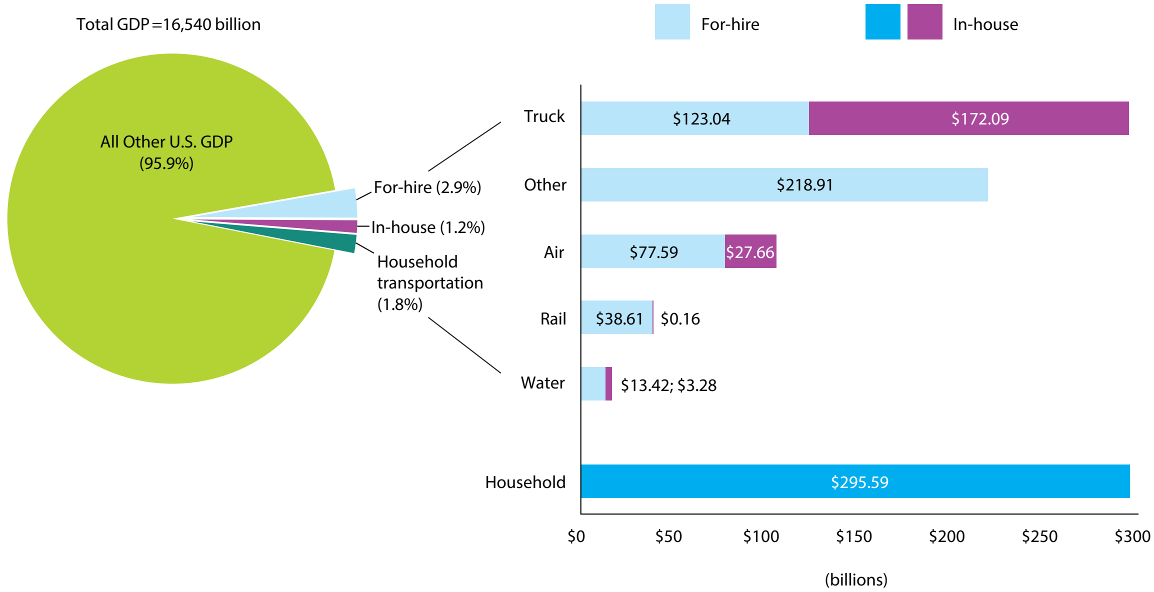
Transportation indirectly contributes to the economy by enabling the production of goods and services. Some industries depend on transportation more than others. In 2012 the wholesale and retail trade industry depended the most on transportation, requiring 10.9 cents of transportation per dollar of output (figure 5-3).

Transportation and Economic Cycles

Total spending on transportation fell in 2008 after the onset of the 2007–2009 economic recession and only as of 2014, returned to the pre-recession level. While total spending on transportation in 2014 exceeds the 2007 level, data on transportation-related demand show that personal consumption of transportation ($978.3 billion in 2014) has not reached the pre-recession level ($1,005 billion in 2007) (table 5-1).

Data for 2014 freight traffic and passenger travel show the transportation related economic recovery. The Transportation Services Index (TSI), created by the Bureau of Transportation Statistics, combines available data on freight traffic and passenger travel to measure the movement of freight and passengers (see box 5-B). All freight traffic and passenger travel

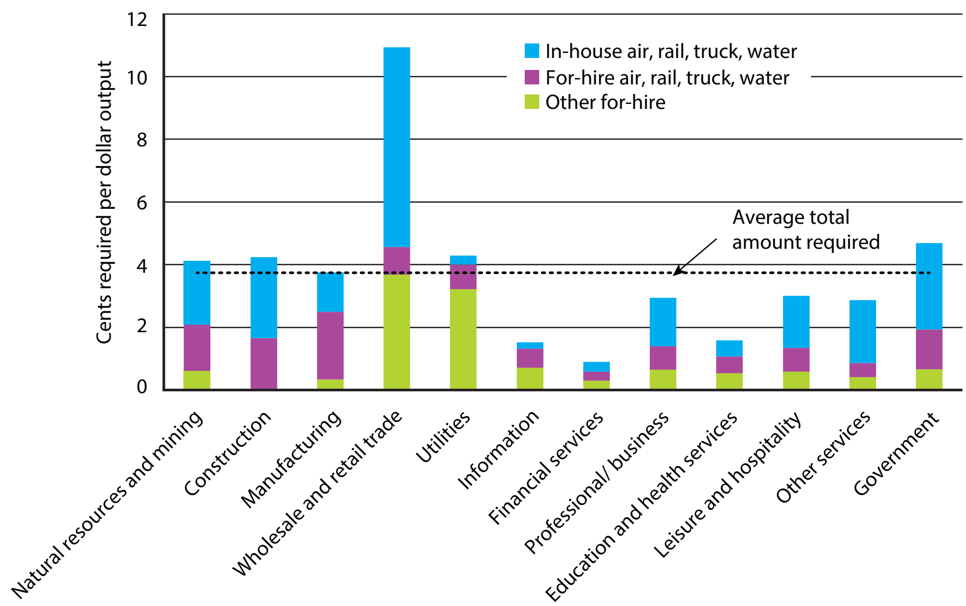
FIGURE 5-2 Value Added by Transportation Mode and Year (current dollars)



NOTES: 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. For-hire transportation consists of the services provided by transportation firms to industries and the public on a fee-basis. 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. 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.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at www.bts.gov, as of August 2015.

FIGURE 5-3 Transportation Required Per Dollar of Output by Sector: 2012



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; 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 2015.

BOX 5-B Transportation Services Index (TSI)

The Transportation Services Index (TSI), produced by the U.S. Department of Transportation (DOT), Bureau of Transportation Statistics (BTS), measures the movement of freight and passengers. The index combines seasonally adjusted data on freight and passenger travel, which have been weighted to yield a monthly measure of transportation services output. The TSI is represented by three indexes: freight transportation services (freight TSI), passenger transportation services (passenger TSI), and total TSI (freight and passenger combined). The TSI freight index combines air revenue ton-miles, rail carloads, rail intermodal traffic, truck tonnage, tonnage carried on U.S. internal waterways, petroleum pipeline movement, and natural gas consumption. The TSI passenger index combines air revenue passenger miles, rail passenger miles, and public transit ridership.

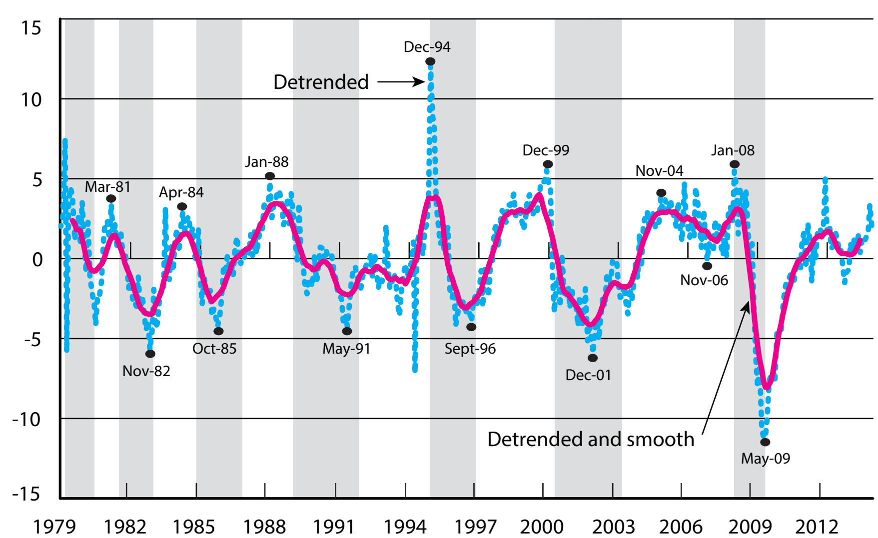
The TSI includes only domestic "for-hire" transportation operated on behalf of or by a company that provides freight or passenger transport services to external customers for a fee. Not included in the for-hire population is taxi and intercity bus services; in-house transportation, which includes vehicles owned by private firms providing services to that firm; and noncommercial passenger travel (e.g., trips in the family car). The for-hire transportation services component constitutes approximately 60 percent of total transportation services [USDOT BTS TSA 2015].

declined during the economic recession but have since rebounded, and the freight and passenger TSI reflects this recovery. The freight TSI reached a consistent monthly level above the January 2008 peak in the first quarter of 2013. The passenger TSI lagged the freight TSI recovery, reaching a consistent monthly level above the May 2007 peak in the second quarter of 2014 [USDOT BTS TSI 2014 2015]. The freight TSI and the passenger TSI peaked in different months because the two indices relate to different economic sectors. BTS has shown the freight TSI to be a leading economic indicator, turning about 4 months prior to accelerations and decelerations (growth cycles) in the economy (figure 5-4). The passenger TSI also moves in anticipation of changes in the economy; however, it tends to lead periods of expansion or recession (business cycles) in the economy (figure 5-5) [USDOT BTS 2014a].

Transportation-Related Employment and Productivity

The transportation sector (transportation service providers and warehousing) is a significant employer in the United States. In 2014 about 4.6 million people worked in transportation services and warehousing, with trucking accounting for 30.5 percent of that total. The transportation and warehousing labor force declined during the 2007 to 2009 recession and continued to fall through 2010 before rising above the 2007 level in 2014 (table 5-2).

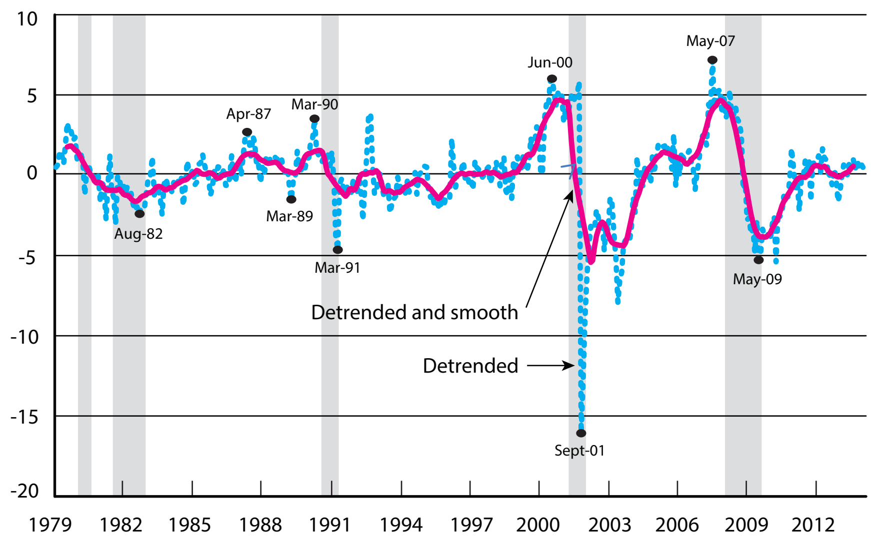
FIGURE 5-4 Detrended Freight TSI, Detrended and Smoothed Freight TSI and Growth Cycles: January 1979–December 2013



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 and the Economy Revisited*, December 2014, available at www.bts.gov as of December 2014.

FIGURE 5-5 **Detrended Passenger TSI, Detrended and Smoothed Passenger TSI and Growth Cycles: January 1979–December 2013**



NOTES: Shaded areas indicate economic recessions (business 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 and the Economy Revisited*, December 2014, available at www.bts.gov as of December 2014.

Employment in transportation is not limited to transportation service providers and warehousing. Many work in businesses with transportation-related functions, such as motor vehicle parts dealers and vehicle and equipment manufacturing. Including these workers brings the total employed in transportation to 12.3 million, or 8.8 percent of the U.S. labor force in 2014 (table 5-2).

Some workers are employed in nontransportation-related industries but hold transportation-related occupations. Truck drivers, for instance, may be employed by grocery chains that operate their own truck fleets. In 2014 there were 2.4 million people employed as truck drivers in the United States. More persons were employed as truck drivers than in any other transportation-related occupation (table 5-3).

The range of annual wage levels for different transportation and transportation-related occupations is wide. For example, in 2014 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 $39,520. The highest wage occupations employ relatively few workers while the lower wage occupations employ millions of workers (figure 5-6).

The size of the transportation workforce depends on the demand for transportation and on firms' utilization of the workforce.

TABLE 5-2 Employment in For-Hire Transportation and Select Transportation-Related Industries: 2000, 2007–2014 (thousands)

Industry	2000	2007	2008	2009	2010	2011	2012	2013	2014
TOTAL U.S. labor force	**132,019**	**137,936**	**137,170**	**131,233**	**130,275**	**131,842**	**134,104**	**136,368**	**139,042**
Transportation related labor force	**13,915**	**13,504**	**13,210**	**12,238**	**12,097**	**12,324**	**12,583**	**12,794**	**12,251**
Percent	10.5%	9.8%	9.6%	9.3%	9.3%	9.3%	9.4%	9.4%	8.8%
Transportation and warehousing	**4,410**	**4,541**	**4,508**	**4,236**	**4,191**	**4,302**	**4,416**	**4,495**	**4,640**
Air transportation	614	492	491	463	458	457	459	449	442
Rail transportation	232	234	231	218	216	228	231	232	235
Water transportation	56	66	67	63	62	61	64	66	67
Truck transportation	1,406	1,439	1,389	1,268	1,250	1,301	1,349	1,380	1,416
Transit and ground passenger transportation	372	412	423	422	430	440	440	446	465
Pipeline transportation	46	40	42	43	42	43	44	44	47
Scenic and sightseeing transportation	28	29	28	28	27	28	28	29	31
Support activities for transportation	537	584	592	549	543	562	580	594	625
Couriers and messengers	605	581	573	546	528	529	534	544	574
Warehousing and storage	514	665	672	637	633	653	687	712	738
Transportation related manufacturing[a]	**2,180**	**1,826**	**1,725**	**1,463**	**1,447**	**1,493**	**1,573**	**1,616**	**1,673**
Petroleum and coal products manufacturing	123	115	117	115	114	112	112	111	111
Transportation equipment manufacturing	2,057	1,712	1,608	1,348	1,333	1,382	1,461	1,505	1,563
Other transportation related industries[a]	**2,783**	**2,770**	**2,674**	**2,463**	**2,449**	**2,522**	**2,581**	**2,657**	**2,742**
Motor vehicle parts dealers	1,847	1,908	1,831	1,638	1,629	1,691	1,737	1,792	1,861
Gasoline stations	936	862	842	826	819	831	844	865	881
Postal service	**880**	**769**	**747**	**703**	**659**	**631**	**611**	**595**	**593**
Government employment, total	**873**	**890**	**895**	**902**	**911**	**892**	**870**	**862**	**U**
U.S. DOT	64	54	56	58	58	58	57	55	55
State and Local	809	835	839	845	853	834	813	807	U

[a] Total is for the selected industries.

KEY: U = data are unavailable.

NOTES: *Totals* are annual averages. *For-Hire Transportation* and warehousing includes transportation equipment; petroleum products; tires; rubber; plastics; search, detection, navigation, guidance, aeronautical, and nautical systems; and instrument manufacturing. Fiscal year data. *Government employment* includes highway, air, transit, and water modes. Details may not add to totals due to independent rounding.

SOURCES: U.S. Department of Labor, Bureau of Labor Statistics Data; U.S. Census Bureau; and U.S. Department of Transportation, as cited in the U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 3-23, available at http://www.bts.gov as of April 2015.

Technological improvements, more efficient utilization of employed persons, and other factors enable firms to produce transportation services with fewer employees.

Labor productivity measures the production of goods and services per hour of labor. From 2000 to 2014, air transportation's labor productivity rose the most among those transportation modes that collect labor productivity data, increasing by 93 percent. Labor productivity for rail increased by about 32 percent during the same period. Smaller increases occurred in freight trucking (20 percent) and the U.S. Postal Service (2 percent) [USDOL BLS Industry Productivity 2015] (figure 5-7). 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

TABLE 5-3 Employment in Select Transportation and Transportation-Related Occupations: 2000, 2007–2014 (thousands)

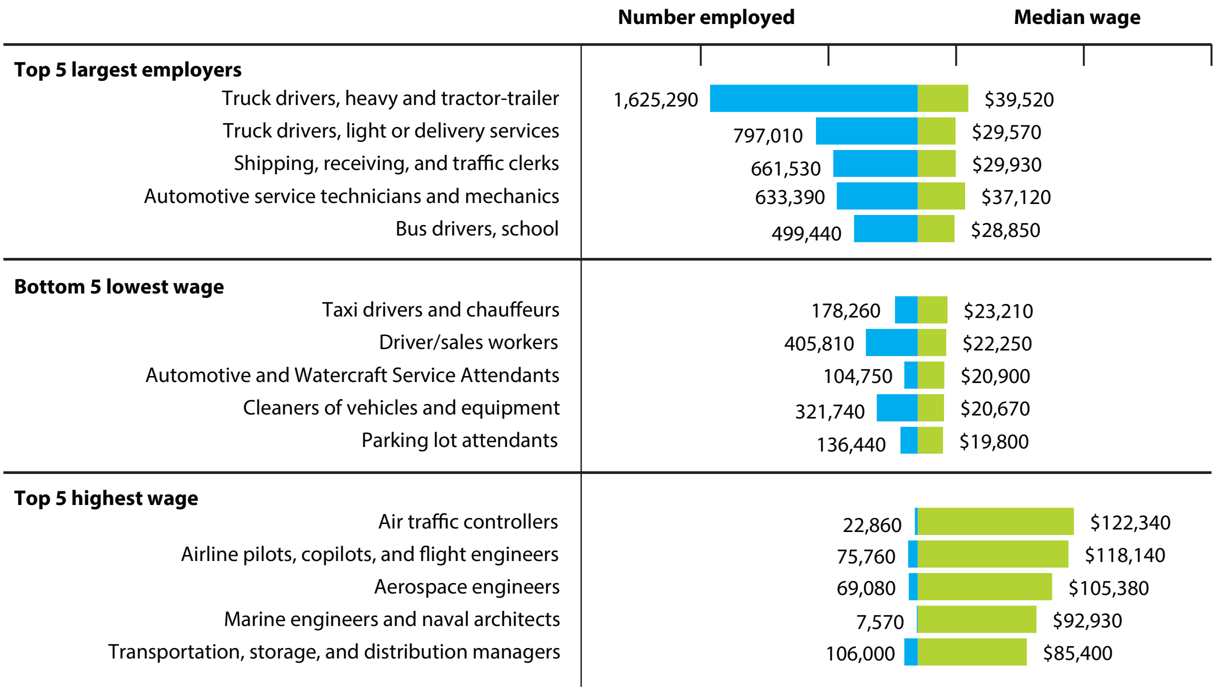
Occupation (SOC code)	2000	2007	2008	2009	2010	2011	2012	2013	2014
Vehicle operators, pipeline operators, and primary support[a]	**3,406**	**3,472**	**3,431**	**3,221**	**4,523**	**3,129**	**3,178**	**3,223**	**3,300**
Airline pilots, copilots, and flight engineers (53-2011)	95	78	77	74	69	68	66	73	76
Air traffic controllers (53-2021)	23	24	24	24	24	24	23	23	23
Driver/sales workers (53-3031)	374	382	373	363	372	388	394	396	406
Truck drivers, heavy and tractor-trailer (53-3032)	1,577	1,694	1,673	1,551	1,467	1,509	1,557	1,585	1,625
Truck drivers, light or delivery services (53-3033)	1,033	923	909	835	780	771	769	777	797
Taxi drivers and chauffeurs (53-3041)	130	166	171	168	1612	167	167	170	178
Locomotive engineers (53-4011)	29	42	43	44	41	39	37	37	38
Rail yard engineers, dinkey operators, and hostlers (53-4013)	4	5	5	5	6	5	5	5	4
Railroad brake, signal, and switch operators (53-4021)	17	23	25	24	23	24	24	24	21
Railroad conductors and yardmasters (53-4031)	40	38	40	42	43	44	43	43	43
Sailors and marine oilers (53-5011)	30	33	32	32	32	31	32	29	28
Captains, mates, and pilots of water vessels (53-5021)	21	31	31	30	29	30	31	30	31
Ship engineers (53-5031)	7	14	11	11	9	10	11	10	10
Bridge and lock tenders (53-6011)	5	5	4	4	3	3	3	3	3
Gas compressor and gas pumping station operators (53-7071)	7	4	4	4	4	4	4	5	5
Pump operators, except wellhead pumpers (53-7072)	14	10	9	10	9	12	12	13	12
Transportation equipment manufacturing and maintenance occupations[a]	**754**	**795**	**759**	**708**	**700**	**719**	**748**	**761**	**767**
Aerospace engineers (17-2011)	72	86	68	71	78	79	80	72	69
Marine engineers and naval architects (17-2121)	5	7	6	5	6	5	7	7	8
Bus and truck mechanics and diesel engine specialists (49-3031)	259	250	249	233	223	223	230	238	243
Rail car repairers (49-3043)	11	23	21	21	19	19	19	19	20
Automotive and Watercraft Service Attendants (53-6031)	106	93	84	79	86	102	109	113	105
Cleaners of vehicles and equipment (53-7061)	301	336	331	299	288	291	303	312	322
Transportation Infrastructure construction and maintenance occupations[a]	**19**	**22**	**24**	**23**	**25**	**26**	**28**	**26**	**25**
Rail-track laying and maintenance equipment operators (47-4061)	10	14	15	15	16	16	17	16	15
Signal and track switch repairers (49-9097)	6	6	7	6	7	8	9	8	8
Dredge operators (53-7031)	3	2	2	2	2	2	2	2	2
Secondary Support Service Occupations[a]	**1,548**	**1,465**	**1,482**	**1,405**	**1,353**	**1,347**	**1,344**	**1,336**	**1,331**
Dispatchers, except police, fire, and ambulance (43-5032)	167	190	193	185	181	182	185	185	190
Parking lot attendants (53-6021)	117	132	136	130	125	126	127	130	136
Postal service mail carriers (43-5052)	355	348	355	339	325	315	305	307	307
Shipping, receiving, and traffic clerks (43-5071)	865	756	761	715	688	688	691	677	662
Transportation inspectors (53-6051)	27	24	25	24	24	25	24	24	24
Tank car, truck, and ship loaders (53-7121)	17	15	12	12	10	11	12	13	12
Other[a]	**117**	**93**	**96**	**92**	**90**	**92**	**99**	**103**	**106**
Transportation, storage, and distribution managers (11-3071)	117	93	96	92	90	92	99	103	106

[a] Total is for the selected occupations.

KEY: SOC = Standard Occupational Classification.

SOURCES: 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; Data from U.S. Department of Labor, Bureau of Labor Statistics, *Occupational Employment and Wages*, available at http://www.bls.gov/oes as of April 2015.

FIGURE 5-6 Employment and Wages in Select Transportation and Transportation-Related Occupations: 2014

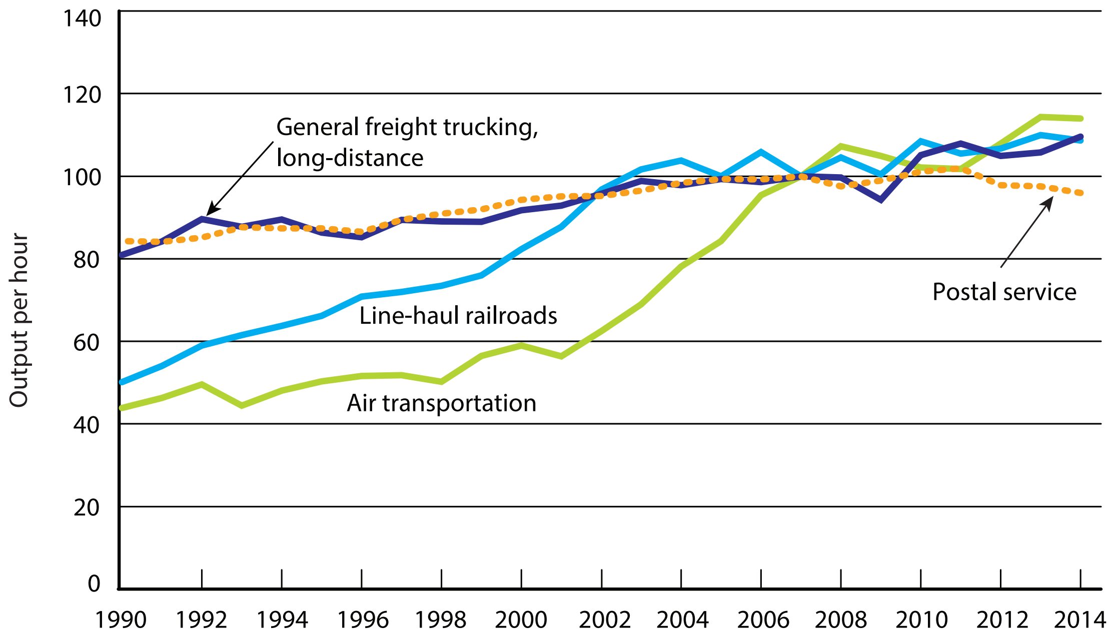


KEY: SOC = Standard Occupational Classification.

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 April 2015.

FIGURE 5-7 Labor Productivity Indices for Selected Transportation Industries: 1990–2014



NOTE: Data in this table are not comparable to the data published in previous editions due to change in base year from 2002 to 2007.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Industry Productivity and Costs, available at http://www.bls.gov/lpc/ as of November 2015

workforce or wages following a recession, and changes in regulations among other potential market forces impacting the alignment between labor and output.

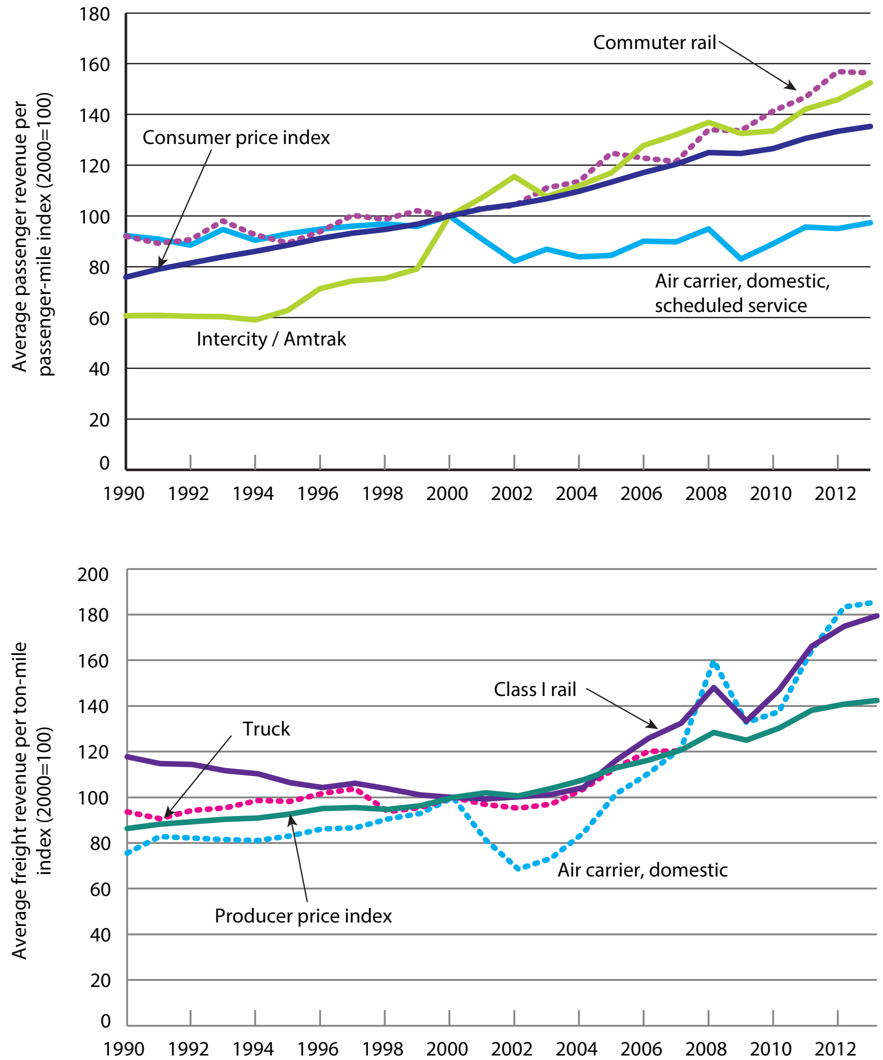
The impact of productivity on transportation companies can be seen through changes in revenue per ton-mile, which is the output of freight transportation modes, and revenue per passenger-mile, which is the output of passenger transportation modes, over time. The increase in labor productivity from 2000 to 2013 corresponds with an increase in revenue per unit of output from 2000 to 2013, exceeding the rate of inflation across air (passenger and freight) and rail (passenger and freight)— the modes for which revenue per unit of output data are available. The only mode not showing an increase in revenue per unit of output between 2000 and 2013 is domestic passenger air travel, which fell after the 9/11 terrorists attacks and has not yet fully recovered, and general freight truck transportation, which grew marginally less than the rate of inflation between 2000 and 2007 (the latest year for which data are available) (figure 5-8).

Transportation Expenditures

Personal Consumption and Household Expenditures

Personal consumption expenditure data and household expenditure survey data provide two ways of looking at spending on transportation.

FIGURE 5-8 Revenue Per Unit of Output for Passenger and Freight Transportation Modes: 1990–2013



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). **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. **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, available at http://www.bls.gov/ppi/ as of Sept. 1, 2015.

Personal consumption expenditures measure transportation consumption – what households spend, in aggregate, on transportation (e.g., expenditures on vehicles, fuel, etc.) and what federal, state, and local governments and other organizations spend on transportation on behalf of households (e.g., transportation subsidies that benefit households). Household expenditure data, on the other hand, capture only the purchases that households make themselves and show the average amount spent by a household.

Personal consumption data provide a picture of all goods and services purchased in the economy by households and by organizations on behalf of households (e.g., employer paid parking and transportation subsidies and health insurance and medical care financed by government programs) [USDOC BEA 2014]. In 2014 expenditures on transportation by U.S. residents were roughly $1,231 billion. This translates to almost 10.4 percent of all personal consumption expenditures (figure 5-9).

Household expenditure survey data show that households spent an average of $9,073 per year on transportation in 2014—roughly 17.0 percent of all expenditures. Average household expenditure is dollars directly paid by households and shows transportation as a larger percent compared to the personal consumption expenditure measure. Personal consumption expenditure account's inclusion of health care payments—a payment largely made on behalf of households—results in health care becoming a significantly larger expenditure compared to transportation (figure 5-10).

The majority of household expenditures on transportation went to the purchase and upkeep of vehicles, including the cost of gasoline, according to both personal consumption expenditure data and household expenditure survey data.

Spending on transportation changes as income rises. Households in the highest income quintile spend on average 4.7 times as much on transportation annually ($16,788) as households in the lowest income quintile ($3,555). The difference in transportation spending results, in part, from a difference in the number of vehicles and earners per household. The average number of household vehicles rises with income (table 5-4).

Household expenditures on transportation rise by income quintile, but households across income quintiles spend a nearly equal percent of their budget on transportation (table 5-4).

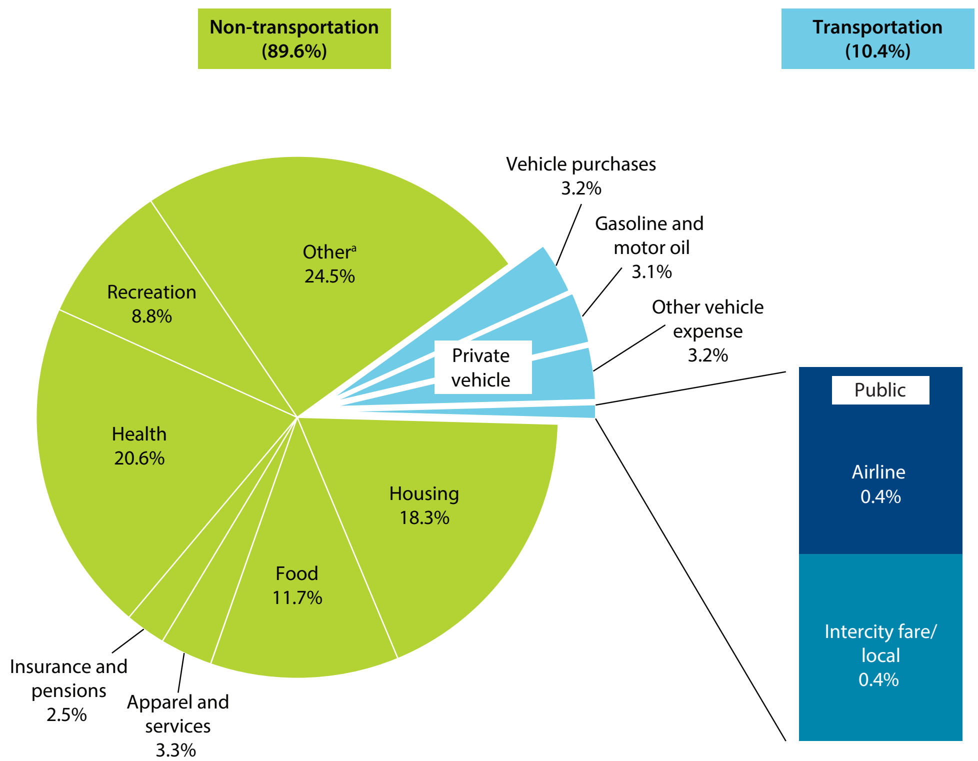
Public and Private Sector Revenue and Expenditures

Expenditures

Federal, state, and local governments spent approximately 5.1 percent ($319.8 billion) of their expenditures on transportation in 2012[1] [USDOT BTS 2014b]. Federal, state, and local governments spent $5.4 billion more in 2012 than 2011 but spent the same percent of their expenditures on transportation in both years. On a per capita basis, government spending on transportation averaged about $1,000 per year [USDOT BTS 2014b]. The

[1] 2012 is the latest year for which comprehensive data have been published.

FIGURE 5-9 Personal Expenditures by Category: 2014



NOTES: Other includes: alcoholic beverages purchased for off-premises consumption; furnishings, household equipment, and routine household maintenance; education; accomodations; financial services (excluding pension funds); other goods and services; et foreign travel and expenditures abroad by U.S. residents; and final consumption expenditures of nonprofit institutions serving households Motor vehicle insurance included in other vehicle purchases.

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 November 2015.

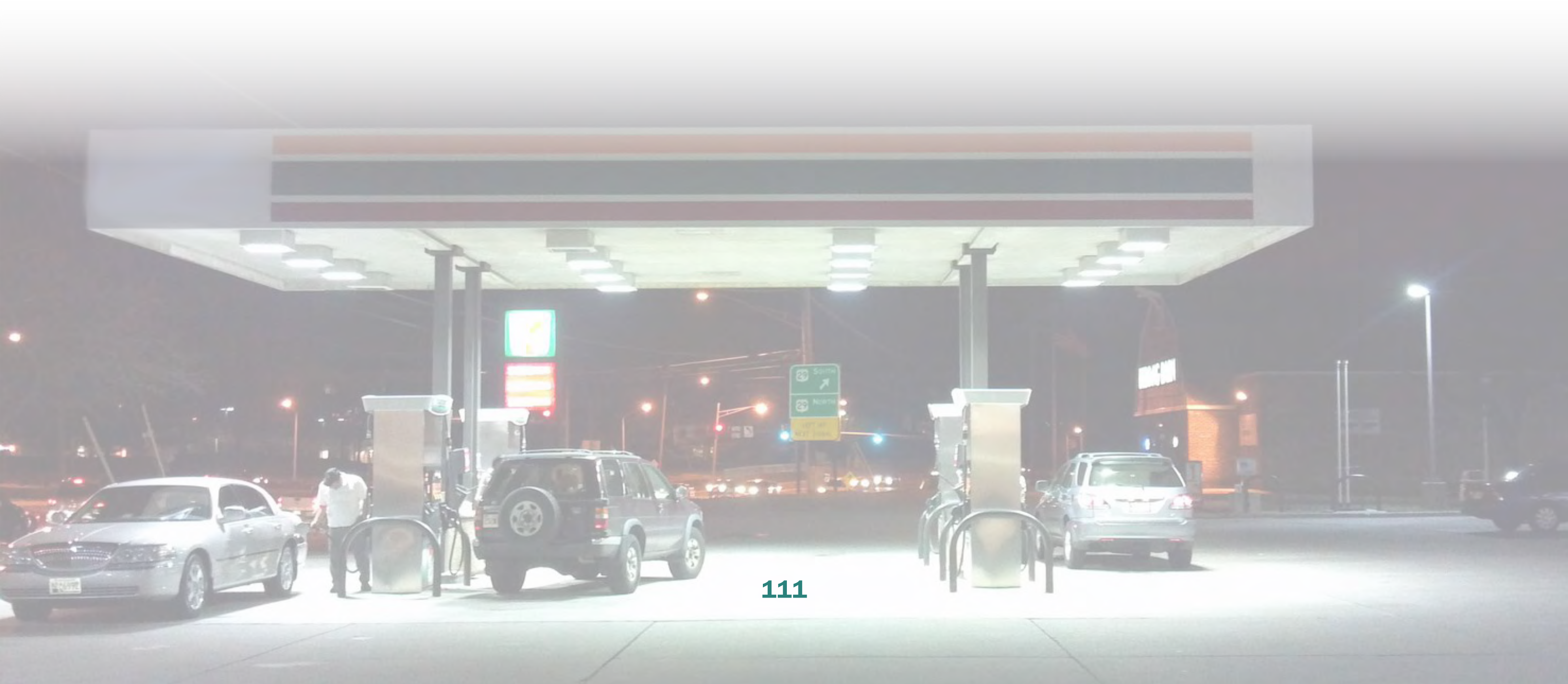
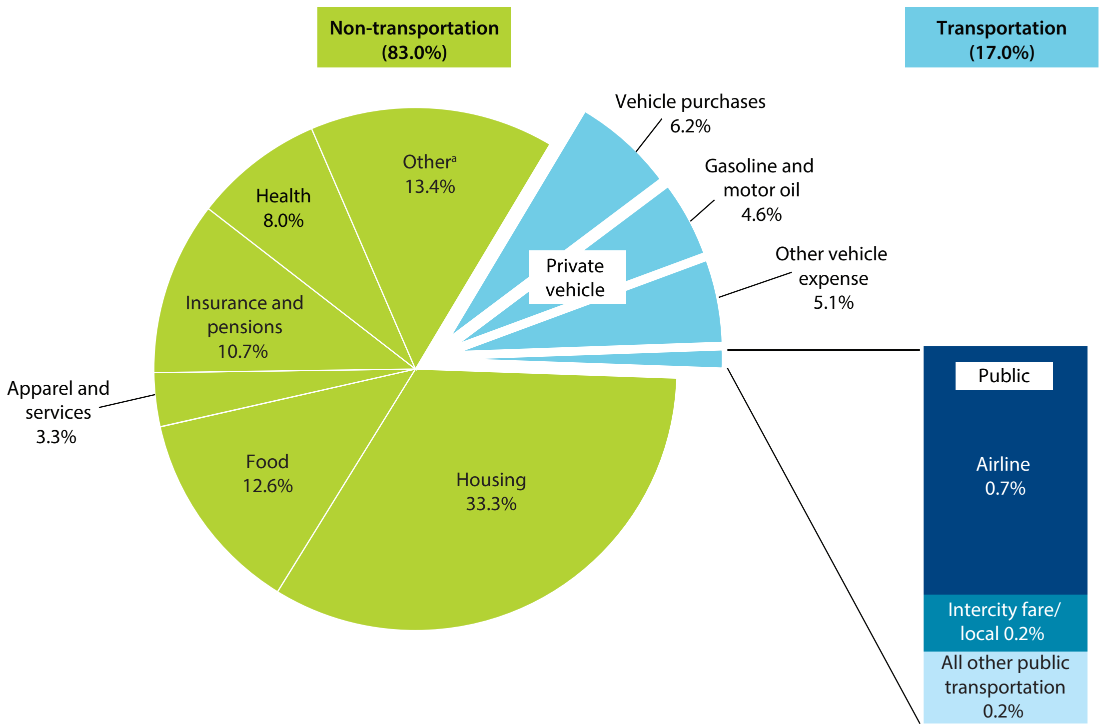


FIGURE 5-10 Average Household Expenditures by Major Spending Category: 2014



Other includes alcoholic beverages, cash contributions, education, entertainment, personal care products and services, reading, tobacco products and smoking supplies, and other items.

SOURCES: U.S. Department of Labor, Bureau of Labor Statistics, *Consumer Expenditure Survey* tables, available at www.bls.gov/cex as of November 2015. Public transportation detail from microdata.

TABLE 5-4 Average Household Expenditures by Income Quintile and Selected Characteristics: 2014

Income quintiles	Avg. annual spending	Earners	Vehicles	Transportation expenditures: Total	Transportation expenditures: % of avg. annual spending
All	53,495	1.3	1.9	9,073	17.0
$17,833 and below	23,713	0.5	0.9	3,555	15.0
$17,834 – $34,958	33,546	0.8	1.4	5,696	17.0
$34,959 – $57,968	45,395	1.3	1.9	8,475	18.7
$34,969 – $95,336	60,417	1.7	2.3	10,844	17.9
$95,337 and above	104,363	2.1	2.8	16,788	16.1

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, available at www.bls.gov/cex as of November 2015.

expenditures covered, among other things, the monies needed to build, operate, and maintain publically owned transportation facilities and implement public policy in areas such as safety and security.

In 2012 state and local governments spent 88 percent of the $319.8 billion (including Federal grant monies) in government transportation spending (table 5-5). Government transportation expenditures increased (without adjusting for inflation) by 71.6 percent between 2000 and 2012. Nearly two-thirds of government expenditures went to highways, followed by transit (17.2 percent), air (13.1 percent), and water (4.1 percent) [USDOT BTS 2014b].

The public sector is the major funding source for transportation infrastructure construction, especially for streets and highways. In 2014 the value of government-funded (public)

TABLE 5-5 Government Transportation Expenditures: 2000, 2007–2012

Millions of current dollars

	2000	2007	2008	2009	2010	2011	2012
All modes, total	**186,420**	**275,256**	**294,048**	**310,837**	**317,316**	**314,377**	**319,817**
Federal	21,330	33,637	37,547	40,363	45,839	43,744	38,467
State and local	165,090	241,619	256,501	270,474	271,476	270,633	281,350
Highway, total	**119,910**	**175,514**	**182,914**	**193,024**	**203,561**	**203,088**	**206,251**
Federal	2,190	2,990	4,293	6,094	15,790	13,289	8,746
State and local	117,720	172,524	178,622	186,930	187,771	189,799	197,505
Transit, total	**35,362**	**46,065**	**51,741**	**54,820**	**54,193**	**52,991**	**55,150**
Federal	4,335	97	89	91	96	98	98
State and local	31,027	45,968	51,652	54,729	54,097	52,893	55,052
Rail, total	**772**	**1,498**	**1,473**	**1,809**	**2,627**	**2,107**	**1,752**
Federal	759	1,493	1,472	1,809	2,627	2,107	1,752
State and local	13	5	1	0	0	0	0
Air, total	**22,332**	**39,466**	**44,564**	**45,875**	**42,774**	**41,425**	**41,794**
Federal	9,172	21,134	23,287	23,125	18,558	18,706	18,217
State and local	13,160	18,332	21,277	22,750	24,216	22,719	23,577
Water, total	**7,278**	**11,351**	**11,989**	**13,758**	**13,151**	**13,677**	**13,261**
Federal	4,138	6,593	7,075	7,744	7,810	8,509	8,092
State and local	3,141	4,758	4,914	6,015	5,341	5,169	5,169
Pipeline, total	**64**	**76**	**73**	**82**	**95**	**98**	**86**
Federal	51	57	50	47	65	66	61
State and local	13	19	23	35	30	32	25
General Support, total	**701**	**1,287**	**1,293**	**1,469**	**915**	**990**	**1,523**
Federal	685	1,274	1,281	1,453	893	969	1,501
State and local	16	13	12	16	22	21	22

NOTES: Federal expenditures include direct Federal spending, excluding grants to state and local governments. State and local expenditures include outlays from all sources of funds, including federal grants, except rail and pipeline modes. Rail and pipeline modes include outlays funded by Federal grants only. The part of expenditures that may be funded by other state and local government funding sources are not covered due to a lack of data. Outlays for U.S. Army Corps of Engineers' civilian transportation-related activities, such as construction, operation, and maintenance of channels, harbors, locks and dams, are not included.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Government Transportation Financial Statistics 2014*. Available at http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/government_transportation_financial_statistics/index.html as of April 2015.

construction underway was about $113.7 billion and accounted for 90 percent of spending on transportation infrastructure construction [USDOC CENSUS 2014]. 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 (figure 5-11). Investment has been growing since 2012. These increases follow a decline in 2011 as the investment associated with the *American Recovery and Reinvestment Act* (Pub. L. 111–5) came to an end.

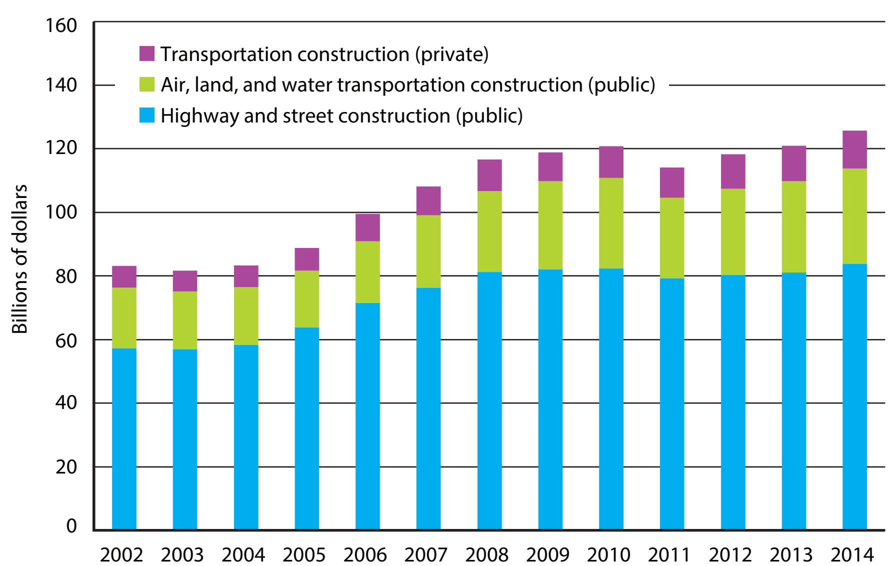
Private sector spending also has grown since declining in 2011. In 2014 the value put in place by private construction of transportation facilities and infrastructure was $11.9 billion [USDOC CENSUS 2014]. Together, government-funded (public) and private investment in transportation construction totaled $125.7 billion in 2014 (figure 5-11).

Revenue

Government transportation revenue comes from user taxes and fees, such as gasoline taxes and tolls, air ticket taxes and fees, and general revenues. In 2012[2] government transportation revenues from all sources totaled $180.[2] billion (current dollars) (table 5-6). State and local governments collected 69.2 percent of all transportation-related revenue, while the Federal Government collected the remaining 30.8 percent. The highway sector generated the greatest revenues (mainly from gas taxes),

[2] 2012 is the latest year for which data are available.

FIGURE 5-11 Value of Transportation Infrastructure Construction Put in Place (current dollars)



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 April 2015.

TABLE 5-6 Government Transportation Revenues: 2000, 2007–2012
Millions of current dollars

	2000	2007	2008	2009	2010	2011	2012
All modes, total	**127,545**	**164,888**	**164,396**	**158,587**	**161,782**	**172,674**	**180,175**
Federal	46,764	54,971	53,276	48,190	48,554	51,660	55,475
State and local	80,781	109,917	111,120	110,397	113,227	121,014	124,699
Highway, total	**90,895**	**115,443**	**112,637**	**109,398**	**111,614**	**118,598**	**125,026**
Federal[a]	34,986	40,652	38,458	35,144	35,026	36,955	40,265
State and local	55,910	74,791	74,179	74,254	76,588	81,642	84,761
Transit, total[e]	**10,670**	**13,868**	**14,586**	**15,288**	**15,328**	**17,234**	**17,607**
Railroad, total[d]	1	0	0	0	0	0	0
Air, total[b]	22,243	29,580	30,895	27,931	28,427	29,968	31,103
Federal	**10,548**	**12,187**	**12,672**	**11,109**	**10,995**	**12,003**	**12,796**
State and local	11,695	17,393	18,223	16,822	17,432	17,965	18,307
Water, total	3,680	5,920	6,202	5,871	6,293	6,760	6,317
Federal	**1,173**	**2,056**	**2,069**	**1,839**	**2,414**	**2,587**	**2,293**
State and local	2,507	3,864	4,133	4,032	3,879	4,173	4,024
Pipeline, total[c,d]	30	60	63	78	90	90	90
General support, total[d]	**26**	**16**	**14**	**20**	**29**	**25**	**31**

[a] Includes both Highway and Transit Accounts of the Highway Trust Fund (HTF) and other receipts from motor fuel and motor vehicle taxes not deposited to the HTF. [b] Receipts from aviation user and aviation security fees also included. [c] Includes Harbor Maintenance Trust Fund, St. Lawrence Seaway tolls, Inland Waterway Trust Fund, Panama Canal receipts through 2000, Oil Spill Liability Trust Fund, Offshore Oil Pollution Fund, Deep Water Port Liability Fund, and excise taxes of the Boat Safety Program. [d] Includes Federal only. [e] Includes state and local government only.

NOTES: Government transportation revenue consists of money collected by governments from transportation user charges and taxes to finance transportation program. The revenue of a transportation mode includes all transportation revenues designated to that mode regardless of the sources or instruments from which the revenues are collected. Tolls from highways, bridges, and tunnels, etc., designated for transit use are counted as transit revenue.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics 2014. Available at http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/government_transportation_financial_statistics/index.html as of April 2015.

accounting for $125.0 billion (69.4 percent) of all revenue, followed by air with $31.1 billion (17.3 percent) mainly from air ticket taxes and fees (table 5-6).

Total transportation revenues fell short of government transportation expenditures in 2012. In 2012 transportation revenues covered 56.3 percent of expenditures. The gap between transportation expenditures and revenues has declined since 2009, when revenues covered 51.0 percent of expenditures [USDOT BTS 2014b]. 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 the shortages.

Costs 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 both businesses 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

The major inputs to produce transportation goods and 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.

The price of transportation equipment has steadily increased since 2004, according to the Bureau of Labor Statistics' Producer Price Index (PPI). Transportation equipment PPI is an index that represents the average change in the price producers' receive for the goods and services they sell. The PPI reflects changes in transportation equipment prices faced by transportation service providers[3]. The average change in prices transportation service providers face when purchasing railroad rolling stock, aircraft, and ship and boat manufacturing, has grown more quickly than for all transportation equipment manufacturing (figure 5-12). Price increases may impact the profitability and decision making of the rail, air, and water transportation sector, lead to greater transportation costs for consumers using one of these modes, and influence prices in other sectors that rely on rail, air, and water transportation, such as wholesale, retail, and warehousing and storage. Similar impacts may be seen among transportation modes and sectors using automobiles. The prices faced by transportation service providers in purchasing automobiles rose in 2012, having remained steady for several years (figure 5-12).

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 peaked in 2012 and have since declined (figure 5-13). In 2012 the average annual fuel price for gasoline was $3.70, while the average annual fuel price for diesel fuel was $3.20. In September 2015 the average fuel price for gasoline (all types) was $2.75, while the average fuel price for diesel was $2.02 [USDOE EIA 2015].

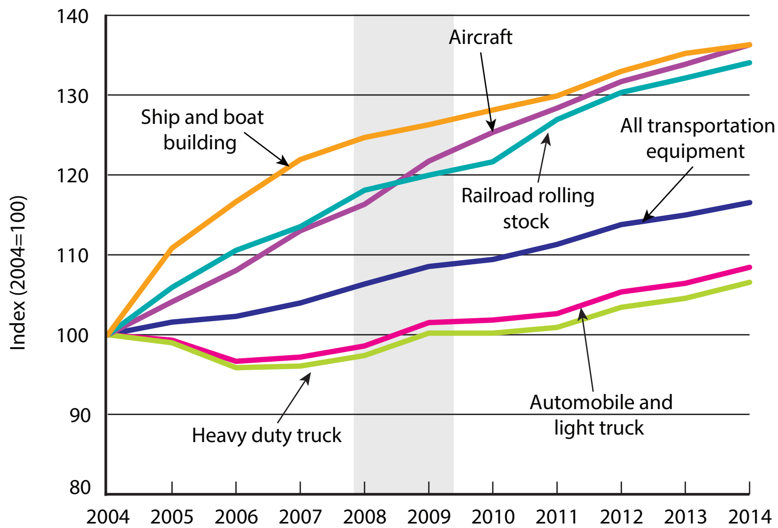
Costs Faced by Businesses

The prices that transportation companies charge for transportation impact the freight shippers' and travelers' transportation decisions (see box 2-A). The relative level and changes to transportation prices faced by businesses is captured in the PPI for transportation services.

The rail transportation PPI grew more rapidly (64.5 percent) than the PPI for any other transportation mode between 2004 and 2014. The relative prices for air and water transportation services also increased during this time period, with prices for trucking services growing at a slightly slower rate (30.8 percent) than air (42.0 percent) and water (36.7 percent) (figure 5-14). Across all modes, transportation prices faced by businesses halted their increasing trend in 2008, at the end of a period of economic growth and rising fuel prices. The cost of transportation services declined during the 2008–2009

[3] 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.

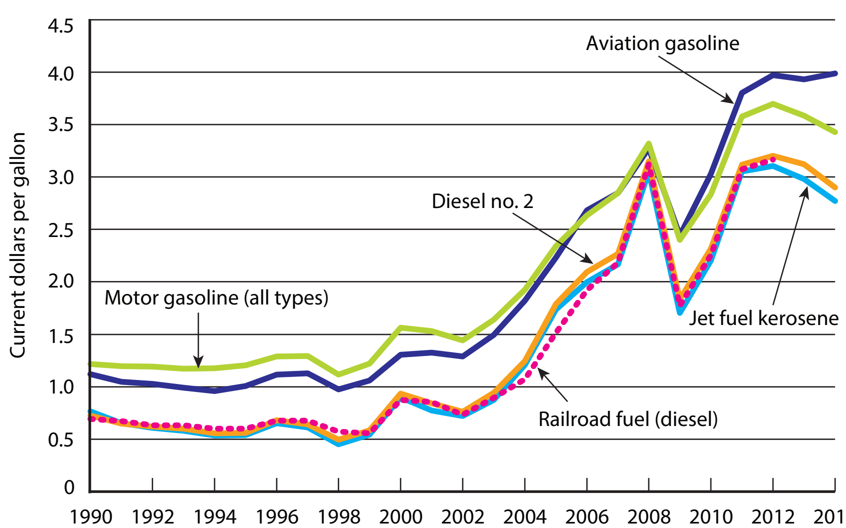
FIGURE 5-12 Average Change in Prices Faced by Transportation Providers in Purchasing Transportation Equipment



NOTE: Annual averages. Rebased to 2004. Shaded areas indicate economic recessions.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index Industry Data, available at http://www.bls.gov/data/#productivity as of April 2015.

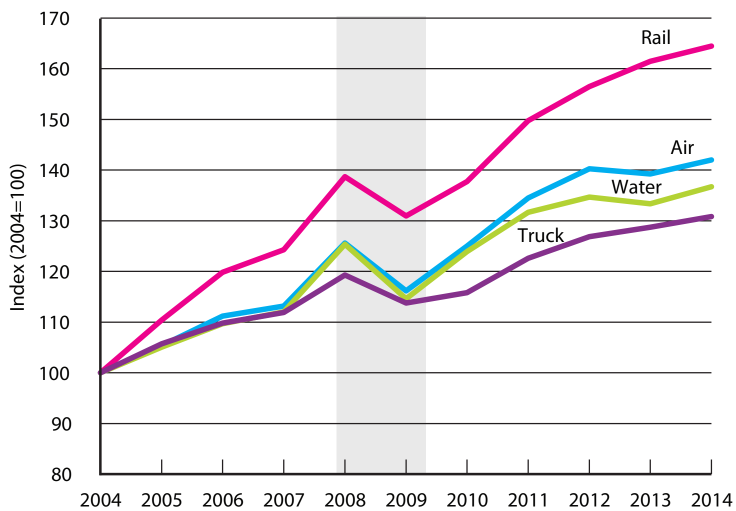
FIGURE 5-13 Sales Price of Transportation Fuel to End-Users (dollars / gallon): 1990–2013



NOTE: Railroad fuel data through 2012.

SOURCES: All data except railroad fuel: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review* (Washington, DC: October 2015), tables 9.4 and 9.7, available at http://www.eia.doe.gov/emeu/mer/prices.html as of November 2015. **Railroad fuel:** Association of American Railroads, Railroad Facts (Washington, DC: Annual Issues), p. 61.

FIGURE 5-14 Average Changes to Transportation Prices Faced by Businesses



NOTE: Annual averages. Rebased to 2004. Shaded areas indicate economic recessions.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index Industry Data, available at http://www.bls.gov/data/#productivity as of April 2015.

economic recession but has since climbed steadily (figure 5-14).

Costs Faced by Households

The costs households face for transportation services (e.g., air travel) and transportation inputs (e.g., motor vehicle fuel) impact household 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 gas, tires, and maintenance (operating costs). Fuel accounts for less than a quarter of the total annual cost of owning and operating a personal motor vehicle on a cents-per-mile basis. In 1990 fuel accounted for 16.4 percent of the total cost of owning and operating a personal motor vehicle; in 2013 fuel accounted for 22 percent of these costs (figure 5-15).

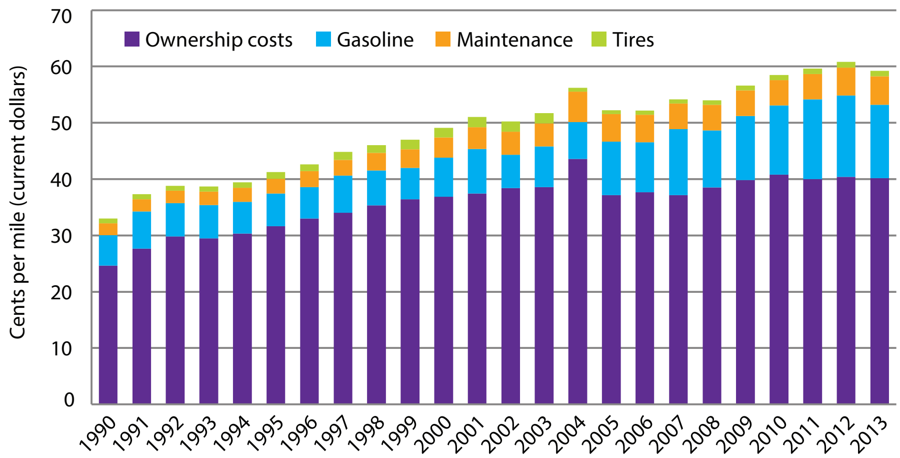
Household transportation costs grew by 62.6 percent from 2000 to 2014, according to the Consumer Price Index for Urban Consumers (CPI-U). Transportation costs fell in 2009 and marginally in 2014. [USDOL BLS CPI-U 2015].

International Trade: An Economic Impact of Transportation

Transportation and Trade

Transportation enables the export of American goods and services and connects U.S. businesses to sources of raw materials. An efficient and reliable domestic transportation

FIGURE 5-15 Average Cost of Owning and Operating an Automobile[a] (assuming 15,000 vehicle-miles per year): 1990–2013



SOURCE: American Automobile Association, *Your Driving Costs* (Heathrow, FL: Annual Issues), available at http://www.aaapublicaffairs.com as of September 2014.

system with good connection to the international transportation system supports the United States in the global market place.

In the global marketplace, the transportation industry moves goods and provides services. Looking at only goods, the value of goods traded (including exports and imports) was $3.5 trillion in 2014 (current dollars). After accounting for inflation, the real value of goods traded grew from 2000 to 2014, despite a slight decline during the 2008–2009 recession. Exports in goods drove growth in 2011 through 2014, but annual imports in goods continue to exceed exports. In 2014 the goods deficit (exports minus imports) was $771 billion in current dollars [USDOC BEA NIPA 2015].

Of the goods traded in 2014, 16.7 percent were related directly to transportation.[4] Petroleum products, including fuel oil, comprised an additional 12.8 percent of all goods traded in 2014 [USDOC BEA ITA 2015].

The transportation industry also provides transportation services, such as sea and air transport, in the global marketplace. The value of transportation services traded (exports and imports) was $184.3 million in 2014 (in current dollars). The U.S. imports more transportation services (e.g., revenue from inbound cargo of U.S. ocean carriers) than it exports (e.g., revenue from outbound cargo of U.S. ocean carriers). However, since 2007 exports have comprised an increased share of all transportation services traded. In 2014 the value of transportation services exported ($90.0 billion) was 95.6 percent of the value of transportation services imported ($94.2 billion) [USDOC BEA International Services 2015].

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

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CHAPTER 6

Transportation Safety

Highlights

- In 2013, on average, about 95 people were killed and nearly 6,400 people injured per day in transportation-related crashes.
- Transportation safety has been improving in recent decades, averaging 27 fewer fatalities and almost 2,400 fewer injuries per day in 2013 than in 2000.
- Almost 95 percent of transportation fatalities and more than 99 percent of transportation injuries involved highway motor vehicles. In 2013, there were more than 32,700 fatalities and 2,313,000 injuries on the Nation's highways.
- In 2013 nearly 4,700 pedestrians and more than 740 pedalcyclists were killed. Alcohol involvement either by the driver or the pedestrian was reported in 49 percent of all pedestrian crashes in 2013.
- Motor vehicle crashes caused an estimated $242 billion or nearly $784 per person in economic costs in 2010.
- Comparing injury rates, crash victims in cars and other light-duty vehicles were 10 times more likely to be injured than crash victims in large trucks. A motorcyclist is 5 times more likely to be injured than a passenger car occupant when involved in a crash.
- Almost 600 people were killed when they were struck by trains while trespassing on railroad property or at public highway-rail grade crossings. Recreational boating and general aviation accounted for more than 550 and about 400 fatalities, respectively.
- Human factors, such as operating a vehicle while under the influence of alcohol or while distracted, are some of the more common contributing factors to transportation fatalities. Cellphone use contributed to 71 thousand motor vehicles crashes. Many people also fail to use safety equipment, such as seat belts or DOT-compliant motorcycle helmets.

There were about 34,500 transportation-related deaths in 2013, a 3.3 percent improvement from the more than 35,700 transportation-related deaths recorded in 2012. Highway motor vehicle crashes accounted for about 94 percent of the fatalities, followed distantly by the rail, water, and air modes of transportation (table 6-1). In 2013 transportation accounted for 1.5 percent of deaths from all causes and 29.1 percent of the total deaths resulting from injury in the United States [USDHHS CDC VITALITY 2015]. There were 2.3 million nonfatal transportation-related injuries in 2013, down about 2.0 percent from 2012 [USDOT BTS NTS 2015]. Transportation-related injuries accounted for 13.5 percent of unintentional, nonfatal injuries that required a visit to the emergency room in 2013 [USDHHS CDC WISQARS 2015].

In recent decades transportation safety has improved, resulting in a considerable decline in fatalities and injuries. In 2013, despite growth in the U.S. population, the number of licensed drivers, and travel (as discussed in Chapter 1), transportation-related fatalities were down 22.1 percent from 2000 (figure 6-1). Even with the improvements, an average of about 95 people died and nearly 6,400 people were injured per day in motor vehicle crashes in 2013 (tables 6-1 and 6-3).

The timeframe and definitions used to attribute a fatality to a transportation crash or accident differ among modes according to their data collection methods, reporting periods, and information management systems. For example, a death that occurs within 30 days of an incident involving highway vehicles is considered a highway fatality, while a death that occurs within 180 days of a rail incident is considered a rail death. Such definitional differences pose challenges when comparing safety records across modes of transportation.

TABLE 6-1 Transportation Fatalities by Mode: 2000, 2010–2013

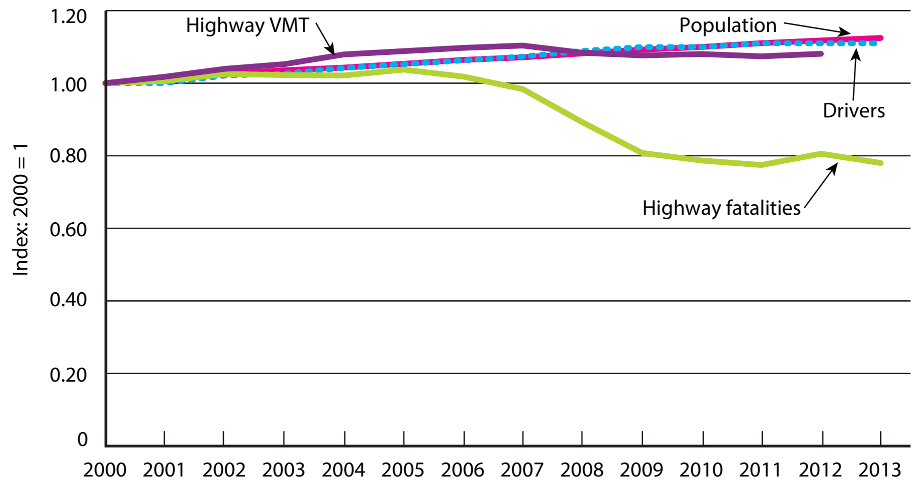
	2000	2010	2011	2012	2013
Total fatalities	**44,276**	**35,034**	**34,568**	**35,699**	**34,509**
Air	764	476	489	449	429
Highway	41,945	32,999	32,479	33,782	32,719
Railroad	937	734	691	677	706
Transit	295	221	228	264	266
Water	701	821	904	765	642
Pipeline	38	19	12	10	9
Other counts, redundant with above					
Railroad, killed at public crossing with motor vehicle	306	136	139	134	140
Transit non-rail	98	100	96	114	122
Transit rail	197	121	132	150	144

KEY: N = data do not exist; P = preliminary; U = data are unavailable.

NOTES: Please see the *National Transportation Statistics* table 2-1 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 2-1. Available at www.bts.gov as of September 2015.

FIGURE 6-1 Licensed Drivers, Resident Population, Highway Fatalities, Highway Vehicle-Miles Traveled (VMT): 2000-2013



SOURCES: Drivers and Resident Population: U.S. Department of Transportation (USDOT), Federal Highway Administration, *Highway Statistics 2013*, tables DL-1C and MV-1, available at http://www.fhwa.dot.gov/policyinformation/statistics/2013 as of June 2015. **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 November 2015.

Box 6-A shows fatality reporting requirements for several modes of transportation.

Fatalities by Mode

Table 6-1 shows that in 2013 transportation-related fatalities decreased by almost 10,000 (22.1 percent) from the number tallied in 2000. Despite this improvement, about 34,500 people died in transportation-related incidents in 2013. Many preventive measures, such as child safety seats, graduated driver licensing, increased seat belt use, expanded enforcement of drunk-driving and driving under the influence laws, and education and enforcement, contributed to declines in highway vehicles deaths and injuries [USDHHS CDC NCI 2010]. Improvements in emergency medical response capabilities also played a role.

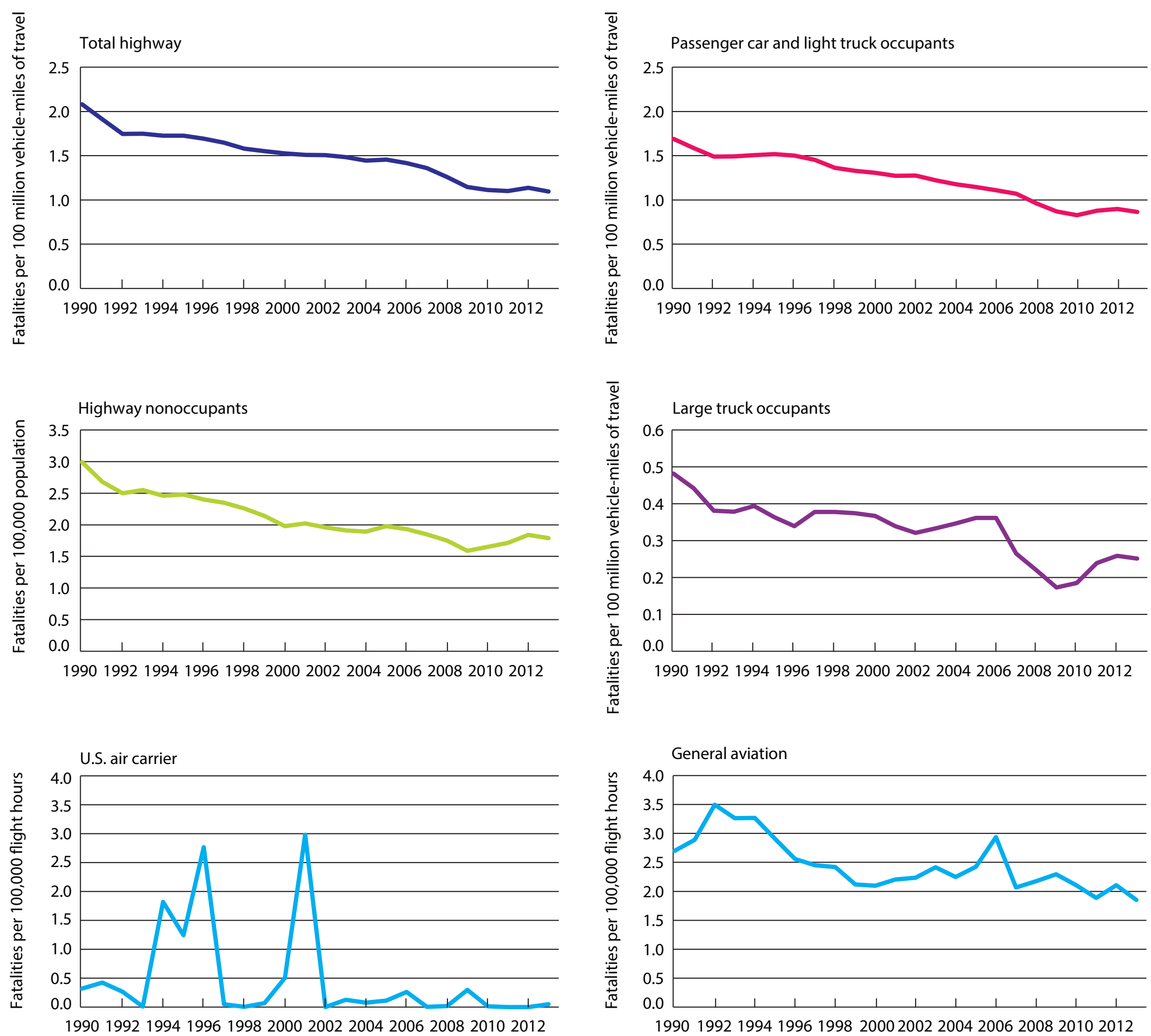
From 1990 through 2013, the overall rate of highway fatalities per vehicle-mile of travel (VMT) declined by 47.6 percent as the highway modes, except for motorcycles, showed across-the-board reductions. Fatalities per 100 million VMT for light-duty vehicle occupants (passenger cars and light trucks), as shown in figure 6-2, decreased 49.1 percent, followed by decreases in the fatality rates of large-truck occupants and highway nonoccupants (e.g., pedestrians, pedalcyclists,

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

KEY: USDOT = U.S. Department of Transportation; USDHS = U.S. Department of Homeland Security.

FIGURE 6-2 Fatality Rates for Select Modes of Transportation: 1990–2013



NOTES: Graphs with same color trend lines have identical scales. *Air carrier* fatalities resulting from the Sept. 11, 2001 terrorist acts include only onboard fatalities. *Nonoccupant* includes pedestrians and riders of nonmotorized bicycles and other pedal-powered vehicles and is measured on a per capita basis because exposure based estimates are not available.

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, and 2-23. Available at www.bts.gov as of March 2015.

BOX 6-B Fatality Reporting

There are two major sources for national reporting of transportation fatalities, most notably for highway fatalities—the U.S. Department of Health and Human Services, Centers for Disease Control's National Vital Statistics System (NVSS) and the U.S. Department of Transportation, National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS). Each data source has its own unique data collection and reporting criteria designed to fulfill the particular needs of the collecting agency. For example, the NVSS reported 35,400 highway fatalities and FARS reported over 32,700 highway fatalities in 2013 [USDHHS CDC VITALITY 2015].

The NVSS is based on death certificates recorded according to the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* (ICD–10) specifications and include not only fatalities that occurred on public roads, but off-road fatalities such as those attributed to bulldozers on non-highway construction sites and harvesters on farms. FARS is based on police accident reports and mostly includes highway fatalities that occurred on public roads. Such differences in data collection, coding schemas, and reporting criteria lead to differing numbers.

and other fatalities per 100,000 population) of 47.9 and 40.1 percent, respectively. Human factors, advances in vehicle design, and improved road design all contributed to these improvements [USDOT NHTSA 2012].

While reductions in fatalities and injuries have been the greatest on the highway, other modes, including general aviation, railway, and recreational boating, have also improved safety records. Figure 6-2 shows that the safety record of air carriers (as measured by fatalities per departure) has remained stable and low. But despite the fact that the general aviation fatality rate (as measured by fatalities per flight hour) decreased by 31.4 percent from 1990 to 2013, over 400 people died in general aviation crashes in 2013.

Highway

In 2013 passenger car and light truck (e.g., sport utility vehicle, minivan, and pickup truck) occupants comprised 61.2 percent of all transportation fatalities (table 6-2). Passenger car and light truck fatalities have declined about 11,100 since 2000, with the reduction in passenger car fatalities accounting for 8,700 of the decrease [USDOT BTS 2015].

In 2013 nearly 4,700 motorcyclists died. While the miles logged by motorcycles represented less than 1 percent of total highway vehicle-miles traveled in 2013, motorcycle fatalities accounted for 13.5 percent of total transportation-related fatalities, increasing nearly 1,800 from 2000 when they accounted for 6.5 percent of transportation-related fatalities. Several factors contributed to this increase, which are discussed later in the chapter (e.g., growing ridership, failing to wear a DOT-compliant helmet). The rise in the percentage share of motorcyclist fatalities also reflects the drop in the share of deaths attributable to other highway categories and nonhighway modes of transportation.

TABLE 6-2 Distribution of Transportation Fatalities: 2013

	2000		2010		2011		2012		2013	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
TOTAL fatalities	**44,276**	**100.0**	**35,034**	**100.0**	**34,568**	**100.0**	**35,699**	**100.0**	**34,509**	**100.0**
Passenger car occupants	20,699	46.7	12,491	35.7	12,014	34.8	12,361	34.6	11,977	34.7
Truck occupants, light	11,526	26.0	9,782	27.9	9,302	26.9	9,418	26.4	9,155	26.5
Pedestrians	4,763	10.8	4,302	12.3	4,457	12.9	4,818	13.5	4,735	13.7
Motorcyclists	2,897	6.5	4,518	12.9	4,630	13.4	4,986	14.0	4,668	13.5
Pedalcyclists	693	1.6	623	1.8	682	2.0	734	2.1	743	2.2
Highway, other incident	591	1.3	709	2.0	699	2.0	729	2.0	702	2.0
Truck occupants, large	754	1.7	530	1.5	640	1.9	697	2.0	691	2.0
Recreational boating	701	1.6	672	1.9	758	2.2	651	1.8	560	1.6
Railroad, trespassers	463	1.0	440	1.3	405	1.2	413	1.2	432	1.3
General aviation	596	1.3	457	1.3	448	1.3	440	1.2	387	1.1
Highway-rail grade crossing	425	1.0	261	0.7	250	0.7	230	0.6	231	0.7
Transit, other incident	N	N	166	0.5	189	0.5	192	0.5	196	0.6
Transit passenger/occupant	N	N	49	0.1	36	0.1	67	0.2	60	0.2
Water, passenger	N	N	87	0.2	96	0.3	84	0.2	57	0.2
Bus occupants	22	0.0	44	0.1	55	0.2	39	0.1	48	0.1
Rail, other incidents	39	0.1	25	0.1	30	0.1	25	0.1	32	0.1
On-demand air taxi	71	0.2	17	0.0	41	0.1	9	0.0	27	0.1
Water, industrial/other	N	N	40	0.1	32	0.1	16	0.0	17	0.0
Train accidents	10	0.0	8	0.0	6	0.0	9	0.0	11	0.0
Train employee/worker	N	N	6	0.0	3	0.0	5	0.0	10	0.0
U.S. air carrier	92	0.2	2	0.0	0	0.0	0	0.0	9	0.0
Water, freight	N	N	22	0.1	18	0.1	14	0.0	8	0.0
Gas pipeline	37	0.1	18	0.1	11	0.0	7	0.0	8	0.0
Commuter carrier	5	0.0	0	0.0	0	0.0	0	0.0	6	0.0
Hazardous liquid pipeline	1	0.0	1	0.0	1	0.0	3	0.0	1	0.0
Other counts, redundant with above										
Rail, freight	717	1.6	519	1.5	497	1.4	478	1.3	509	1.5
Rail, passenger	220	0.5	215	0.6	194	0.6	200	0.6	198	0.6
Transit, rail	197	0.4	120	0.3	132	0.4	150	0.4	144	0.4
Railroad, killed at public crossingwith motor vehicle	306	0.7	136	0.4	139	0.4	134	0.4	140	0.4
Transit, non-rail	98	0.2	100	0.3	96	0.3	114	0.3	122	0.4

KEY: N = data do not exist.

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.

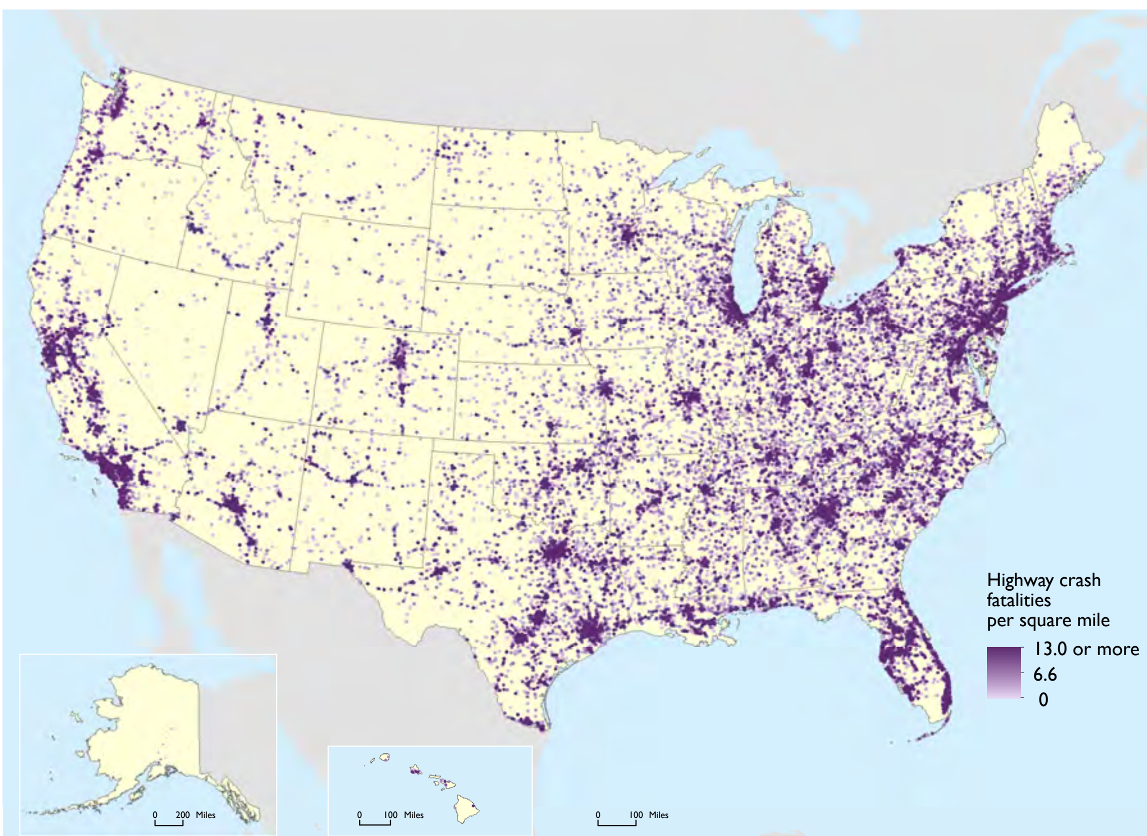
SOURCES: Various sources as cited U.S. Department of Transportation, Bureau of Transportation, *National Transportation Statistics*, table 2-4. Available at www.bts.gov as of July 2015.

In 2013 nearly 5,500 pedestrians and pedalcyclists were struck and killed by motor vehicles, up from about 5,100 in 2010. Pedestrians and pedalcyclists—who increasingly share the roads with motor vehicles—accounted for 15.9 percent of total transportation-related deaths in 2013, thus they account for a larger share today than in 2000 (12.3 percent).

Highway fatalities in 2013 were concentrated along the major corridors in the populated areas of California, Florida, Illinois, Texas, and throughout the populous and heavily traveled Northeast region near Boston, MA, down to the Middle Atlantic region, near Washington, DC. In addition, fatalities were also highly concentrated along major highway corridors and around urban areas in the South Atlantic region (figure 6-3).

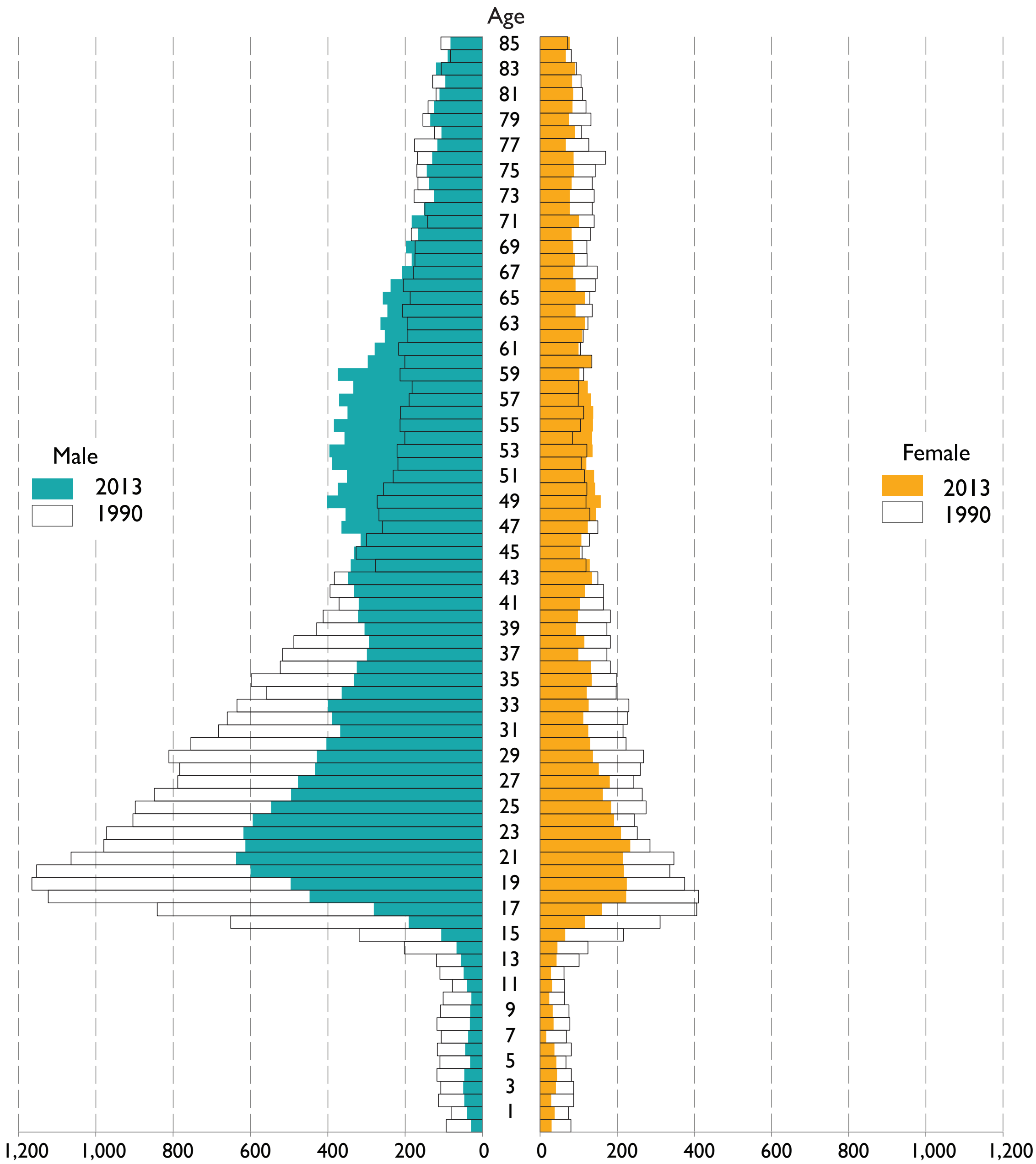
In 2013 the ratio of males to females in the total U.S. population was 0.97, with females outnumbering males by about 5 million [USDOC CENSUS 2014]. However, the number of males killed on the highway exceeded the number of females killed for most age groups in 1990 and 2013 (figure 6-4). This difference is partially due to the fact that males, on average, drive more than females and thus have a higher rate of exposure to accidents.

FIGURE 6-3 Highway Crash Fatalities: 2013



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Fatality Analysis Reporting System*, available at www.fars.nhtsa.dot.gov as of March 2015.

FIGURE 6-4 Fatalities Number by Age and Sex: 1990 and 2013



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Fatality Analysis Reporting System*, available at ftp.nhtsa.dot.gov as of March 2015.

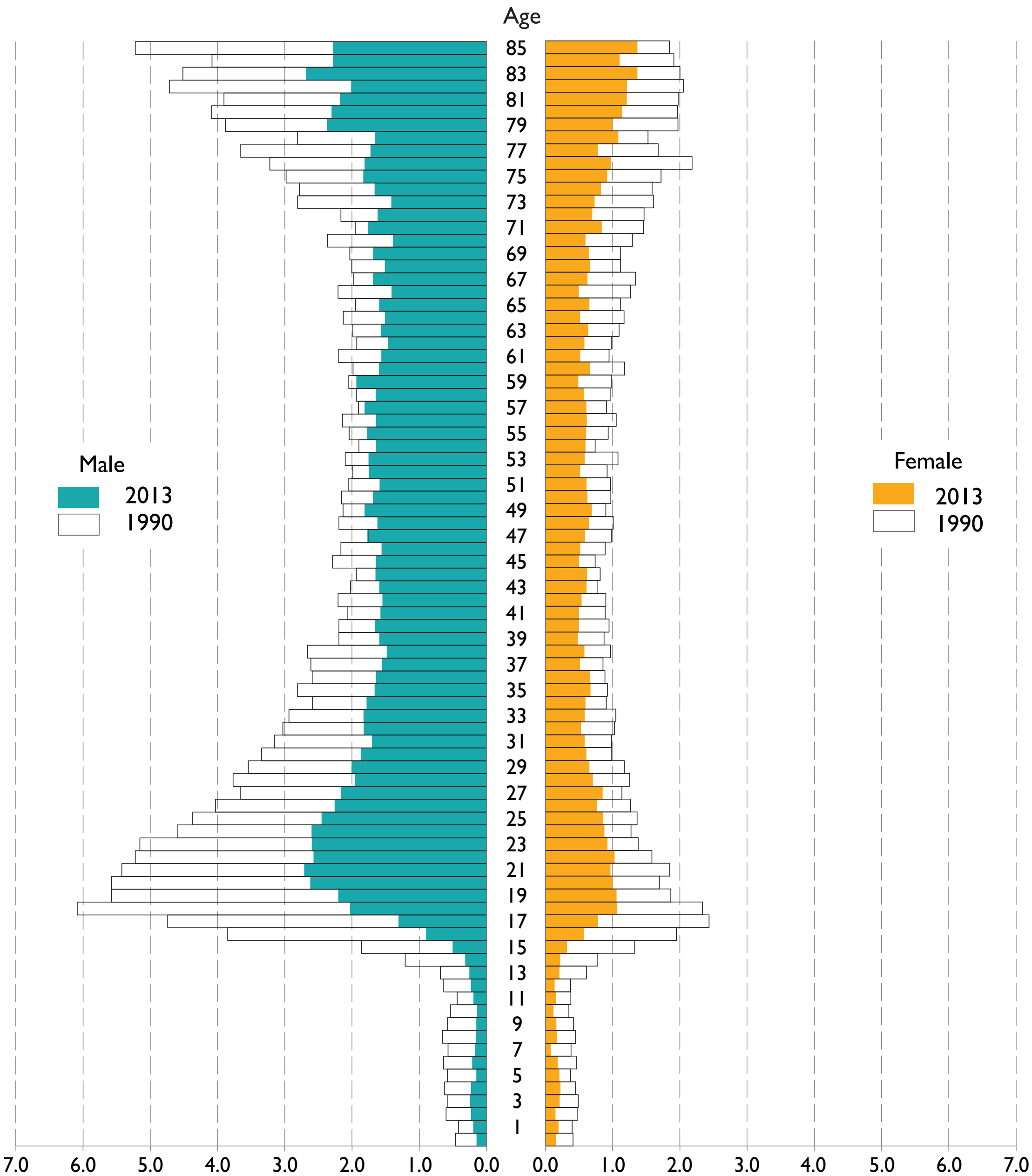
Teenagers and younger adults had the highest fatality numbers in 2013, although their deaths have declined considerably since 1990. A potential contributing factor is that those under age of 30 in 2013 drove significantly less miles than their 1990 counterparts, reducing the exposure to highway crashes.

In 2013 males comprised 70.7 percent of highway fatalities, up slightly from 69.3 percent in 1990. The greatest numbers of highway fatalities by age and gender in 2013 were among 21-year-old males and 22-year-old females (figure 6-4). Motor vehicle crashes are the leading cause of death for teens aged 16 to 20 years [USDHHS CDC WISQARS 2015]

Graduated driver licensing (GDL) programs were established to help inexperienced, young drivers safely gain experience while limiting their exposure to high-risk driving conditions, such as night driving and carrying teen passengers during early months of licensure. GDL programs along with other factors have contributed to a considerable reduction in teenage and young adult fatal and nonfatal injury crashes [USDHHS CDC PHLP 2014].

Since 1990 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 in both 2013 and 1990 were among males between the ages of 18 and 29, followed by those 79 and older. Female fatalities per capita in both 2013 and 1990 peaked for those between 16 and 27 years of age, followed by those over the age of 80. The 1990 rates were again higher (figure 6-5).

FIGURE 6-5 Fatalities Rate by Age and Sex: 1990 and 2013

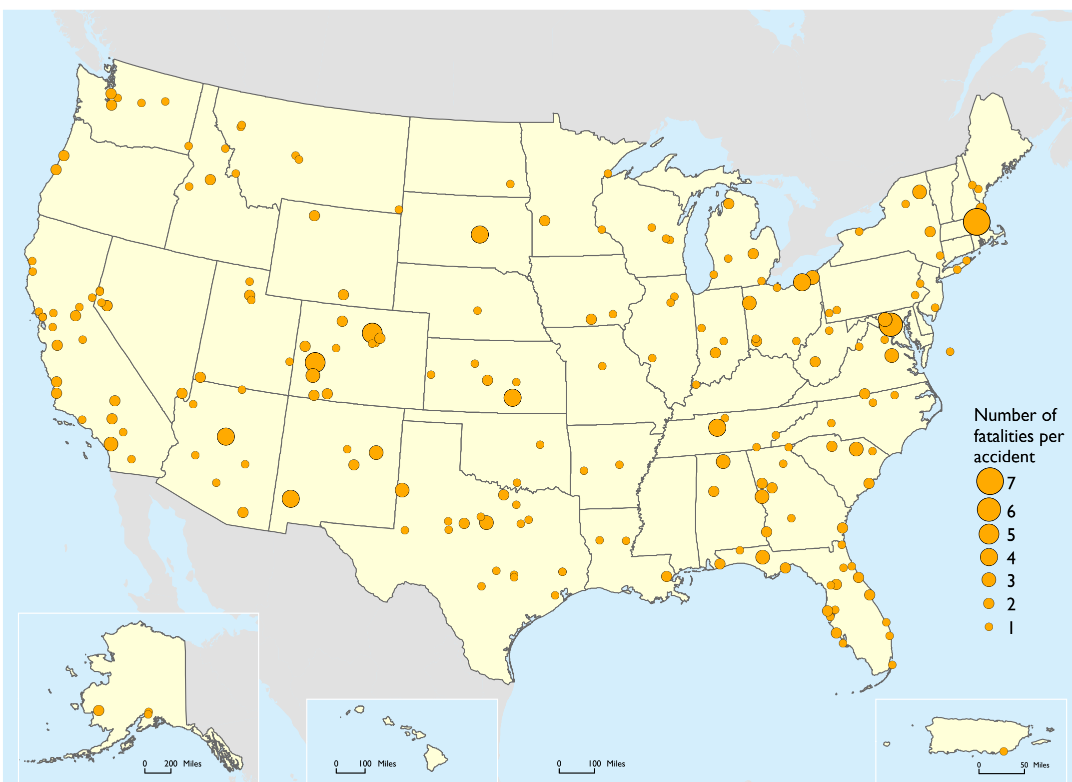


SOURCES: Fatality Data: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Fatality Analysis Reporting System*, available at ftp.nhtsa.dot.gov as of March 2015. **Population Data**: U.S. Department of Commerce, U.S. Census Bureau, available at www.census.gov as of March 2015.

Aviation

Unlike the large U.S. air carriers and commuter airlines, which combined had less than 20 fatalities in 2013, each year general aviation fatalities number in the hundreds. In 2013 about 390 people were killed in general aviation accidents (table 6-1), but even this relatively high number represents a significant drop from previous years. In the 10 years spanning 1990 to 1999, general aviation accidents killed an average of 716 persons per year and then dropped to 567 deaths per year in the following decade. Most general aviation accidents involved single-engine, piston-powered airplanes, which account for the majority of general aviation aircraft and flight hours [USDOT FAA 2013]. The loss of control inflight contributed 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]. Ballistic parachutes are a standard feature on some general aviation airplanes and are retrofitted to others. They can help prevent fatal or serious injuries from mid-air collisions, loss of engine power, loss of airplane control, structural failure, pilot disorientation, or pilot incapacitation with a passenger on board [GPO FR 1997].

FIGURE 6-6 General Aviation Fatalities: 2014



SOURCE: National Transportation Safety Board, *Aviation Accident Database*, available at http://www.ntsb.gov/ as of July 2015.

BOX 6-C Drones Pose New Aviation Threat

The rising popularity of unmanned aircraft systems (UAS), commonly known as "drones," presents a major safety risk to manned aircraft crews, airline passengers, and anyone below their flight paths. For example, unauthorized UAS flights recently interfered with aerial tankers battling wildfires, which grounded the manned aircraft and put firefighters on the ground at greater risk [USDOT FAA 2015a].

In all of 2014, pilots reported 238 unmanned aircraft sightings. But as of Aug. 9, 2015, pilots of all aircraft types, including large, commercial passenger aircraft reported more than 650 UAS sightings. In June 2015 alone, 138 pilots reported seeing drones at altitudes up to 10,000 feet, up from 16 reported sightings in June 2014. Unauthorized drone operators may be subject to fines of up to $25,000 and 20 years in jail [USDOT FAA 2015b].

On October 19, the U.S. Department of Transportation announced plans to develop an Unmanned Aircraft Systems (UAS) registration process, which helps hold unsafe operators accountable and responsible for ensuring public safety in the air and on the ground [USDOT FAA 2015c].

References

U.S. Department of Transportation (USDOT), Federal Aviation Administration (FAA):

—2015a. FAA: Wildfires and Drones Don't Mix. Available at http://www.faa.gov/ as of August 2015.

—2015b. Pilot Reports of Close Calls With Drones Soar in 2015. Available at http://www.faa.gov/ as of August 2015.

—2015c. U.S. Transportation Secretary Anthony Foxx Announces Unmanned Aircraft Registration Available at https://www.transportation.gov/ as of October 2015.

Fatal general aviation accidents were widely dispersed across the country in 2014. Nearly two-thirds of general aviation accidents resulted in a single fatality, another quarter resulted in two fatalities, and the remainder yielded multiple fatalities (figure 6-6). The popularity of unmanned aircraft systems (UAS), commonly known as "drones," poses several challenges, which are discussed in box 6-C.

Recreational Boating

Recreational boating accounted for 560 transportation-related fatalities in 2013, second to number of fatalities occurring in highway crashes (table 6-1). 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 [USDHS USCG 2014].

Other Modes

Pipeline fatalities averaged about 15 per year between 2000 and 2013. Transit fatalities in 2013 were about 30 less than they were in 2000 (a 9.8 percent drop). In 2013 rail fatalities—primarily those killed when they were struck by trains while trespassing on railroad property—decreased 24.7 percent from 2000. Rail transit accounts for most of the decline in transit fatalities, but still accounts for slightly more than half all transit fatalities (table 6-2).

Injured People by Mode

All transportation-related injuries declined about 885,000 (27.5 percent) in 2013 from 2000 (table 6-3), which was largely due to an 876,000 (27.5 percent) reduction in highway-related injuries over that time period. All modes of transportation showed a decline in injuries between 2000 and 2013. Highway modes accounted for 99.1 percent of 2013 transportation injuries.

According to National Highway Traffic Safety Administration (NHTSA) estimates, there were more than 2.3 million people injured in highway crashes in 2013. In contrast to fatalities, which are pulled from police accident reports and a census of all fatal accidents, NHTSA estimates the total number of people injured 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 6,300 people per day are injured in motor vehicle crashes.

In addition to the people injured on the Nation's highways, in 2013 about 21,000 people were injured in nonhighway-related incidents. Rail and rail transit accounted for the greatest number of injuries (about 9,100 and 8,800, respectively), followed by water (about 3,400)—mostly from recreational boating.

The injury rate for highway crashes per vehicle-miles traveled in 2013 was 66.4 percent of that in 2000. Comparing injury rates, crash victims in cars and other light-duty vehicles were 10 times more likely to be injured than crash victims in large trucks (figure 6-7). The air carrier injury rate (measured by the number of injuries per departure) remained relatively low and stable, including the general aviation injury rate (measured by the number of injuries per flight hour) between 2000 and 2013.

TABLE 6-3 Transportation Injuries by Mode: 2000, 2010–2013

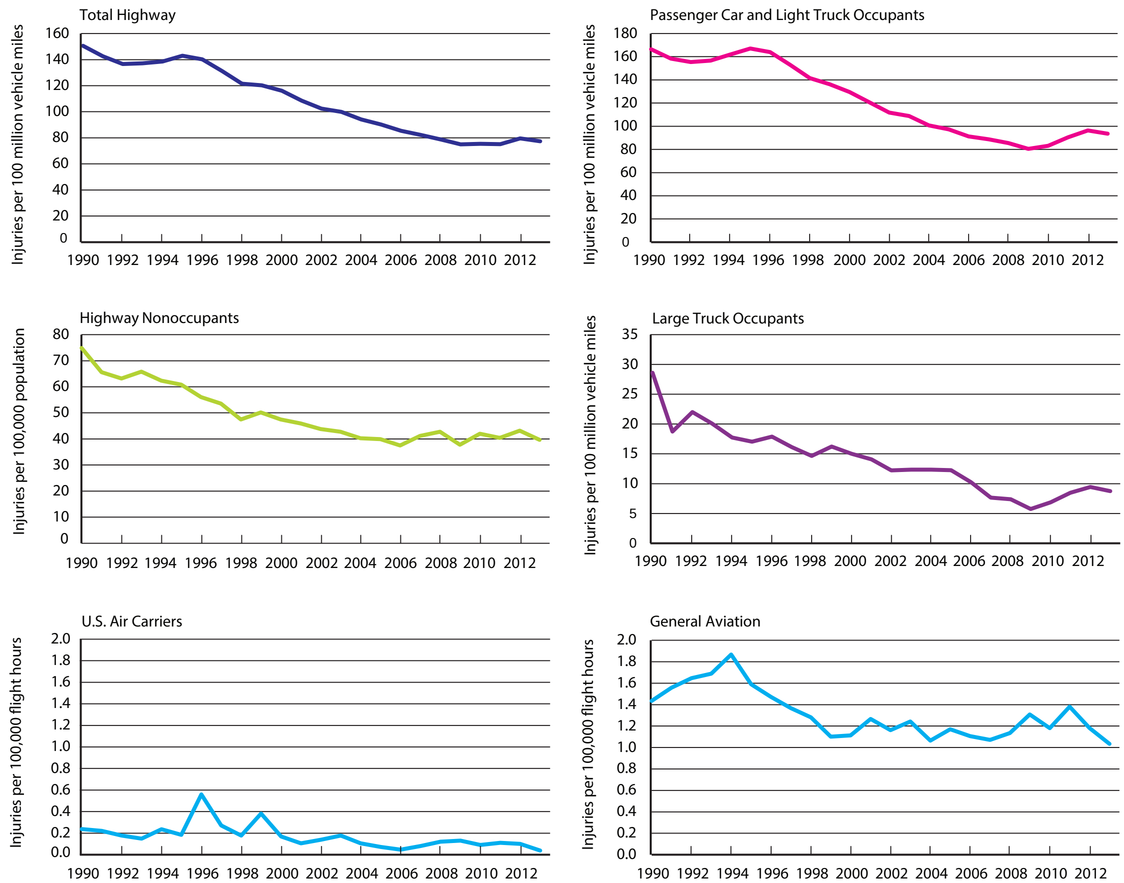
	2000	2010	2011	2012	2013
Total	**3,218,900**	**2,259,731**	**2,237,378**	**2,382,010**	**2,333,903**
Air	359	278	363	274	250
Highway	3,188,750	2,239,000	2,217,000	2,362,000	2,313,000
Railroad	12,057	8,767	8,790	8,836	9,135
Transit	56,697	25,222	22,919	23,325	24,622
Water	N	3,770	3,823	3,327	3,432
Pipeline	81	109	56	58	44
Other counts, redundant with above					
Railroad, injured at public crossing with motor vehicle	1,029	718	827	763	775
Transit non-rail	42,713	16,697	14,746	15,047	15,805
Transit rail	13,984	8,525	8,173	8,278	8,817

KEY: N = data do not exist.

NOTES: Please see the *National Transportation Statistics* table 2-2 for complete source notes and an expanded time-series. To reduce double counting, the following adjustments are made to *Total Injuries*: 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* 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 injuries. *Other counts, redundant with above* help eliminate double counting in the *Total injuries*. Water injury 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 2-2. Available at www.bts.gov as of September 2015.

FIGURE 6-7 Injury Rates for Select Highway Modes: 1990–2013



SOURCE: National Transportation Safety Board, *Aviation Accident Database*, available at http://www.ntsb.gov/ as of July 2015.

Costs of Motor Vehicle Crashes

Motor vehicle crashes caused an estimated $242 billion in economic costs in 2010 (the latest year for which estimates are available), up by $11.4 billion (4.9 percent) over the nearly $231 billion estimated for 2000. Approximately 27 percent (or about $3.1 billion) of the increase is attributed to inflation. The $242 billion in economic costs can be broken down as follows:

- lost productivity accounted for $77.3 billion (31.9 percent);
- property damage losses totaled $76.1 billion (31.4 percent);
- congestion impacts reached $28 billion (11.6 percent);
- medical expenses amounted to $23.4 billion (9.7 percent); and
- other crash-related costs, such as insurance administration and legal fees, accounted for the remaining 37.2 billion (15.4 percent) [USDOT NHTSA 2015b].

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 2015b].

Motorcycles accounted for less than 1 percent of the vehicle-miles traveled but 14 percent of highway fatalities in 2010, largely due to the lack of protection available to occupants of other highway vehicles and the increase in motorcycle vehicles-miles traveled. Per vehicle-mile of travel, a motorcyclist was about 30 times more likely than a passenger car occupant to die in crash and 5 times more likely to be injured. In 2010 motorcycle crashes cost $12.9 billion in economic impacts and $66 billion in comprehensive costs. Compared to other motor vehicle crashes, these costs are disproportionately caused by fatalities and serious injuries [USDOT NHTSA 2015b].

Selected Contributing Factors

Human, environmental, and vehicle factors contribute to transportation crashes. Human factors are the most common cause and involve driver errors or risky behaviors, such as speeding, driving while under the influence of alcohol or drugs, while distracted, or while fatigued. Environmental factors include roadway design (e.g., narrow lanes, no shoulders), roadway hazards (e.g., utility poles at the side of the road, plants or branches blocking views, and potholes), and operating conditions (e.g., wet roads). Vehicle factors include equipment- and maintenance-related failures (e.g., tire separations and worn out parts) [GAO 2003].

In 2013 one or more (driver-related) human factors were recorded for 70.9 percent of the drivers of passenger vehicles (cars, vans, pickup trucks, and sport utility vehicles) involved in single-vehicle fatal crashes and 51.6 percent of the passenger vehicle drivers in multi-vehicle fatal crashes. For comparison, one or more (driver-related) human factors were recorded for 55.6 percent of the drivers of large trucks involved in single-vehicle fatal crashes and for 28.1 percent of the drivers of large trucks involved in multi-vehicle fatal crashes [USDOT FMCSA 2015a].

Speeding was the most frequently coded driver-related factor for both driver types, while distracted/inattentive driving was the second most common factor for large-truck drivers, and impairment (fatigue, alcohol, illness, etc.) was the second most coded factor for passenger vehicle drivers. In 2013 vehicle factors, most commonly truck tires, were recorded for 4.3 percent of the large trucks involved in fatal crashes and 3.4 percent of the passenger vehicles involved in fatal crashes [USDOT FMCSA 2015a].

Alcohol Use

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]. Table 6-4 shows that about 10,100 people were killed in alcohol-impaired motor vehicle crashes in 2013. Figure 6-8 shows that over 6,500 (64.7 percent) were drivers with BACs of 0.08 or

TABLE 6-4 Fatalities by Highest Blood Alcohol Concentration (BAC) in Highway Crashes: 1990, 2000, 2010–2013

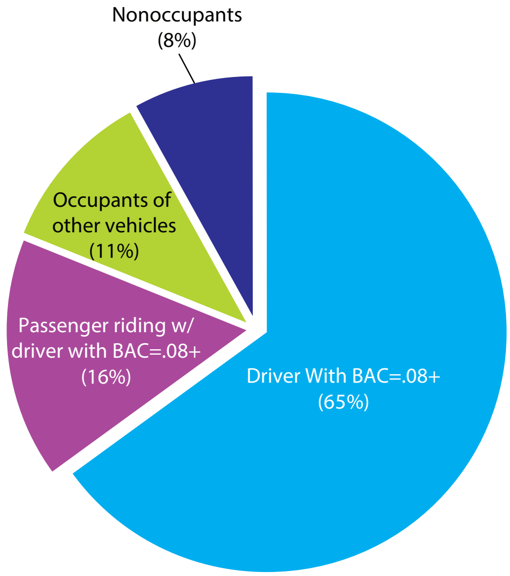
	1990	2000	2010	2011	2012	2013
Total fatalities	**44,599**	**41,945**	**32,999**	**32,479**	**33,782**	**32,719**
Fatalities in alcohol-related crashes (BAC = 0.01+)	**20,607**	**15,746**	**11,906**	**11,527**	**12,118**	**11,896**
Percent	46.2	37.5	36.1	35.5	35.9	36.4
BAC = 0.00						
Number	23,823	26,082	21,005	20,848	21,563	20,713
Percent	53.4	62.2	63.7	64.2	63.8	63.3
BAC = 0.01 - 0.07						
Number	2,901	2,422	1,771	1,662	1,782	1,820
Percent	6.5	5.8	5.4	5.1	5.3	5.6
BAC = 0.08+						
Number	17,705	13,324	10,136	9,865	10,336	10,076
Percent	39.7	31.8	30.7	30.4	30.6	30.8

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 = 0.01+) 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). Available at http://www-nrd.nhtsa.dot.gov/ as of September 2015, as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-26, available at http://www.bts.gov as of October 2015.

FIGURE 6-8 Fatalities, by Role, in Crashes Involving at Least One Driver With a BAC of .08 or Higher: 2013



SOURCE: Fatality Analysis Reporting System 2013 Annual Report File (ARF) as cited in U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA). *Impaired Driving 2013* (December 2014). DOT HS 812 010 Available at http://www.nhtsa.gov/ as of October 2013.

higher, about 1,600 were passengers of an impaired driver, nearly 1,200 were occupants of other vehicles (27.0 percent), and more than 800 were pedestrians or other nonoccupants (8.3 percent) [USDOT NHTSA 2014c]. A combination of awareness, educational, and enforcement efforts (e.g., the Drive Sober or Get Pulled Over campaign and sobriety checkpoints) has helped to raise awareness [USDOT NHTSA 2014b].

All 50 states and the District of Columbia have adopted the legal drinking age of 21 years [USDHHS NIH NIAAA 2014]. As previously mentioned, motor vehicle crashes continue to be the leading cause of death for teens aged 16 to 20 years; alcohol-impaired driving was a contributing factor in 17.2 percent of fatal crashes involving drivers aged 16 to 20 in 2013. In 2013, 666 drivers age 16 to 20 with a BAC of 0.08 or higher were killed in alcohol-impaired crashes. In 2013, 31 percent of total traffic fatalities involved a driver with a BAC of 0.08 or higher [USDOT NHTSA 2014a]. Alcohol involvement either by the driver or the pedestrian was reported in 49 percent of all fatal pedestrian crashes in 2013 [USDOT NHTSA 2015d].

In 2013 alcohol-impairment was listed as a contributing factor in 305 boating accidents, 94 fatalities, and 250 boating injuries; it was listed as the primary factor in 16.8 percent of deaths [USDHS USCG 2014]. As of Jan. 1, 2014, 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 standards [USDHHS NIH NIAAA 2014].

Distraction and Fatigue

In 2013 about 2,900 fatal crashes and an estimated 284,000 motor vehicle crashes involving distracted drivers. That year distracted driving accounted for 9.7 percent of fatal crashes, 17.9 percent of injury crashes, and 15.2 percent of all property damage only crashes involving a motor vehicle (table 6-5). Those 20 to 29 years of age accounted for the largest share (27.0 percent) of distracted driving crashes [USDOT NHTSA 2015c]. Figure 6-9 shows the trend on the percent of distracted driving related highway fatalities and injuries.

Although many activities (e.g., cellphone use, eating, sipping coffee, smoking, grooming, adjusting a radio) are distracting to drivers 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. Distraction-affected crashes involving cell phones increased from 5.2 percent in 2010 to 7.9 percent in 2013 [USDOT NHTSA 2015c].

According to a 2012 AAA Foundation for Traffic Safety survey, 88.5 percent of licensed drivers reported that they considered drivers talking on cell phones to be a “somewhat” or “very” serious risk to their personal safety. In addition, 95.7 percent of respondents considered text messaging or emailing behind the wheel risky. Further, 90.3 percent of respondents believe that distracted drivers are “somewhat” or a “much bigger” problem compared to responses given 3 years earlier [AAA 2013]. Figure 6-10 shows the 14 states and the District of Columbia that prohibit drivers’ use of handheld cell phones; and the 43 states plus

TABLE 6-5 Distraction-Affected Motor Vehicle Crashes and Distraction-Affected Crashes Involving Cell Phone Use: 2010–2013

	Total Crashes Crashes			
	Fatal crash	Injury crash	PDO crash	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	30,057	1,591,000	4,066,000	5,687,000

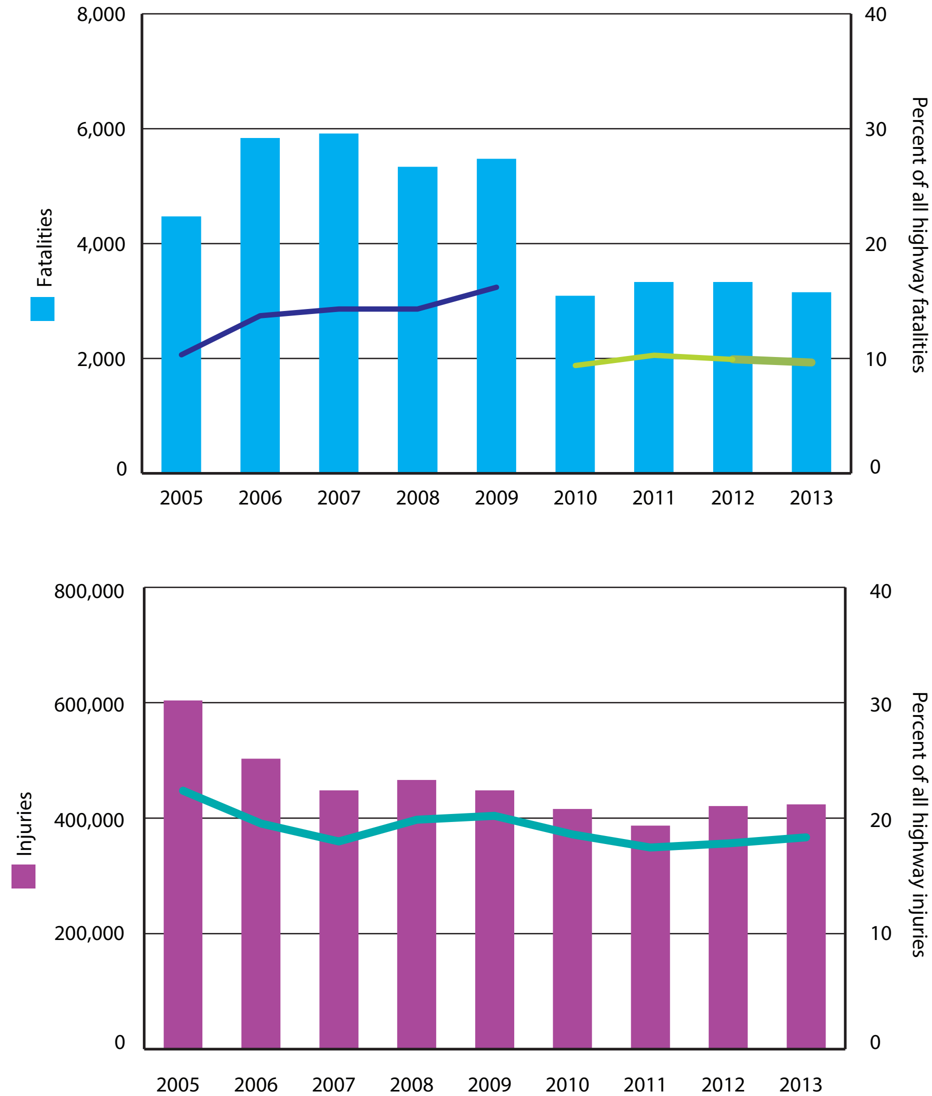
	Distraction-Affected Crashes							
	Fatal crash	% of fatal crashes	Injury crash	% of Injury crashes	PDO crash	% of PDO crashes	Total	% of total
2010	2,993	9.9%	279,000	18.1%	618,000	16%	900,000	16.6%
2011	3,047	10.2%	260,000	17.0%	563,000	15%	826,000	15.5%
2012	3,098	10.0%	286,000	17.5%	619,000	16%	908,000	16.2%
2013	2,910	9.7%	284,000	17.9%	616,000	15%	904,000	15.9%

	Distraction-Affected Crashes Involving Cell Phone Use (% of D-A Crashes)							
	Fatal crash	% of fatal crashes	Injury crash	% of injury crashes	PDO crash	% of PDO crashes	Total	% of total
2010	366	1.2%	16,000	1.0%	30,000	1%	47,000	5.2%
2011	354	1.2%	15,000	1.0%	35,000	1%	50,000	6.1%
2012	380	1.2%	21,000	1.3%	39,000	1%	60,000	6.6%
2013	411	1.4%	24,000	1.5%	47,000	1%	71,000	7.9%

KEY: D-A = distraction-affected; PDO = property damage only.

SOURCE: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA). *Distracted Driving 2013* (April 2015), Table 6. Available at http://www-nrd.nhtsa.dot.gov/ as of July 2015.

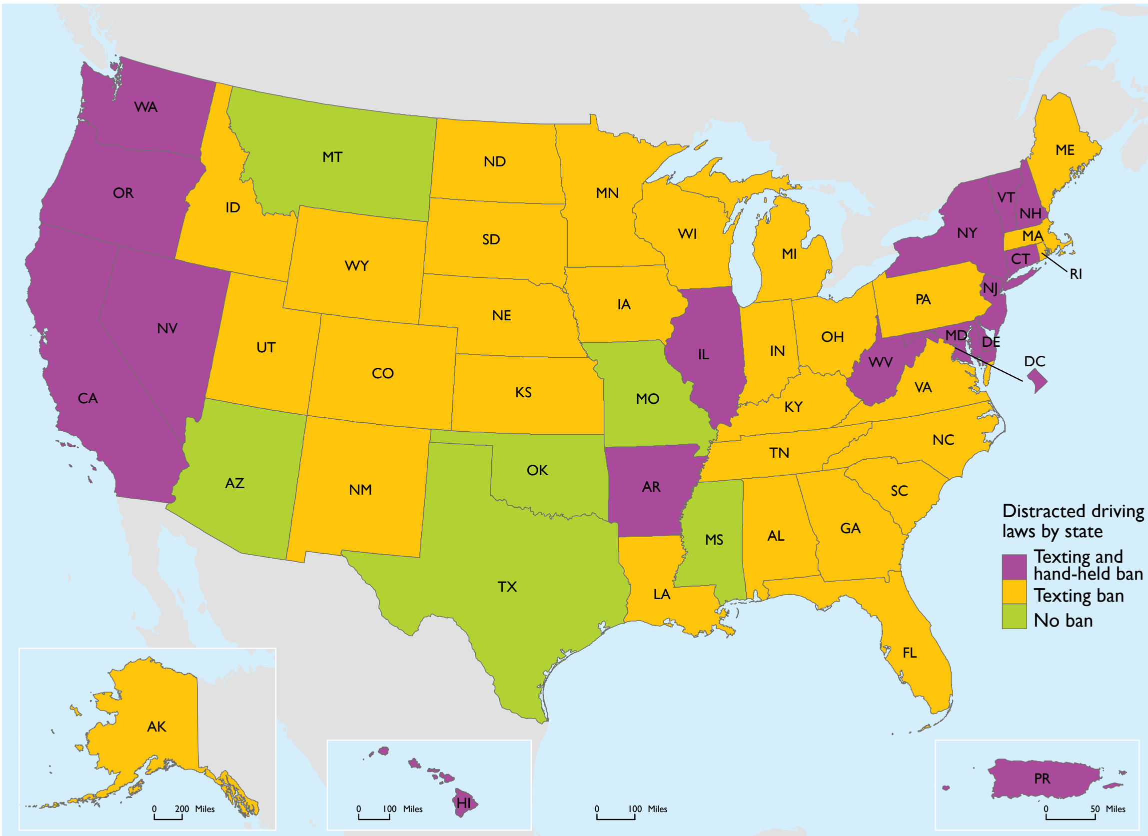
FIGURE 6-9 Distracted Driving Fatalities and Injuries: 2005–2013



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, available at www.nhtsa.gov as of September 2015.

FIGURE 6-10 State Laws on Distracted Driving Ban on Hand-Held Devices and Texting While Driving: March 2015



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, State Laws on Distracted Driving, available at http://www.distraction.gov/ as of June 10, 2015.

the District of Columbia that ban texting while driving.

Distracted driving by commercial motor vehicle drivers was a contributing factor in 5.9 percent of fatal crashes involving large trucks in 2013 [USDOT FMCSA 2015a]. Distracted driving is not just limited to motor vehicles, distracted vehicle operators are found in all modes of transportation, including airline pilots, bus drivers, train engineers, and tugboat operators [NTSB 2014b]. Operator inattention is first among the primary contributing factors in recreational boating accidents, contributing to 14.0 percent of recreational boating accidents, 10.2 percent of related fatalities, and 14.2 percent of injuries [USDHS USCG 2014].

In 2013 drowsy and fatigued driving was a factor for 1.6 percent of drivers and motorcycle riders involved in fatal crashes, down from 2.8 percent in 2012. Steps have been taken to reduce the risk. Distraction/inattention was the second most common driver-related factor, contributing to 5.9 percent of fatal crashes, involving large trucks. In addition, truck driver impairment (e.g. fatigue, drugs/alcohol, illness, etc.) was a factor in 3.8 percent of fatal crashes [USDOT FMCSA 2015a].

Lives Saved by Occupant Protection Equipment

When properly used, safety devices significantly reduce the risk of death or serious injury. NHTSA estimated that almost 16,900 lives were saved on the highways in 2013—up from about 7,500 in 1990—by occupant protection devices, including seat belts, frontal air bags, child restraints, and motorcycle helmets, as shown in table 6-6. Seat belts saved almost 12,600, frontal air bags about 2,400, child restraints almost 300, and DOT-compliant motorcycle helmets more than 1,600 lives in 2013 (table 6-6).

Another 3,500 lives could have been saved had these devices been used universally—an estimated 2,800 more lives could have been saved if seats belts were used 100 percent of the time and about 715 more from 100 percent use of DOT-compliant motorcycle helmets [USDOT NHTSA 2015a]. In total, vehicle safety technology (e.g., advanced safety technologies such as airbags, stability control, and collision warning systems, as well as preventing motorists from driving under the influence) can help prevent impending crashes by alerting drivers to dangers or helping the driver recover control of a vehicle [KAHANE 2015].

Despite such estimates, many people choose not to use seat belts or helmets. Eighty-seven percent of occupants of cars, vans, and sport utility vehicles (SUVs) used safety belts in 2013, up from 71 percent in 2000 and 85 percent in 2010. In 2013 vans and sport utility vehicles occupants had the highest seat belt usage at 90 percent, and pickup trucks occupants had the lowest at 78 percent (table 6-7).

DOT-compliant helmets are an effective safeguard, reducing the risk of dying in a motorcycle crash by 37 percent. Moreover, wearing a helmet reduces the need for emergency medical care, hospitalization,

TABLE 6-6 Estimated Lives Saved by Occupant Protection, Motorcycle Helmets, and 21-Year-Old Minimum Legal Drinking Age Law: 1990, 2000, and 2010–2013

	Child restraints	Seat belts	Frontal air bags	Motorcycle helmets	Minimum drinking age law
	Lives saved, age 4 and younger	Lives saved, age 5 and older	Lives saved, age 13 and older	Lives saved, all ages	Lives saved
1990	222	6,592	37	655	1,033
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	12,584	2,388	1,630	504

SOURCE: U.S. Department of Transportation (USDOT), 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 2015 as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-31. Available at http://www.bts.gov as of April 2015.

TABLE 6-7 Safety Belt and Motorcycle Helmet Use: 2000, 2010–2013
Percent

	2000	2010	2011	2012	2013
Overall Safety Belt Use	**71**	**85**	**84**	**86**	**87**
Drivers	72	86	84	87	88
Right-Front Passengers	68	83	82	84	85
Passenger cars	74	86	85	87	88
Vans and sport utility vehicles	U	88	87	89	90
Pickup trucks	U	75	74	77	78
Motorcycle Helmet Use[a]	**71**	**54**	**66**	**60**	**60**
Operators	72	55	67	63	62
Passengers	62	51	64	46	50

[a] 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.

KEY: U = data are unavailable.

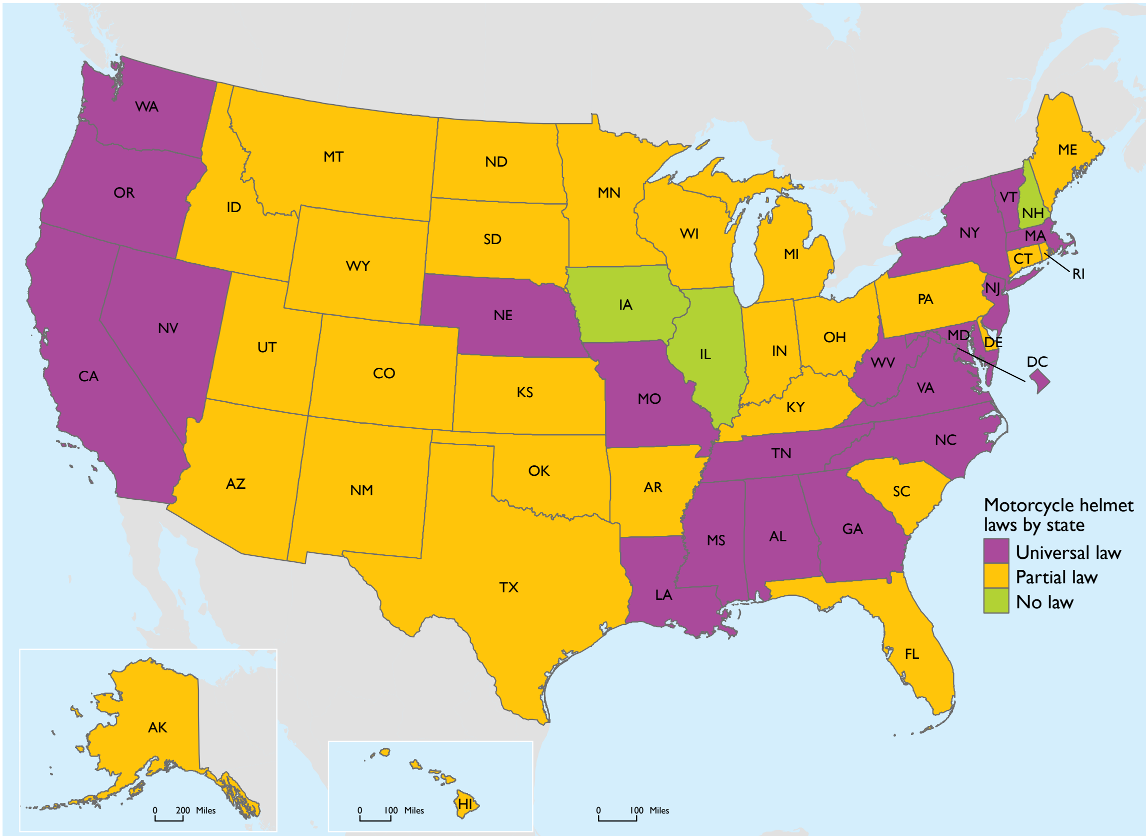
NOTE: Occupants of commercial and emergency vehicles are excluded.

SOURCES: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, Traffic Safety Facts: Research Notes, *Seat Belt Use* (Annual issues); and *Motorcycle Helmet Use—Overall Results* (Annual issues). Available at http://www-nrd.nhtsa.dot.gov as of June 2014 as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-30, available at http://www.bts.gov as of March 2015.

intensive care, rehabilitation, and long-term care following crashes involving a motorcycle [NTSB 2010]. Overall usage of DOT-compliant helmets by motorcyclists stood at 60 percent in 2013, down from 71 percent in 2000 (table 6-7). 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). 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]. By 1975, 47 states and the District of Columbia had adopted universal helmet use laws, which required motorcycle helmets for all riders. However, many states repealed such laws in the following years after the adoption of helmet laws as a prerequisite for attaining Federal highway construction funds was withdrawn in 1975 [COSGROVE 2007].

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 [USDHS USCG 2013]. In 2013, 89.3 percent of boating deaths took place on boats operated by someone who was not known to have received boating safety education [USDHS USCG 2014].

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.

Drowning accounted for 71.1 percent of all fatal boating accidents in 2013. Of these, 82.4 percent of victims were not wearing a life jacket [USDHS USCG 2013]. 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].

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 by far for the traffic stop, accounting for 46.1 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 58.5 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 accounts for only 13.7 percent of vehicle-miles traveled [USDOT FHWA NHTS 2009].

In 2013, according to the Federal Bureau of Investigation, law enforcement agencies across the country made an estimated 1.2 million arrests for driving under the influence. Males accounted for three out of four DUI arrests [USDOJ FBI 2013]. Studies have shown sobriety checkpoints are an effective countermeasure to reduce alcohol-impaired driving, saving an estimated 1,500 to 3,000 lives annually [USDHHS CDC NCI 2011].

Commercial Motor Vehicles

The Federal Motor Carrier Safety Administration (FMCSA) has a mission to reduce crashes, injuries, and fatalities involving the Nation's approximately 503,000 interstate freight carriers[1], 13,000 interstate buses, and 16,000 interstate hazardous material carriers [USDOT FMCSA 2015b]. FMCSA issued over 20,500 warning letters in 2014 to commercial motor carriers whose safety data showed a lack of compliance with motor carrier safety regulations and whose safety performance had fallen to an unacceptable level [USDOT FMCSA 2014]. Over 3.4 million roadside inspections were conducted in fiscal year 2014 (table 6-8). Vehicle violations put 20.4 percent of inspected vehicles out-of-service, while driver violations put 5.1 percent out-of-service, which commonly include hours-of-service noncompliance. Vehicle violations outnumbered driver violations 1.4 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.

[1] Most of these are independent truckers or small trucking firms.

Hazardous Materials Transportation

Transporting hazardous materials requires special precautions, handling, and packaging. There are specialized safety regulations, and standards, and reporting systems in place for pipelines, rail, highway, air, and marine vehicles that transport hazardous materials. These special requirements recognize that incidents involving the transportation of hazardous materials can affect the environment in addition to potentially risking injury and death. Table 6-9 shows more than 17,000 hazardous materials incidents in 2014, excluding pipeline. Hazardous materials shipments by mode and hazard class are discussed in chapter 3. Only 1.9 percent of these incidents are vehicle related with the remaining 98.1 percent related to other incidents, such as chemical spills from package failure or lithium ion and metal battery fires.

In 2014 less than 2 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 occur on highways or in truck terminals. Most hazardous materials incidents occur because of human error or package

TABLE 6-8 Activity Summary of Roadside Safety Inspection By Motor Carrier Inspection Type: 2010 and 2014

	2010	2014
Roadside Inspections	**3,569,373**	**3,413,211**
With no violations	1,225,324	1,363,261
With violations	2,344,049	2,050,106
Driver inspections	**3,470,871**	**3,292,651**
With OOS Violations	183,350	166,305
Driver OOS Rate	5.3%	5.1%
Vehicle inspections	**2,413,094**	**2,341,352**
With OOS Violations	480,416	476,871
Vehicle OOS Rate	19.9%	20.4%
Hazardous material inspections	**211,154**	**196,164**
With OS Violation	9,210	7,791
Hazmat OOS Rate	4.4%	4.0%

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*, special tabulation, August 2015.

TABLE 6-9 Hazardous Materials Transportation Incidents: 2010–2014

	2010	2011	2012	2013	2014
Total Incidents	**14,795**	**15,029**	**15,445**	**16,051**	**17,123**
Total Vehicular Accident / Derailment Incidents	**358**	**377**	**398**	**367**	**323**
Vehicular Accident-related Percent of Total Incidents	**2.4%**	**2.5%**	**2.6%**	**2.3%**	**1.9%**
Air	**1,295**	**1,401**	**1,460**	**1,442**	**1,321**
Vehicular Accident-related	2	2	2	3	3
Highway	**12,648**	**12,812**	**13,254**	**13,880**	**15,045**
Vehicular Accident-related	320	335	363	333	303
Rail	**747**	**745**	**661**	**666**	**711**
Vehicular Accident-related / Derailment Incidents	35	40	33	31	17
Water[1]	**105**	**71**	**70**	**63**	**46**
Vehicular Accident-related	1	0	0	0	0

[1] Water include only packages (nonbulk) marine. Non-packaged (bulk) marine hazardous material incidents are reported to the U.S. Coast Guard and are not included.

NOTES: *Incidents* are defined in the Code of Federal Regulations (CFR): 49 CFR 171.15 and 171.16 (Form F 5800.1). 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 Mar. 18, 2015). Available at https://hip.phmsa.dot.gov/ as of March 2015.

failure, particularly during loading and unloading.

Table 6-10 provides a summary of the over 700 hazardous liquid-related and gas-related pipeline incidents reported in 2014, which resulted in 19 fatalities, 96 injuries, and more than $310 million in property damage, down from $1.5 billion. Hazardous liquid accounts for about half the incidents and the majority of the property damage, down from $1.1 billion in 2010. Nearly 47,000 barrels of hazards liquids were spilled in 2014, of which 48.4 percent was recovered. Gas distribution accounts for the majority of the fatalities and injuries. Oil spills from pipelines and railroad tanker cars are discussed in more detail in chapter 7.

Statistics show that the U.S. transportation system has become safer over the past few decades, even as use increases. This improvement is true across all modes. However, despite this progress, transportation remains a leading cause of death and injury each year. To continue the reduction in the number of deaths and injuries, USDOT has established safety improvement as its top priority. As part of these efforts, several agencies within the department have established data programs to gauge the safety performance of the transportation system, and new data programs to identify potential risk factors (box 6-D).

TABLE 6-10 All Reported Hazardous Liquid and Gas Incidents: 2010–2014

Total - All reported

Year	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	$228,447,641	45,884	29,247
2013	620	10	47	$347,806,517	117,467	85,696
2014	702	19	96	$310,272,540	47,297	22,913

Gas distribution

Year	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	107	9	39	$18,426,443
2014	113	18	94	$74,859,503

Gas gathering

Year	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

continued next page

TABLE 6-10 All Reported Hazardous Liquid and Gas Incidents: 2010–2014 (continued)

Gas tranmission

Year	Number	Fatalities	Injuries	Property damage as reported
2010	107	10	61	$411,031,047
2011	118	0	1	$123,710,870
2012	103	0	7	$55,031,817
2013	105	0	2	$48,962,098
2014	132	1	1	$51,233,578

Hazardous liquid

Year	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	$144,910,768	45,884	29,247
2013	401	1	6	$278,438,819	117,467	85,696
2014	445	0	0	$105,534,704	47,297	22,913

LNG

Year	Number	Fatalities	Injuries	Property damage as reported
2010	U	U	U	U
2011	U	U	U	U
2012	1	0	0	$10,000
2013	1	0	0	$1,500
2014	3	0	1	$72,679,328

KEY: *Haz Liq* = Hazardous Liquid, *LNG* = Liquefied Natural Gas, U = Data unavailable.

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 availbale at https://hip.phmsa.dot.gov/Hip_Help/pdmpublic_incident_page_allrpt.pdf as of November 2015.

SOURCE: U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Hazardous Materials Safety, *HAZMAT Intelligence Portal* (as of November 12, 2015). Available at https://hip.phmsa.dot.gov/ as of November 2015.

BOX 6-D Close Call Data Program

The Close Call Data Program (CCDP) is a confidential, voluntary collection of precursor safety data, such as near-miss or close call data. A close call is an accident that could have happened but did not. If ignored, close calls can lead to serious consequences. CCDP's goal is to improve safety by learning from near-miss or close call incidents and unsafe conditions. CCDP identifies the root causes of close calls and develops preventative measures or corrective actions that, when implemented, can reduce the risk of a serious accident. Ultimately, the goal is to develop a safety culture in which safety critical data can be reported confidentially without the threat of administrative discipline. BTS protects data and information collected under the Confidential Information Protection and Statistical Efficiency Act of 2002, which established uniform confidentiality provisions for the disclosure and use of data for statistical purposes.

BTS operates CCDP under agreements with the Washington Metropolitan Area Transit Authority (WMATA) and the Department of the Interior's Bureau of Safety and Environmental Enforcement (BSEE), allowing employees in the transportation and energy sectors to report confidentially on close call events without the fear of disciplinary action. Based on knowledge gained from employee close call reports, WMATA has implemented a number of preventative safety actions aimed at making movements of heavy equipment safer and improving overall safety while performing various tasks on the track system by strengthening the employee training program, by supporting more thorough recordkeeping, and by enforcing stronger compliance with established procedures.

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—2014b. *Enforcement & Justice Services* (December 2014). Available at http://www.nhtsa.gov/ as of March 2015.

—2014c. *Impaired Driving 2013* (December 2014). DOT HS 812 010 Available at http://www.nhtsa.gov/ as of October 2013.

—2014c. *Motorcycle Helmet Use in 2014—Overall Results* (January 2015). DOT HS 812 110. Available at http://www.nhtsa.gov/ as of July 2015.

—2012. *An Analysis of Recent Improvements to Vehicle Safety* (June 2012). DOT HS 811 574. Available at http://www-nrd.nhtsa.dot.gov/ as of March 2014.

CHAPTER 7

Transportation Energy Use and Environmental Impacts

Highlights

- Despite transportation's continued dependence on petroleum, recent trends show decreasing import dependence, sharply reduced emissions of air pollutants, and small reductions in greenhouse gas emissions. U.S. dependence on imported oil has decreased from a high of 60.3 percent in 2005 to 26.5 percent in 2014, 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 has decreased from a peak of 97.3 percent of transportation energy use in 1978 to 91.5 percent in 2014. This is due in part to increased blending of domestically produced ethanol in gasoline and improved fuel economy.

- The highway mode continues to dominate transportation energy use. Highway vehicles used 83.2 percent of total transportation energy in 2013, with personal vehicles accounting for 71.1 percent of highway energy use and 59.2 percent of total transportation energy use.

- Transportation is the second largest producer of greenhouse gas emissions (GHG), accounting for 27 percent of total U.S. emissions in 2013. Aside from greenhouse gases, the six most widespread or common air pollutant emissions from transportation fell below their 1990 levels, and continued to decline from 2009 to 2014 due to many factors, including motor vehicle emissions controls that have contributed to considerable reductions.

- Across the 169 continuously monitored urban areas, the total number of very unhealthy air quality days that could trigger heath emergences warnings rose from 291 in 1990 to 361 in 2014.

- Significant pipeline oil spill incidents involved annual average spillage of about 69,000 barrels of oil (or 2,898,000 gallons) and other hazardous liquids each year for the 3-year period 2012 through 2014. Between

2010 and 2013, derailments of oil tank cars released on average slightly less than 600,000 gallons per year.

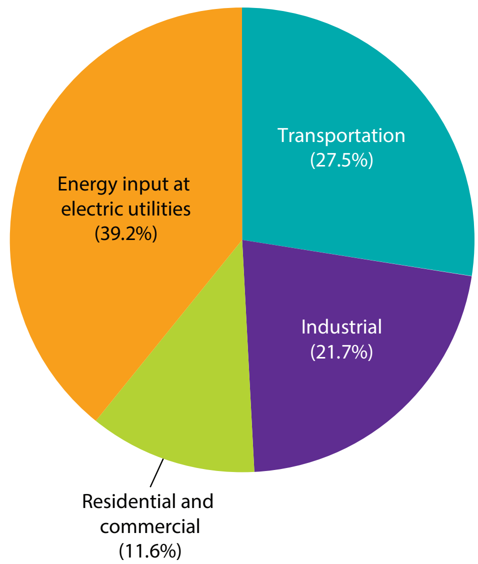
- The energy required to move one person one mile, or one ton of freight one mile has generally declined over time.

This chapter reviews the patterns and trends in transportation energy use energy and transportation's impact on the environment. These 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 reduce U.S. petroleum dependence on imported oil as a result of increased domestic production and improved fuel economy. U.S. dependence on imported oil peaked at 60.3 percent in 2005, but has since decreased from 49.2 percent in 2010 to 26.5 percent in 2014 [USDOE EIA 2015b].

In 2014 the U.S. transportation sector used 27.1 quadrillion Btu (British thermal unit) of energy, second only to electricity generation but down from the peak of 28.9 quadrillion Btu in 2007 (figures 7-1 and 7-2).[1] Transportation relied on petroleum for 91.5 percent of the energy it used in 2014, down from a peak of 97.3 percent in 1978 (figure 7-2). The United States consumes more than 19.0 million barrels of oil per day, of which 13.4 million barrels (70.5 percent) are consumed by the U.S. transportation system [USDOE EIA 2015b]. Despite transportation's continued dependence on petroleum, recent trends show decreasing import dependence, sharply reduced emissions of air pollutants, and small reductions in greenhouse gas emissions.

FIGURE 7-1 U.S. Energy Use by Sector: 2014



KEY: Btu = British thermal unit.

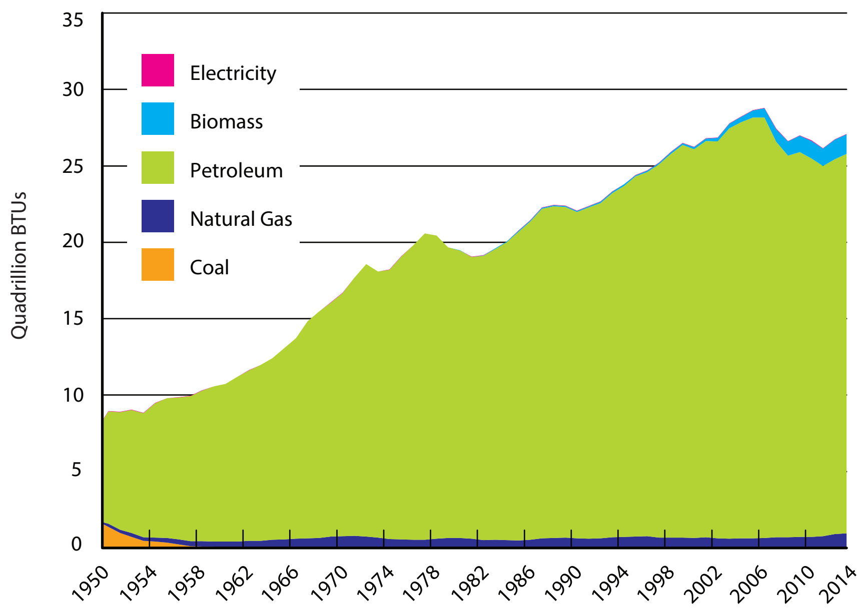
NOTES: The data for *Residential, Commercial, and Industrial* sectors include only fossil fuels consumed directly. Most renewable fuels are not included. The data for the *Transportation* sector includes only fossil and renewable fuels consumed directly. The data for *Electric utilities* includes all 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 June 2015.

Greenhouse gas (GHG) emissions (carbon dioxide, hydrofluorocarbons, methane, and nitrous oxide) closely parallel transportation energy use and, as a result, were 16.4 percent higher in 2013 than in 1990 [USEPA 2015a]. Between 2005 and 2013, however,

[1] Total transportation energy use reported in 2014 is about 1 quad higher than the detailed 2013 modal breakdown shown in table 7-1. Differences in definitions, data sources, and estimation methods also may account for the difference. For example, table 7-1 excludes some off-highway use of gasoline and diesel fuel as well as energy for international air transport and shipping.

FIGURE 7-2 Transportation Energy Use by Energy Source: 1950-2014



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 June 2015.

transportation GHG emissions decreased as a result of less vehicle travel, improved energy efficiency, and increased use of biofuels. GHG emissions increased slightly from 2012 to 2013 [USEPA 2015a].

Energy Use Patterns and Trends

Transportation's petroleum dependence decreased from 96.3 percent in 2005 to about 91.5 percent in 2014, chiefly due to increased blending of domestically produced ethanol from biomass in gasoline [USDOE EIA 2015b]. Today almost all gasoline sold in the United States contains 10 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. Recently, lower prices and abundant domestic supplies have increased interest in natural gas as a motor fuel (figure 7-2).

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 tightened fuel economy standards [USDOE EIA 2015c]. 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, freight tonnage is forecast to grow 1.3 percent annually during this period (table 3-1).

Alternative fuels use (excluding gasohol) by motor vehicles is increasing. Total alternative fuel use exceeded 500 million gasoline-equivalent gallons in 2011, up 12.7 percent over 2010 levels, the latest year for which data are available [USDOE EIA 2013b]. In comparison, gasoline consumption[2] in the United States has grown from about 134 billion gallons in 2011 to nearly 137 billion gallons in 2014. [USDOE EIA 2015b]. Compressed and liquefied natural gas accounted for almost one half of the total, 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.

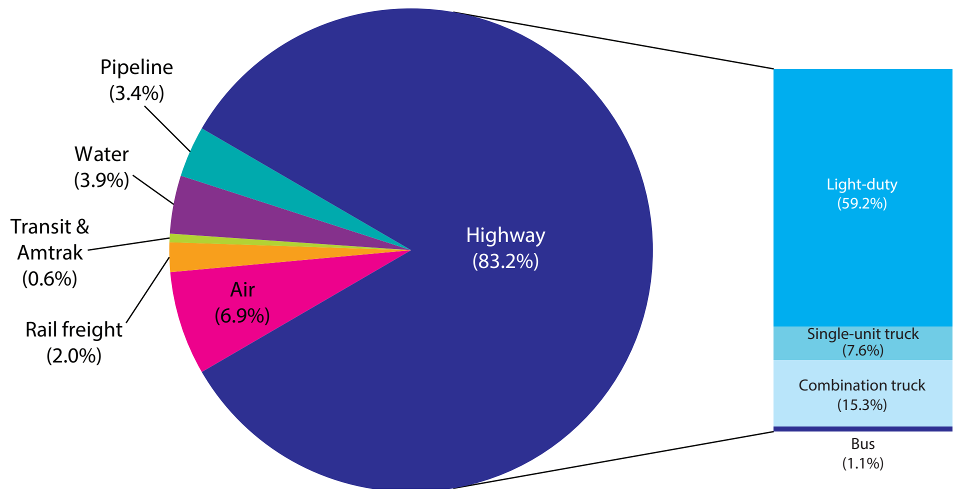
The highway mode dominates transportation energy use (figure 7-3). Highway vehicles used five times more energy than all other modes combined in 2013. Light-duty vehicles (passenger cars, sport utility vehicles, minivans, and pick-up trucks) accounted for 71.1 percent of highway energy use and 59.2 percent of total transportation energy use. The predominance of the highway mode in domestic transportation energy use in 2013 is shown in greater detail in table 7-1. Highway vehicles accounted for 83.2 percent of the total. Air transport came in a distant second with 6.9 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 3.9 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]. This is more than double the amount 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.

[2] 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.

Greenhouse Gas Emissions

The transportation sector is the second largest producer of greenhouse gas (GHG) emissions, accounting for approximately 27 percent of total U.S. emissions in 2013 [USEPA 2015a]. 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. Passenger cars were the largest source of CO_2 from transportation, accounting for 42.7 percent, followed by freight trucks (22.8 percent), and light-duty trucks (17.0 percent). Domestic operation of commercial aircraft produced 6.6 percent of transportation CO_2 emissions, while pipelines were responsible for 2.8 percent of emissions, followed by rail (2.8 percent) and ships and boats (2.3 percent) [USEPA 2015a].

FIGURE 7-3 Energy Use by Mode of Transportation: 2013



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/ft^3.
Electricity 1kWh = 3,412 Btu, negating electrical system losses.
To include approximate electrical system losses, multiply this conversion factor by 3.

SOURCES: 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 March 2015.

TABLE 7-1 Domestic Transportation Energy Use by Mode: 2013

Energy and physical units of measure

	Trillion Btu	Percent of total	Units	Physical units
Air				
Certificated carriers[a]				
Jet fuel	1,595	6.1%	million gallons	11,812
General aviation[b]				
Aviation gasoline	24	0.1%	million gallons	202
Jet fuel	191	0.7%	million gallons	1,413
Highway				
Gasoline, diesel and other fuels				
Light duty vehicle, short wheel base and motorcycle[c]	11,076	42.3%	million gallons	88,611
Light duty vehicle, long wheel base[c]	4,395	16.8%	million gallons	35,159
Single-unit 2-axle 6-tire or more truck	2,011	7.7%	million gallons	14,502
Combination truck	3,994	15.3%	million gallons	28,795
Bus	301	1.1%	million gallons	2,167
Transit				
Electricity	23	0.1%	million kWh	6,651
Motor fuel				
Diesel[d]	84	0.3%	million gallons	609
Gasoline and other nondiesel fuels[e]	13	0.1%	million gallons	107
Compressed natural gas	18	0.1%	million gallons	132
Rail, Class I (in freight service)				
Distillate / diesel fuel	515	2.0%	million gallons	3,713
Amtrak				
Electricity	2	0.01%	million kWh	525
Distillate / diesel fuel	9	0.04%	million gallons	66
Water				
Residual fuel oil	630	2.4%	million gallons	4,212
Distillate / diesel fuel oil	232	0.9%	million gallons	1,676
Gasoline	153	0.6%	million gallons	1,223
Pipeline				
Natural gas	888	3.4%	million cubic feet	861,583
Total	**26,155**			

KEY: Btu = British thermal unit.

[a] Domestic operations only. [b] Includes fuel used in air taxi operations but not commuter operations. [c] *Light duty vehicle, short wheel base* includes passenger cars, light trucks, vans and sport utility vehicles with a wheelbase (WB) equal to or less than 121 inches. *Light duty vehicle, long wheel base* includes large passenger cars, vans, pickup trucks, and sport/utility vehicles with wheelbases (WB) larger than 121 inches. [d] *Diesel* includes diesel and biodiesel. [e] *Gasoline and all other nondiesel fuels* include gasoline, liquefied petroleum gas, liquefied natural gas, methane, ethanol, bunker fuel, kerosene, grain additive, and other fuel.

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.

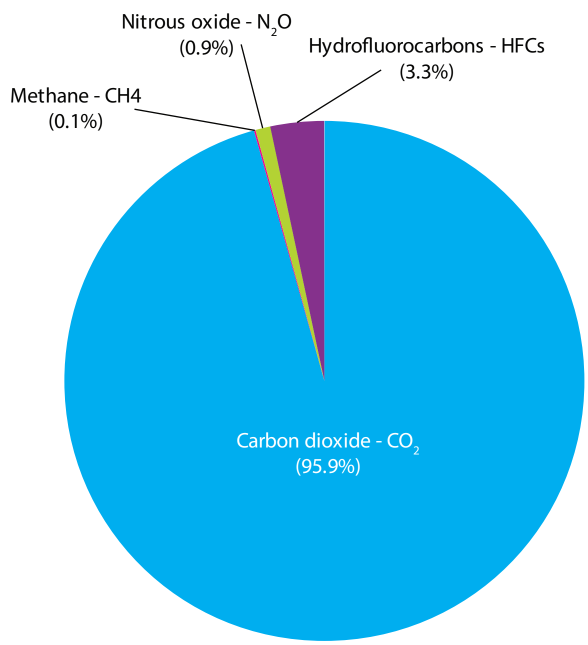
SOURCES: **Air**: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, Fuel Cost and Consumption, available at http://www.transtats.bts.gov/fuel.asp as of June 2015. **Highway**: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, table VM-1, available at http://www.fhwa.dot.gov/policyinformation/statistics.cfm as of June 2015. **Transit**: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, table 17, available at www.ntdprogram.gov as of June 2015. **Rail**: Association of American Railroads, *Railroad Facts 2014* (Washington, DC: 2014), p. 63. **Amtrak**: National Railroad Passenger Corporation (Amtrak), personal communication with Energy Management Department and Government Affairs Department, June 2015. Water: Residual and distillate/diesel fuel: U.S. Department of Energy, Energy Information Administration, *Fuel Oil and Kerosene Sales* (Washington, DC: 2014), available at http://www.eia.gov/petroleum/fueloilkerosene/ as of June 2015. **Gasoline**: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, table MF-24, available at http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.cfm as of June 2015. **Pipeline**: U.S. Department of Energy, *Natural Gas Annual*, DOE/EIA-0131(04) (Washington, DC), table 15, available at http://www.eia.gov/naturalgas/annual/ as of June 2015.

Hydrofluorocarbons (HFC), methane (CH4), and nitrous oxides (N2O) are the other principle GHGs emitted by the transportation sector. Each GHG has a different global warming potential. Figure 7-4 shows the common metric of equivalent grams of CO_2 for each emission. Hydrofluorocarbons and other ozone-destroying gases once used in automotive air conditioners are second behind CO_2 in importance.[3] HFCs are the most potent 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 95.9 percent of transportation GHG emissions are CO_2 produced by fossil fuel combustion and because petroleum comprises 91.5 percent of transportation energy use, modal GHG emissions closely track modal

[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 7-4 Transportation-Related Greenhouse Gas Emissions: 2013



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-8, available at http://epa.gov/climatechange/emissions/usinventoryreport.html as of August 2015.

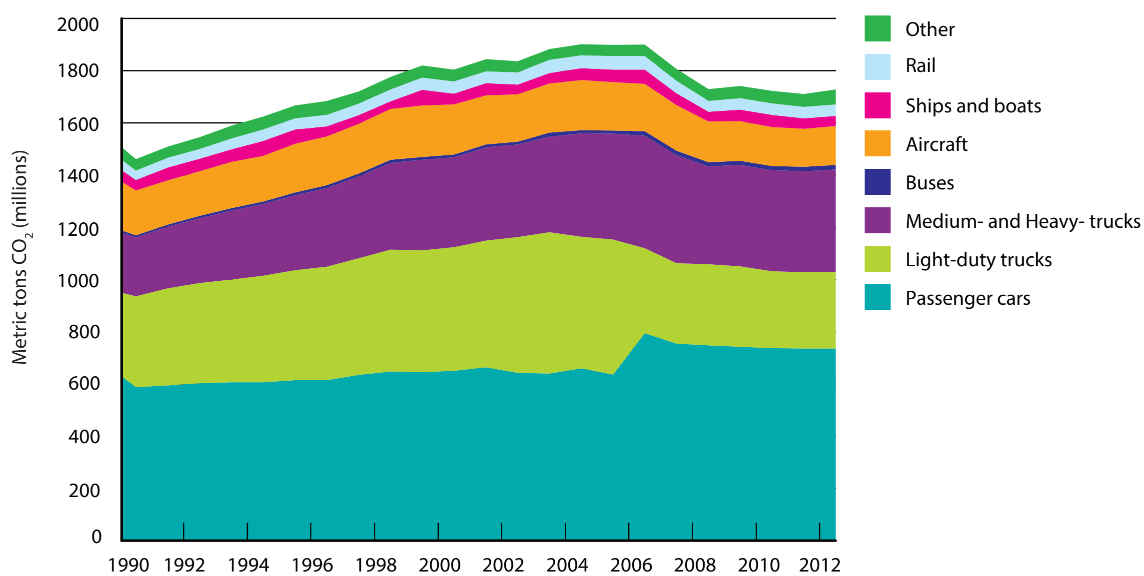
energy use. Transportation GHG emissions increased from 1990 to 2007 (figure 7-5), fell by 4.2 percent during the economic recession in 2008, and then stabilized at about 1,800 teragrams (million metric tons) from 2009 to 2013 [USEPA 2015a]. The short-term decrease in economic activity and the related decline in transportation demand contributed, in part, to the decrease in CO_2 emissions during the recession. However, the long-term trend from 1990 to 2013 shows that total transportation GHG emissions rose by 16.5 percent as a result of an increase in vehicle-miles traveled by light-duty motor vehicles, economic growth, and low fuel prices during the beginning of this period [USEPA 2015a].

Evident in figure 7-5 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

In the past, transportation reduced the growth of its energy use by improving the efficiency with which energy was used. The fuel

FIGURE 7-5 Carbon Dioxide (CO_2) Greenhouse Gas (GHG) Emissions by Mode: 1990-2013



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*).

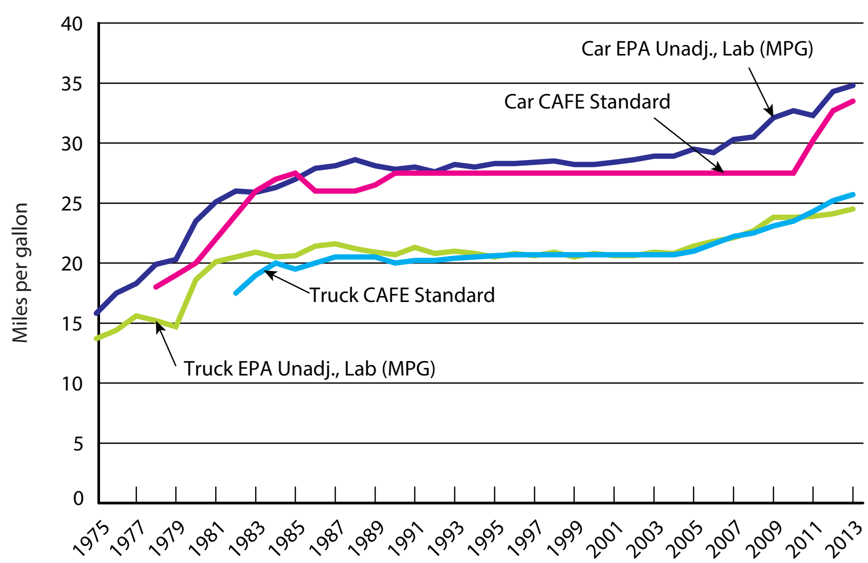
SOURCE: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (2012), table 2-13, available at http://epa.gov/climatechange/emissions/usinventoryreport.html as of June 2015.

economies of passenger cars and light trucks have closely tracked the Corporate Average Fuel Economy (CAFE) standards since they took effect in 1978 (figure 7-6). The miles per gallon (mpg) values shown in figure 7-6 are the unadjusted test values on which compliance with the standards is based. However, 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 estimated on-road fuel economy for all personal vehicles (passenger cars and light trucks) increased through 1987 but remained nearly constant through 2000. After 2000, fuel prices increased and CAFE standards were raised, first for light trucks and then for passenger cars. 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 miles per gallon.

Starting in 2007, the U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA) has reported vehicle travel and fuel consumption statistics using the classifications of short- and long-wheelbase light-duty vehicles rather than the previous categories of passenger cars and two-axle,

FIGURE 7-6 Car and Truck Corporate Average Fuel Economy (CAFE) and Miles per Gallon (MPG): Model Years 1975-2013



KEY: MPG = Miles per Gallon; EPA = U.S. Environmental Protection Agency.

NOTE: Corporate Average Fuel Economy (CAFE) standards, which must be met at the manufacturer level, were established by the *U.S. Energy Policy and Conservation Act of 1975* (PL 94-163).

SOURCES: All Car and All Truck CAFE Stds: Davis, S.C., S.W. Diegel and R.G.Boundy. *Transportation Energy Data Book*, Edition 33 (July 2014), Oak Ridge National Laboratory, Oak Ridge, TN. Tables 4-21 and 4-22. Available at cta.ornl.gov/data as of June 2015. **Car and All Truck EPA MPG**: U.S. Environmental Protection Agency (EPA), *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 - 2013. Table 9.1.* Available at http://epa.gov/otaq/fetrends.htm as of June 2015.

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.

Personal vehicle travel and fuel use before 1975 typically moved in parallel tracks (figure 7-7). Fuel economy improvements after 1975 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 21.7 in 2013. 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." In 2013 light-duty vehicles used 78.5 billion fewer gallons of motor fuel than they would have used assuming the same level of vehicle travel but 1975 average on-road fuel economy. The average price of gasoline in the United States in 2013 was $3.44 per gallon [USDOE EIA 2015d], or $2.95 before motor fuel taxes, implying a net savings due to fuel economy improvements of approximately $231.6 billion dollars in 2013 alone.

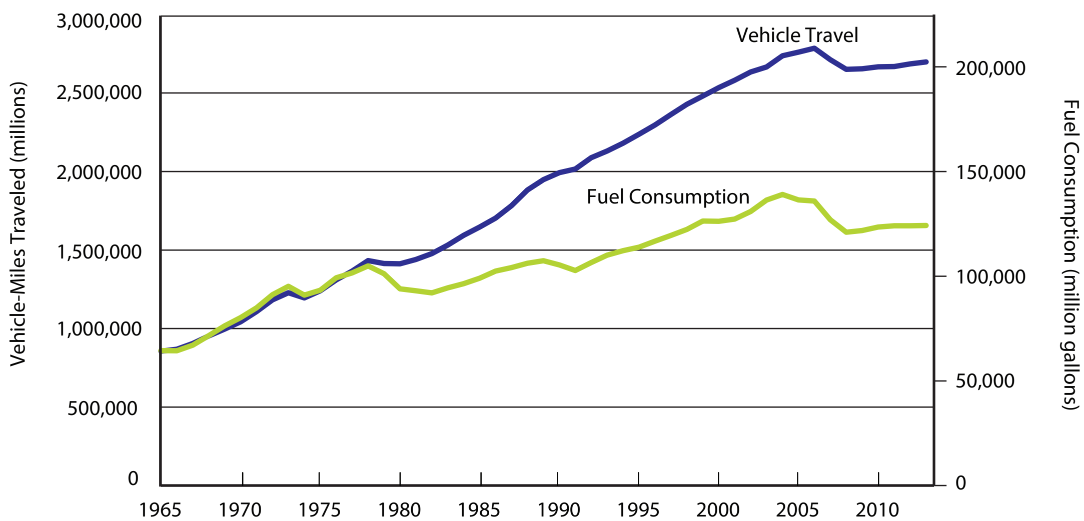
On August 28, 2012, the USDOT and the EPA set fuel economy and GHG emissions standards for passenger cars and light trucks through 2025. Nominally, the standards require a total fleet average of 54.5 mpg (163 grams of CO_2 equivalent) for new personal vehicles by 2025 [USEPA 2012]. However, this is based 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 more efficient air conditioners that leak less HFC, which is a potent greenhouse gas; 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. Additional credits may be earned for production of plug-in electric vehicles, hydrogen fuel cell vehicles, and vehicles powered by compressed natural gas. Furthermore, the new standards vary with the size of the vehicles a manufacturer produces. 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.

Medium- and heavy-duty highway vehicles 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 USEPA announced the first fuel economy and emission standards for this vehicle class for model years 2014–2018

[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.

[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).

FIGURE 7-7 Vehicle-Miles of Travel and Fuel Use by Personal Vehicles: 1965–2013



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.

SOURCES: Vehicle-Miles of Travel: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (multiple years), Vehicle-miles of travel tables, available at http://www.fhwa.dot.gov/policyinformation/statistics.cfm as of June 2015. **Fuel Consumption**: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics (multiple years); Motor-Fuel Use table, available at http://www.fhwa.dot.gov/policyinformation/statistics.cfm as of June 2015.

[USEPA 2011]. The standards apply to highway vehicles with gross vehicle weights above 8,500 pounds and set targets that vary depending on the type of vehicle and its functions. With the promulgation of these standards, nearly all highway vehicles became subject to fuel economy and CO_2 emissions rules. By 2018 the requirements for combination tractor trailers specify fuel economy improvements ranging from 9 to 23 percent, depending on the truck type. Goals for pickups and vans average 12 percent for gasoline engines and 17 percent for diesels. Similar improvements are required for the diverse class of vocational vehicles, such as dump trucks, cement mixers, and school buses. The EPA standards also require reductions in methane and nitrous oxides emissions and HFC leakage.

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 7-8). 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 2007 to 2013, the energy intensity of short- and long-wheel base light-duty vehicles rose while the energy intensity of other passenger modes—air, transit bus, and Amtrak—all declined.

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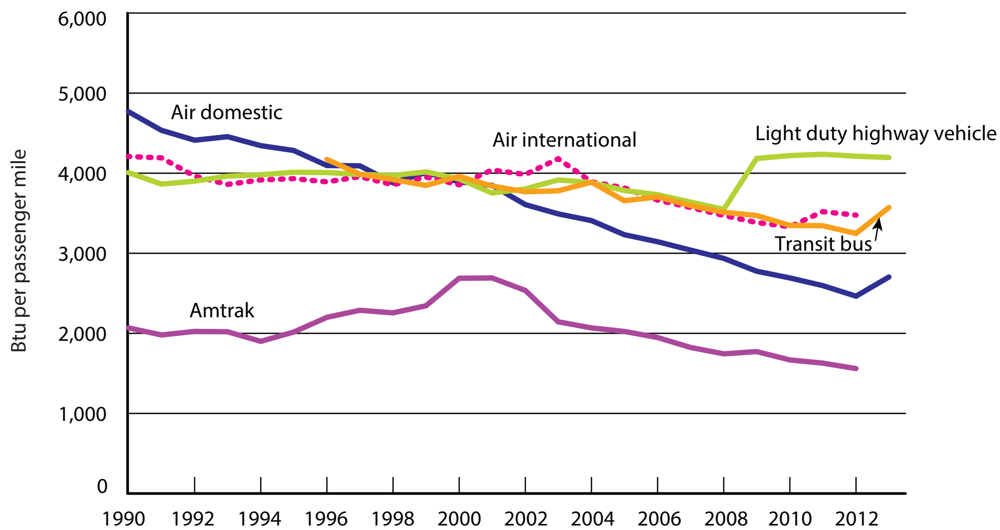
[6] Energy intensity is the amount of energy used to produce a given level of output or activity, e.g., energy use per passenger-mile of travel.

FIGURE 7-8 Energy Intensity of Passenger Modes: 1990–2013



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.

SOURCES: 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 March 2015.

The energy intensity of rail freight transport decreased at an average annual rate of 1.6 percent per year since 1990. Moving 1 ton of freight 1 mile in 2013 required 70.1 percent as much energy as it did in 1990. This was accomplished mostly through reducing energy use per freight car-mile by 14.1 percent and improving locomotive and operational efficiency while simultaneously increasing tons per car-miles by 132.2 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 reaching 36 billion gallons by 2022 [USLOC

CRS 2013 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 2015b]. More than 37 billion gallons of diesel fuel were consumed by vehicles in 2013 [USDOE EIA 2015e]. Box 7-A discusses diesel-powered passenger car and light-truck sales and emissions.

There is still almost no 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. This means that additional ethanol production can

[7] Cellulosic ethanol is produced from non-food based feedstock, such as wood and crop residues (corn husks, cobs and stalks), and switch grass.

BOX 7-A Diesel-powered Automobiles

Diesel-powered automobiles have been making the headlines following emission concerns raised by the U.S. Environmental Protection Agency (see the recent letter on these issues at: http://www3.epa.gov/). Diesel vehicles are a small percentage of the Nation's motor vehicle fleet, mostly medium and heavy trucks. For example, 72 percent of the trucks with a gross vehicle weight rating 10,001 and above sold in the United States in 2013 were diesel-powered, up from 69 percent in 2009 [USDOE ORNL 2015].

Sales of Diesel-Powered Passenger Cars and Light Trucks

In Model Year 2014, over 16.4 million passenger cars and light trucks were sold in the United States [USDOC BEA 2015]. Only 1.5 percent of all light duty vehicles (including passenger cars, sport utility vehicles, minivans, and all but the largest pickup trucks and vans) were diesel-powered. This percentage is up from less than 0.1 percent in the mid-90s, but below the peak of 5.9 percent in Model Year 1981. In Model Year 2014 Volkswagen had the highest percentage with 20.1 percent of diesel-powered light duty vehicles in its fleet across all automakers in the United States. Daimler had the next highest percentage with 6.9 percent, followed by BMW (6.0 percent), Chrysler-Fiat (2.8 percent), and GM (0.5 percent) [USEPA 2014a].

Emissions from Diesel-Powered Motor Vehicles

Diesel-powered motor vehicles account for about 4 percent of the fleet, but they account for about half of the on-road NOx emissions. In 2013, gasoline-powered motor vehicles contributed 2,365 kilotons; in comparison, diesel-powered motor vehicles contributed 2,125 kilotons of on-road NOx emissions [USEPA 2015]. Diesel-powered vehicles generally have better fuel economy than gasoline-powered ones, thus their CO_2 per vehicle-mile travelled is generally lower than a comparable gasoline-powered vehicle. However, diesel remains a major source of harmful pollutants (e.g., ozone forming emission, including nitrogen compounds NO_x as well as particulate matter (PM), which is a mixture of solid particles and liquid droplets found in the air) when burned. According to the U.S. Environmental Protection Agency, using ultra low sulfur diesel fuel and advanced emission control systems can reduce vehicle PM and NO_x emissions [USDOE EIA 2014].

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 2014 motor vehicles used nearly 137 billion gallons of gasoline, including almost 13.5 billion gallons of ethanol [USDOE EIA 2015b]. Higher levels of ethanol of up to 15 percent (E15) may pose difficulties for motorcycles, older vehicles, and off-highway engines. The EPA has not approved or tested E15 for proper engine performance and fuel economy in motorcycles [FRANK 2013]. Generally, manufacturers have been reluctant to extend their warrantees to include higher level blends. 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 (the majority of personal vehicles on the road). However, manufacturers have challenged the ruling based on concerns about the potential for misfueling of older vehicles not capable of using E15 and risking mechanical problems. Concern about the potential risk of misfueling appears to be responsible for the very limited availability of E15. As of October 2015, the number of public refueling stations offering E15 in the United States more than doubled from 2 years ago, amounting to 2,990 [USDOE AFDC 2015] out of a total of 211,000[8] gasoline stations [DOC CENSUS 2014].

Flexible-fuel vehicles (FFVs) can safely use mixtures of up to 85 percent ethanol (E85) with gasoline.[9] FFVs accounted for 91.8 percent of the nearly 2.1 million projected alternative fuel vehicles operating on U.S. roads in 2014 (table 7-2) [USDOE EIA 2015a]. 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 by 2016 unless actual use of E85 increases substantially. Together, liquid petroleum gas/propane and compressed/liquefied natural gas-powered vehicles accounted for less than 1 percent of alternative

[8] These include businesses primarily engaged in retailing automotive fuels (114,000) and those engaged in retailing automotive fuels in combination with a convenience store (97,000).

[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.

TABLE 7-2 Projected Number of Onroad Alternative Fueled Vehicles: 2014

	Light duty	Medium duty	Heavy duty	Total
Ethanol/flex fuel	1,398,800	0	W	2,085,001
Liquid petroleum gas/propane (LPG)	156	W	W	3,421
Natural gas	W	W	W	0
Compressed natural gas (CNG)	W	W	7,002	12,628
Liquefied natural gas (LNG)	0	0	W	276
Electric/battery	169,147	W	W	170,062
Hydrogen (H)	W	0	W	5
Total	**1,568,103**	**0**	**7,002**	**2,271,393**

KEY: W = withheld to avoid disclosure of individual company data.

SOURCE: U.S. Department of Energy, Alternative Fuel Vehicle Data, *Projected Number of Onroad Alternative Fueled and Hybrid Vehicles to be Made Available, by Fuel Type and Vehicle Type*, 2014 available at http://www.eia.gov/ as of November 2015.

fuel vehicles in use in 2014 [USDOE EIA 2015a]. Electrically driven motor vehicles may someday transform transportation energy use, but at present there is substantial uncertainty about their ability to compete with the internal combustion engine in the mass market.

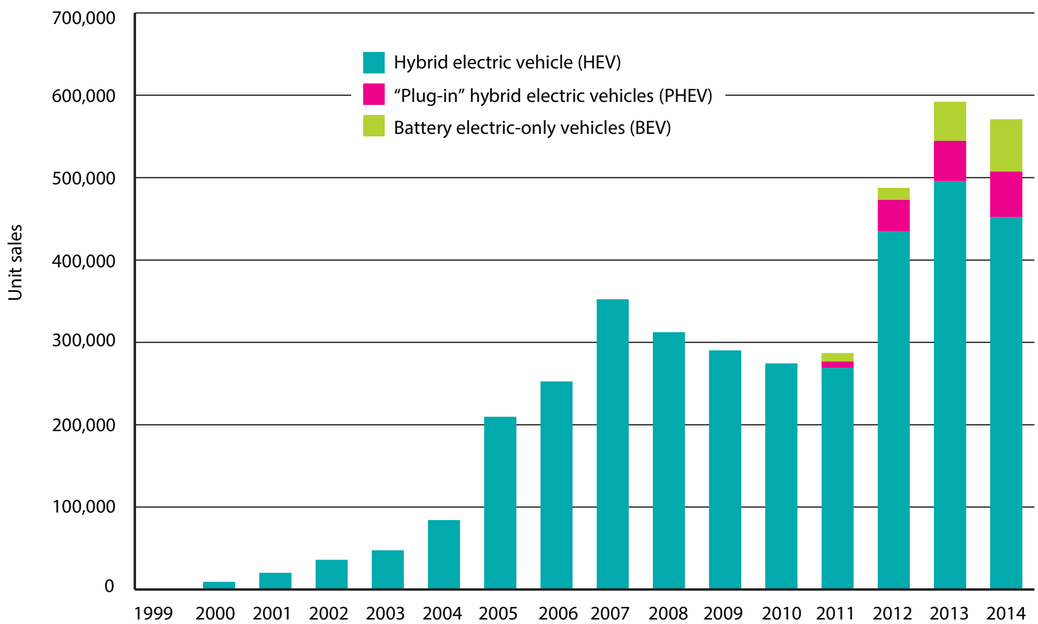
Until recently, gasoline or diesel fuel alone powered nearly all motor vehicles. The first mass-produced hybrid electric vehicle (HEV), powered by an internal combustion engine and an electric motor, was introduced in 1999. The internal combustion engine continues to provide all the energy for this kind 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 declining in 2014 to about 571,000 (figure 7-9). In 2014, 52 makes and models of HEVs were offered for sale in the United States [USDOE and USEPA 2015]. According to the U.S. Department of Energy (USDOE), Energy Information Administration (EIA), there were approximately 4.4 million hybrid electric vehicles (passenger cars and light trucks) on the road in 2014 [USDOE EIA 2015c].

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 2014 combined sales of grid-connected vehicles totaled more than 119,000 units [HYBRIDCARS 2014]. Over the same period, the number of makes and models of battery electric-only vehicles increased from 3 to 15, while plug-in hybrid offerings increased from 1 to 10 [USDOE and USEPA 2015].

Hybrids and grid-connected vehicles comprised about 3.5 percent of the 16.4 million light-duty vehicle sales in 2014 [HYBRIDCARS 2014]. Both types of vehicles

[10] The total includes hybrid electric vehicles, "plug-in" hybrid electric vehicles, and battery electric-only vehicles.

FIGURE 7-9 Sales of Hybrid, Plug-in Hybrid and Battery Electric Vehicles: 1999–2014



SOURCE: HybridCars, December Dashboards, Annual Issues, available at www.hybridcars.com as of October 2015.

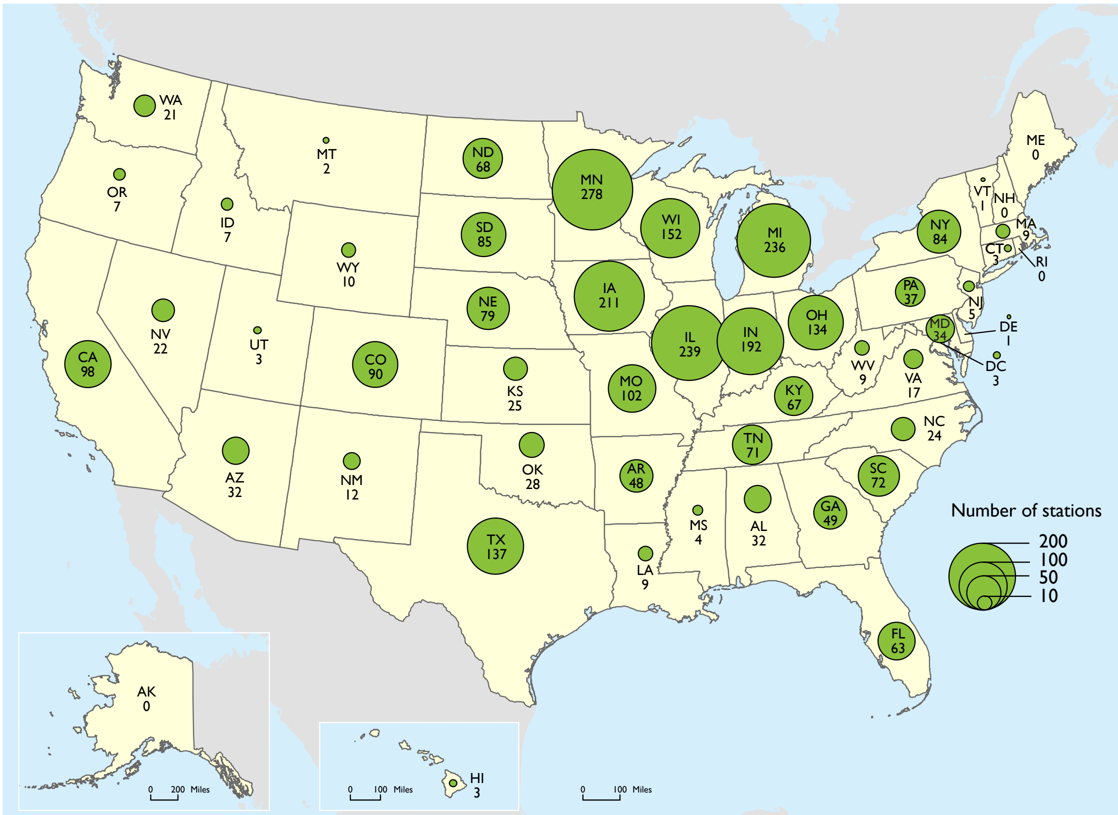
face several challenges: reducing costs, overcoming the market's unfamiliarity with the new technology, decreasing the length of time required for recharging batteries, and developing a recharging infrastructure. Considerable progress has been made in creating a nationwide recharging infrastructure. As of June 2015, there were more than 11,800 recharging stations with more than 29,800 nonresidential charging outlets across the United States, up from almost 3,400 outlets in 2011[USDOE AFDC 2015].[11]

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. E85 stations are disproportionately concentrated in states that grow corn and produce ethanol (figure 7-10). The distribution of electric vehicle recharging stations tends to favor states that have opted into California's Zero Emission Vehicles (ZEV) standards (figure 7-11).[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).

[11] A single electric vehicle recharging station may include multiple recharging outlets. Residential recharging locations are not included in the station count. *Transportation Statistics Annual Report 2013* presented the number of recharging outlets rather than stations as it 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*.

FIGURE 7-10 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.

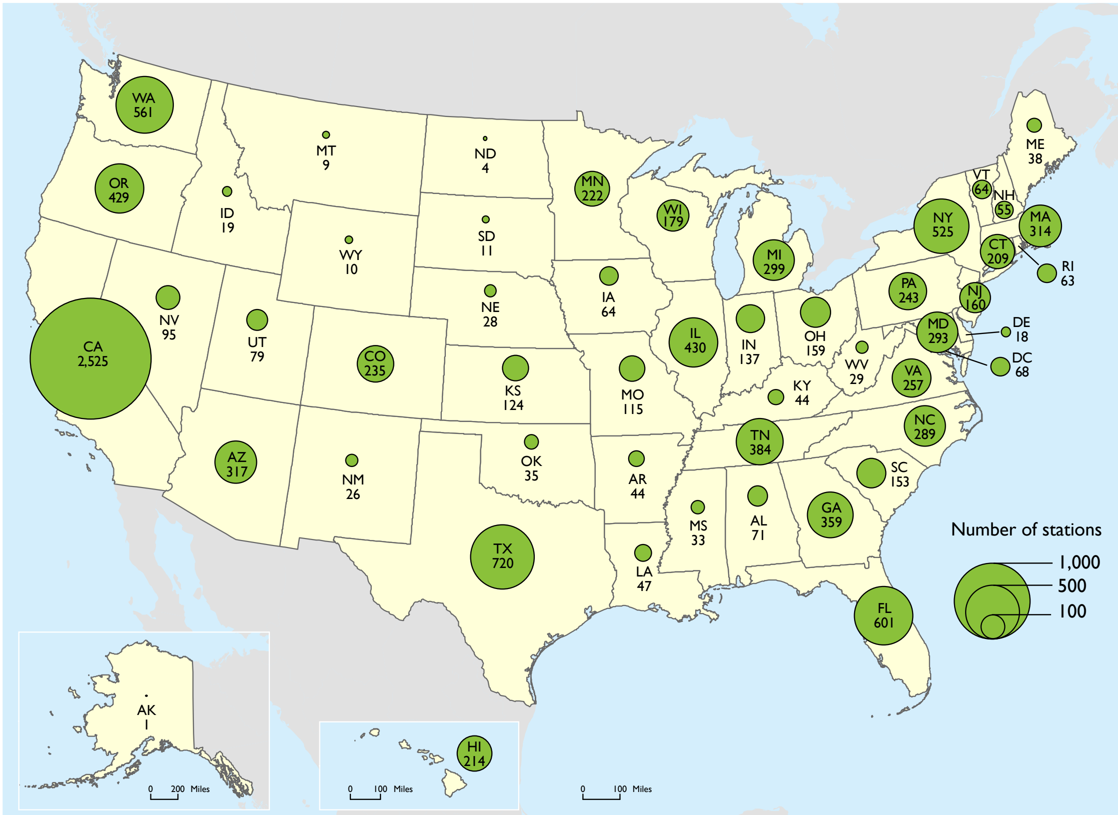
Transportation's Energy Outlook

The EIA has projected the likely effects of current trends and existing policies on transportation's future energy use and GHG emissions. The 2014 projections anticipate transportation energy use remaining at or near the current level of 27 quadrillion Btu through 2040 [USDOE EIA 2015c]. Existing 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

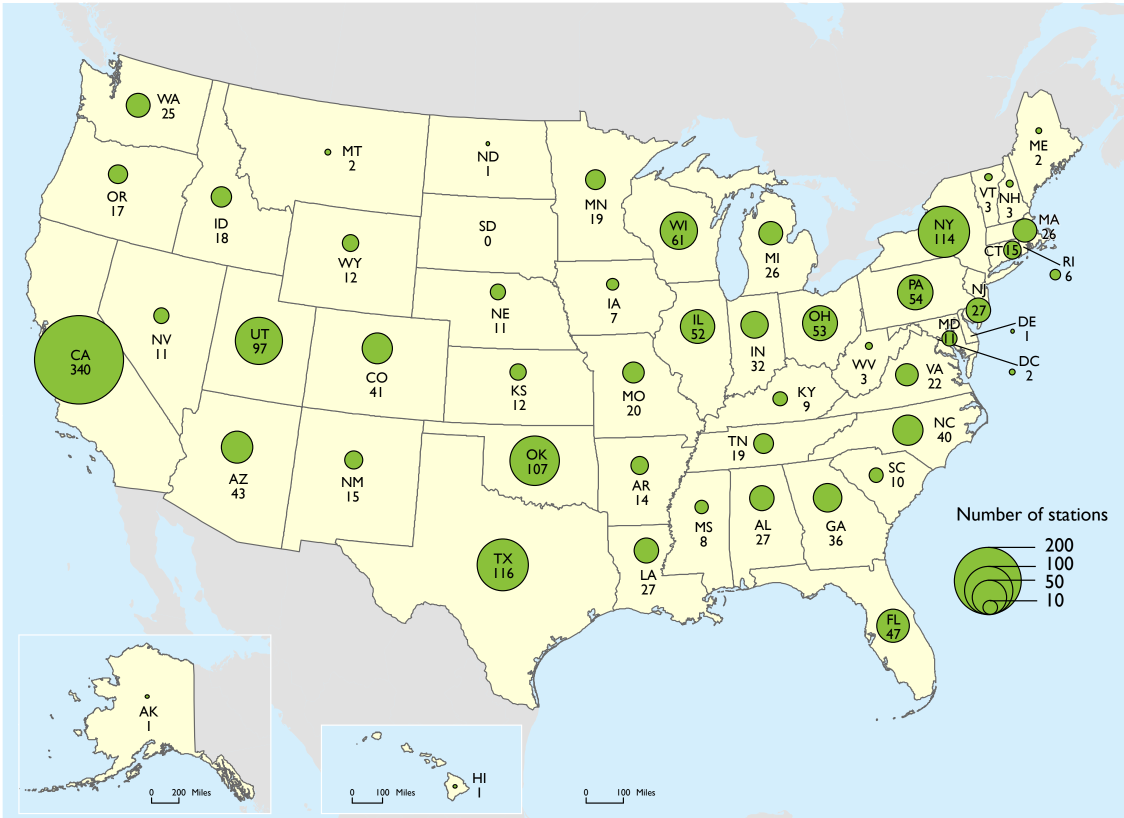
[13] EIA's *Annual Energy Outlook* does not include a scenario in which oil prices decrease over the 2013-2040 period.

FIGURE 7-11 Electric Vehicle Refueling Stations by State: 2015



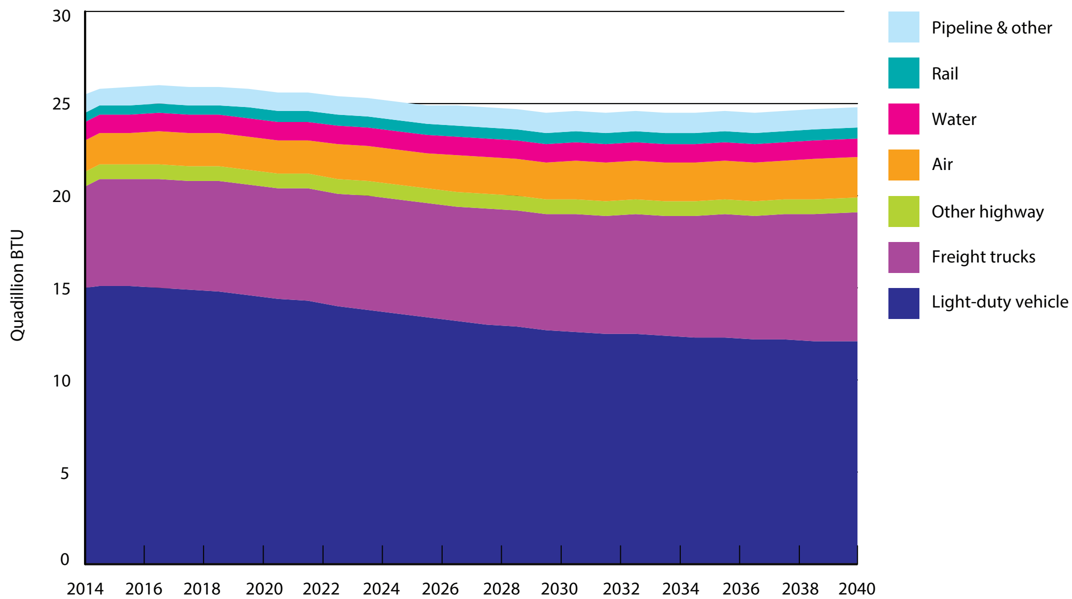
SOURCE: U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Alternative Fuels Data Center*. Ethanol Fueling Station Locations. Available at http://www.afdc.energy.gov/ as of October 2015.

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.

FIGURE 7-13 Transportation Energy Use: 2014–Projected to 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.

to increase from just 0.05 quads in 2013 to 0.7 quads by 2040 [USDOE EIA 2015c]. 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).

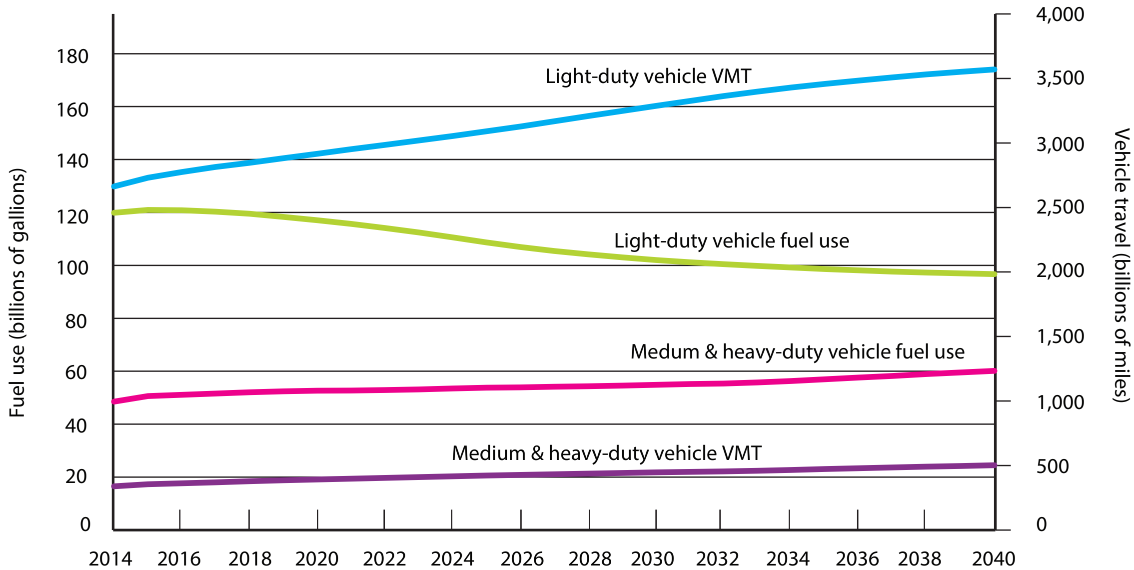
By fuel type, EIA projects gasoline use to decline from 15.9 quads in 2013 to 12.6 in 2040, in line with light-duty vehicle energy use. Diesel fuel use will increase from 5.8 to 7.9 quads, which is consistent with the growth of truck freight energy use. E85 and electricity use will increase but will still amount to only 0.28 quads and 0.06 quads of energy in 2040, respectively [USDOE EIA 2015c].

Air and Water Quality, Noise, and Habitat Impacts

With the exception of greenhouse gases, addressed earlier in the chapter, vehicle emissions controls and other policies have reduced transportation's six most common air pollution emissions to below their 1990 levels, a trend that continued through 2014[14] (figure

[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 7-14 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 June 2015.

7-15). Smog-forming emissions of volatile organic compounds (VOC) and nitrogen oxides (NO_x) were 66.8 and 46.5 percent lower, respectively, in 2014 than they were in 1990. 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.

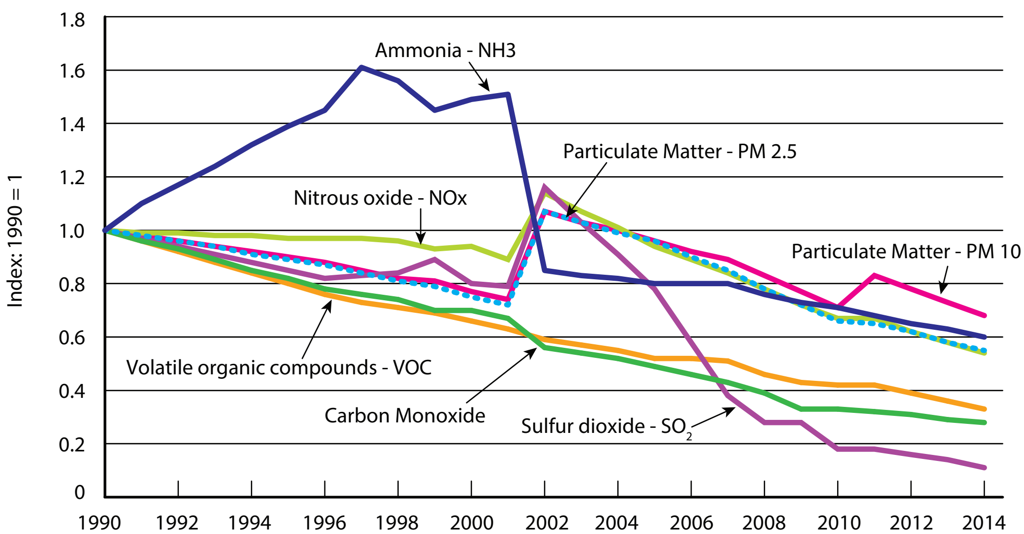
Transportation's share of total U.S. PM-2.5 emissions decreased from 8.2 percent in 1990 to 5.7 percent in 2014, while the share of PM-10 emissions decreased from 2.6 in 1990 to less than 2.4 percent of total emissions over the same period.

Emissions of sulfur dioxide (SO_2) were 87.8 percent lower in 2013 than in 1990, 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; 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, increased between 1990 and 2001, but in 2013 they were 38.1 percent of the 1990 level. Transportation comprised 2.4 percent of total U.S. emissions of ammonia in 2013.[15]

[15] Ammonia is not a by-product of fuel combustion but is formed in a vehicle's three-way catalytic emissions control systems. The introduction of 3-way catalytic converters initially caused increased NH_3 formation, but this was later offset by improvements in newer emissions control systems and the aging and retirement of vehicles with the earliest three-way catalytic systems.

FIGURE 7-15 Indexes of Key Air Pollutant Emissions from U.S. Transportation: 1990–2014



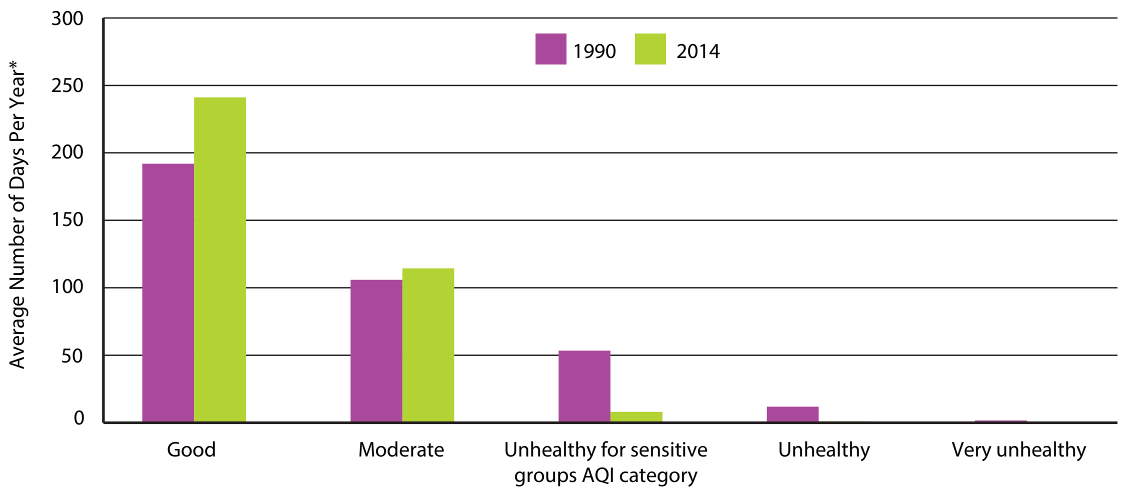
SOURCE: U.S. Environmental Protection Agency, National Emissions Inventory *Air Pollutant Emissions Trends Data, 1970-2014*, Average Annual Emissions All Criteria Pollutants, Available at http://www.epa.gov/ttn/chief/trends/index.html as of June 2015.

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 169 continuously monitored urban areas in 1990 and in 2014. The number of days from the 169 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 an accumulated total of 9,025 in 1990 to 1,363 in 2014; the number of days with unhealthy air quality for the population as a whole declined from 2,009 in 1990 to 180, and the number of very unhealthy days (which could trigger health emergency warnings for the general public) rose from 291 to 361. The great majority of days had good or moderate air quality in both 1990 and 2014, but 2014 had many more days of good or moderate air quality in these cities. In 2014 good air quality days totaled 40,758 days—about 8,300 more good air quality days than in 1990. Also for 2014, there were 19,348 moderate air quality days—compared to 17,908 moderate days in 1990 [USEPA 2015b].

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.[16] The annual volume spilled varies greatly from year to year and is strongly affected by infrequent, large events (figure 7-17). For example, Hurricane Katrina caused numerous spills into navigable waterways from a variety of sources in Louisiana and Mississippi in 2005 as the volume of petroleum spilled jumped to 9.9 million in 2005, more than three times the

[16] Safety issues associated with spills of hazardous materials are covered in Chapter 6.

FIGURE 7-16 Air Quality Index for 169 U.S. Cities: 1990 and 2014

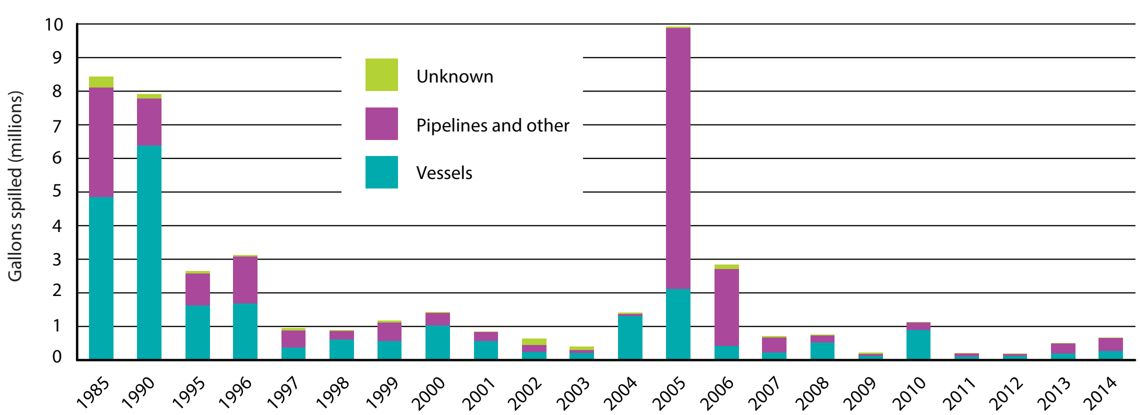


NOTES: Based on number of days in the year in which an AQI measurement was reported from any monitoring site in the county or Metropolican Statistical Area to the Air Quality Statistics database.

Days Good: number of days in the year having an AQI value 0-50
Days Moderate: number of days in the year having an AQI value 51-100
Days Unhealthy for Sensitve Groups: number of days in the year having an AQI value 101-150
Days Unhealthy: number of days in the year having an AQI value 151-200
Days Very Unhealthy: number of days in the year having an AQI value greater than 200. This includes the AQI categories very unhealthy and hazardous.

SOURCE: U.S. Environmental Protection Agency, Air Quality Index Information. Available at http://www.epa.gov/airtrends/aqi_info.html as of August 2015.

FIGURE 7-17 Petroleum Spills Impacting Navigable Waterways: 1985, 1990, and 1995–2014



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 involved an incident on the mobile offshore drilling unit (MODU) *Deepwater Horizon* beginning Apr. 20, 2010. The most commonly accepted spill amount from the well is approximately 206.6 million gallons, plus approximately 400,000 gallons of oil products from the MODU and are excluded from above.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-54, Available at http://www.bts.gov as of November 2015.

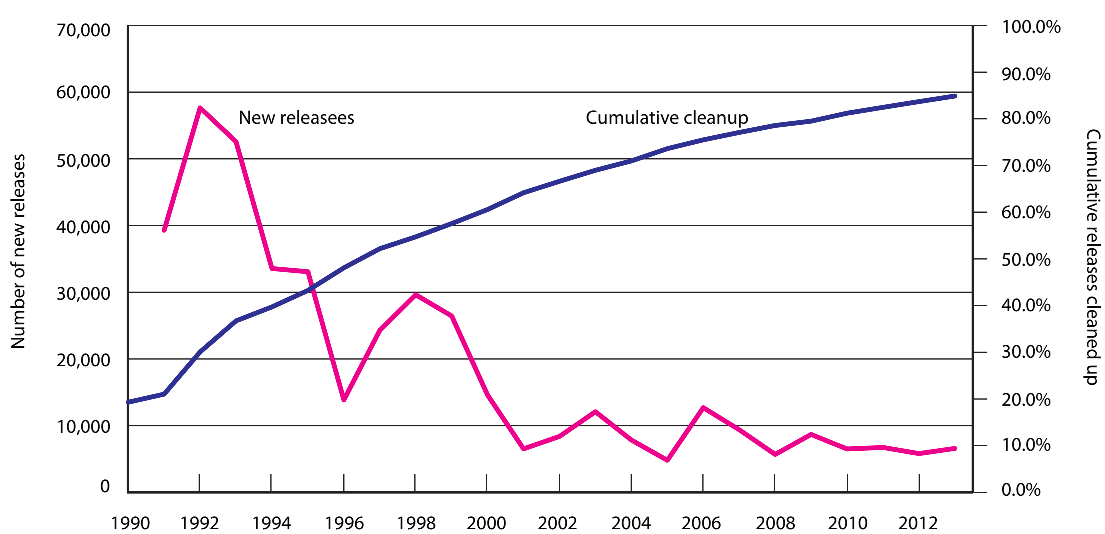
amount of petroleum spilled in any other year from 1995 through 2014.[17] While the number fluctuates from year-to-year, the 1,716 spill incidents from vessels in 2014 were slightly less than the 2005 to 2014 average of about 1,735 spills. The 963 spill incidents from pipelines into navigable waters in 2014 were slightly less than the 973 annual averages for the 2005-2014 period.

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 2015c]. 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 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 indepth 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

[17] 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 2013).

FIGURE 7-18 Leaking Underground Storage Tank Releases and Cleanup: 1990–2014



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 June 2015.

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 impacts, from salamander and badger tunnels to mountain goat underpasses on highways to fish passages through culverts.[18] 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 greatly 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].

[18] 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.

Transportation noise is pervasive and difficult to avoid in the United States [USDOT FHWA HEP 2013]. 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 2014]. Similar methods could be applied to collect and analyze noise issues in the United States.

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.[19] 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 7 million in 1970 and from 2.7 million in 1990. The

[19] Noise (sound) is measured in decibels (dB) on a logarithmic scale. Each increase of 10 dB represents a doubling of the noise level.

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 2014]. 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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CHAPTER 8

The State of Transportation Statistics

Highlights

- Extensive data are available on local passenger travel and most long-distance freight movement, but data gaps exist 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, and the contributions of transportation to the economy have not adequately been quantified and are poorly articulated.
- 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.
- BTS strives to create increasingly robust, credible statistics that support evidence-based decision making 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 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]

BTS highlighted the evolution of transportation issues requiring statistical information, sources of transportation statistics, and the Bureau's efforts to improve transportation statistics in *Two Decades of Change in Transportation: Reflections from 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 strengths and weaknesses of current 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.

[1] 49 U.S.C. § 6302(b)(3)(B)(vi)

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.

While extensive statistics exist on the extent and use of the transportation system, some of the underlying data were collected for different reasons and are consequently inconsistent:

- States developed their own highway inventory systems,
- various studies of highway traffic required different information about vehicle use,
- railroad networks were mapped at different levels of detail and completeness for different reasons, and
- ports customized local performance measures to support promotional material.

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.	• Piecemeal representation of intercity and transit 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 car-loadings 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 among ports. • Condition of urban bus and rail transit maintenance facilities, and rail transit infrastructure.	• 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.

Several initiatives are underway to improve the range and consistency of highway performance measures and to unify geospatial representations of the highway and railroad networks. Proposals to develop nationally consistent port performance measures are under consideration.

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 that spreads delay evenly over all travelers works better than a system that concentrates the same total delay on only a portion of the travelers. Delay also matters more for some purposes than others. Delay is critical for responses to medical emergencies but may only be a minor irritant for leisurely sightseeing. Delay is generally a greater problem for perishable or high-valued goods than for bulk commodities. Statistics on travelers, shippers, and the carriers who use the transportation system; on the purposes of travel; and on the goods being moved are needed 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.

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 nonprofit 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.

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 Patrol [USDHS CBP OFO 2015], the Federal Transit Administration's National Transit Database [USDOT FTA NTD 2014], the BTS monthly passenger enplanement data [USDOT BTS 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 2012].

The NHTS collects not only information on individual trips but also demographic, household vehicle ownership, and neighborhood characteristic data 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.

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 size 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,

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 U.S. 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.

wholesale, and selected retail industries covering all modes of transportation. It also provides comprehensive data on domestic hazardous material shipments. The CFS is conducted every 5 years as part of the Economic Census.

The Freight Analysis Framework (FAF) builds on the CFS to provide national estimates of total freight movement by mode of transportation and type of commodity for over 130 regions based on states and metropolitan areas. 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 and other national data sources are described at USDOT's freight transportation website at freight.dot.gov.

The FAF is based on observed data wherever possible, but must turn to models and assumptions to fill the remaining data gaps. Among the data gaps 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 has not been measured since the 1970s.

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 direct economic contribution 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.

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

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.	• Up-to-date depreciation rates by type of transportation infrastructure.	• Asset management for efficient maintenance of transportation condition and performance.
Transportation expenditures and investments	• Total transportation expenditures and investments by households, businesses, and government.	• Business investments and expenditures by mode of transportation. • Differentiation of own account (in-house) transportation services from purchased transportation services.	• Expenditures reflect transportation's contribution to the economy and the likely consequences on each sector of the economy of transportation investments and regulations. • Transportation expenditures are also an indicator of general economic conditions.
Transportation costs and prices	• Gasoline and diesel prices. • Costs of automobile ownership. • Air carrier costs for selected categories. • Carrier price indices. • Cost to maintain highway 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.	• 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.	• Transportation as a share of state and metropolitan domestic product. • Economic activity enabled by transportation. • Value of the transportation system and services to the economy.	• Input to establishing the appropriate size of investment programs and levels of revenue collection.

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. To provide a complete picture, the TSI is being expanded to include in-house transportation.

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 of transportation, safety dominates the statistical activities of 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.

The relatively low fatality rates in 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

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.

under the Confidential Information Protection and Statistical Efficiency Act,[2] 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 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 development.

[2] Title V of Public Law 107-347, Dec. 17, 2002

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 two decades. As a consequence, current discussions about trends in passenger travel and the consequences of travel are dominated by measures of local travel. This limitation may result in misguided conclusions because long-distance travel involves different trip purposes and conditions than local travel, and one long-distance trip can generate as many miles of travel as dozens or even hundreds of local trips. Without information on long-distance travel, decision makers do not know how local congestion affects long-distance travel, how long-distance travel contributes to local congestion and the local economy, and how the total of local and long-distance travel contributes to safety risks and environmental problems.

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.*

Challenges facing BTS and its partners are not limited to filling data gaps. The simple availability of data does not assure that effective statistics exist to help answer the questions of decision makers. Significant quality issues and inadequate methods for summarizing data into useful information can undermine the effectiveness of key data programs. All data sources have quality issues, but some questions about statistical quality have greater potential consequences for misguiding decision makers and for undermining the credibility of evidence-based decisions with the public.

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[3] 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

[3] 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.

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 analyze markets, social and political trends, and the performance of professional athletes 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 revolutionizing transportation analysis is great, but research is needed 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 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.[4] 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].

Statistics for evidence-based decision making can be based on ongoing performance measurement, randomized controlled trials, and analyses of public actions that approximate controlled trails through careful monitoring of conditions surrounding the public action.

[4] 49 U.S.C. § 6302(b)(3)(B)(i)

Analyses that approximate controlled trials; also known as quasi-experimental designs, range from simple before-and-after studies to very sophisticated time-series analysis.

The Urban Mass Transportation Administration (predecessor to the Federal Transit Administration) made extensive use of quasi-experimental designs in its Service and Methods Demonstration Program, established in 1974 "to provide a consistent and comprehensive framework within which innovative transportation management techniques and transit services could be developed, demonstrated and evaluated, and the resultant findings disseminated in a timely manner to transportation planners, policymakers and transit operators" [USDOT UMTA 1979]. This systematic approach to evaluating technologies, projects, and programs could serve as a useful model for supporting evidence-based decision making throughout the field of transportation.

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 upon 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]. As part of its leadership role, BTS represents the transportation community in the Interagency Council on Transportation Statistics of the Office of Management and Budget. BTS provides advice to the rest of USDOT on sampling methods for proposed information collections under the *Paperwork Reduction Act*.[5] BTS also advises USDOT on the statistics used in the Department's annual Performance and Accountability Report. BTS is establishing the USDOT Statistical Policy Council to help departmental units validate the statistics in the Performance and Accountability Report and improve the quality of all statistics published by the Department.

BTS continues to improve its own data products, including the Commodity Flow Survey, Intermodal Transportation Database, the National Transportation Atlas Database, the National Ferry Database, data collected on commercial aviation, and the Bureau's compilations of statistics on transportation trends, performance, and impacts. BTS also continues 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. The website has grown over two decades, and is long overdue for restructuring to make its large and diverse collection of information easier to find and use by transportation decision makers and the public. BTS is initiating a major redesign of the website in 2016. BTS is also expanding its Facts and Figures series and developing new

[5] Public Law 104-13, May 22, 1995

visualizations for statistics in BTS reports and visual analytics on the website to highlight and explain the data collected and compiled by BTS.

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. 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.

Under the 5-year plan BTS developed in November 2014, the Bureau strives 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

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

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Appendix A–*Legislative Responsibilities, including Cross Reference*

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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.

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