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


Transportation Statistics Annual Report

2022









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Quality Assurance Statement

The Bureau of Transportation Statistics (BTS) provides high quality information to serve government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. BTS reviews quality issues on a regular basis and adjusts its programs and processes to ensure continuous quality improvement.

Notice

Introduction

Transportation is fundamental to the vibrancy of the Nation and creates both the economy and the quality of life. It enables people to engage in productive pursuits, carry out commerce, and experience the social interactions that are fundamental to people's happiness and success. Transportation affects and is affected by a full spectrum of societal elements:

- The built and natural environment,
- The economy,
- People's health and safety, and
- The social interactions that underpin our culture, all of which are impacted by transportation and the infrastructure and services that provide it.

Recognizing the importance of transportation and the importance of objective statistics for transportation decision-making, Congress requires the Director of the Bureau of Transportation Statistics (BTS) of the U.S. Department of Transportation (USDOT) to provide the *Transportation Statistics Annual Report* (TSAR) each year to Congress and the President.[1] BTS published the first TSAR in 1994. This 28th TSAR edition documents the conduct of the duties of BTS as called out in the statute.

Historically, transportation trends generally change unassumingly from year to year. However, the COVID-19 pandemic, first recognized as a national emergency in March 2020, produced unprecedented changes in transportation supply, demand, and performance in a matter of months. At the same time, ongoing technological change, shifting national priorities, and cultural, demographic, and economic challenges have altered expectations of what is important to report to transportation stakeholders. To adjust to the colossal changes, data needs have become more foundational to decision-making. Emerging patterns, such as a better understanding of the impact of telework and eCommerce on transportation; identifying the roles of ride-hailing services, E-scooters, and E-bikes in providing mobility; measuring supply chain performance; and reporting on equity, sustainability, and climate are critical concerns identified in the FY 2022-26 USDOT Strategic Plan and are among the current challenges of providing data to support transportation decision-making.

The U.S. Department of Transportation and many other organizations, such as the Transportation Research Board of the National Academy of Sciences, Engineering, and Medicine and the University Transportation Centers program overseen by USDOT, are actively exploring new measures and methods of gathering data to support transportation. More frequent and timely data collection, more geographic detail, and leveraging digital communications and data tools to speed the collection and processing of data are supporting the advancements in data reporting.

[1] 49 U.S. Code § 6302.

This report is organized into 7 chapters that reflect the topics in BTS's legislative mandate, including some new data items. Aside from this Introduction, the report components are Chapter 1 - State of the System, Chapter 2 - Passenger Travel and Equity, Chapter 3 - Freight and Supply Chain, Chapter 4 - Transportation Economics, Chapter 5 - Transportation Safety, Chapter 6 - Energy and Sustainability and Chapter 7 - State of Transportation Statistics. The report also provides an update to the State of Transportation Statistics and Recent BTS Accomplishments. The box to the right displays examples of the new data items in this report.

The concluding chapter on the state of transportation statistics documents lessons BTS and its partners have learned from measuring fast-evolving events and highlights changing data needs in response to new legislation.

A notable addition to this report is the coverage of the effects that the Coronavirus (COVID-19) pandemic has had on all modes of transportation—effects that BTS closely monitors. BTS provides a wide range of transportation statistics online, showing the pandemic's effects on passenger travel and freight shipments. These measures are available at https://www.bts.gov/covid-19.

BTS welcomes comment on the *Transportation Statistics Annual Report* (TSAR) and the Bureau's other products. Comments, questions, and requests for printed copies should be sent to bts@dot.gov or to the Bureau of Transportation Statistics, U.S. Department of Transportation, 1200 New Jersey Avenue SE, Washington DC, 20590.

Example of New Data Items Included in TSAR 2022

Chapter 2 - Passenger Travel and Equity:

- Consumer Expenditure Survey analysis of time spent in travel, adding insight on spending on intercity/international travel.
- Extensive treatment of race and ethnicity aspects of travel.
- New public and private sources providing insight on telework.

Chapter 6 - Transportation Safety:

- NHTSA collected data on crashes involving advanced or automated driving systems that were deployed within 30 seconds of a crash.
- Consumer Products Safety Commission (CPSC) information on injury, fatality, and hazard patterns for e-scooters, e-bikes, and hoverboards.
- Information on harassment and crime on passengers and operators.

Previous editions of the TSAR are available at www.bts.gov/tsar.

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CHAPTER 1
State of the Transportation System

Introduction

In 2020, the U.S. transportation system served 331 million U.S. residents residing in 122 million households, including people who may not own a vehicle or rarely travel, and millions of foreign visitors (see Chapter 2 - Passenger Travel and Equity). Transportation is used to commute to work, obtain goods and services, visit with family and friends, and travel for leisure and work. It also drives the economy, connecting 8.0 million business establishments with customers, suppliers, and workers [USDOC CENSUS 2022].

From the 2008 recession to the onset of the COVID-19 pandemic in early 2020, the use of the American transportation system grew appreciably, while the supporting infrastructure remained largely built out and stagnant. The transportation system needs resilience to withstand traditional disruptions, such as

Highlights

- The COVID-19 pandemic dramatically changed the availability and use of the U.S. transportation system. Schedules and ridership for commercial airlines, Amtrak, transit systems, ocean vessel services, and other forms of transportation shrank to record lows beginning in March 2020 as passenger volumes and freight movement declined. Not until mid-2022 did traffic on most travel modes begin to return to pre-pandemic levels.
- Transportation activity is often highly concentrated on portions of the network. For example, the more than 48,000-mile Interstate Highway System in 2020 comprised 1 percent of total highway lane-miles available but carried 25 percent of total highway vehicle-miles of travel.
- Automated vehicle development is advancing across all transportation modes, with 39 state-level jurisdictions actively engaged in permitting testing or full deployment of driverless highway vehicles in 2022, more widespread autonomous port systems and ships, and the use of Positive Train Control in railroads.
- **Roads, Bridges, and Vehicles:**
  - Due to the COVID-19 pandemic's effects on travel, vehicle-miles traveled (VMT) in 2020 decreased 11 percent from 2019 to a level last seen in 2003.
  - Between 2011 and 2020, the percentage of rural road mileage rated as rough remained relatively stable. Only 5 percent of rural higher function roads (interstates and other arterial highways) have a poor ride quality compared to about 20 percent of such roads in urban areas. This is generally attributed to more activity and wear on urban than on rural roads.

Continued »

Highlights Continued

  - Urban roads have a larger share of VMT on roads with poor pavement condition (14 percent) than rural roads (3 percent).
  - Between 2010 and 2021, the number of the Nation's bridges in poor condition declined by 15,719, from about 10 to about 7 percent of all bridges.
  - New passenger car sales in the United States declined from 5.3 million vehicles in 2018 to 3.4 million in 2020 due to shortages of labor and vehicle components (especially electronics), resulting in reduced vehicle production and increased vehicle prices.
- **Congestion Conditions in Most U.S. Cities:** In the COVID-19 initial pandemic year of 2020, highway congestion dropped from between 43 to 51 percent as compared to 2019. Annual hours of delay per commuter dropped from 54 hours in 2019 to 27 hours in 2020, a value not seen since 1989, more than three decades ago.
- **Public Transit:** While 2020 saw little change in public transit infrastructure, the COVID-19 pandemic caused transit ridership to plummet. Passenger trips dropped from 9.0 billion in 2019 to 5.4 billion in 2020, a 40 percent reduction.
- **Aviation:**
  - Total passenger enplanements at U.S. airports were down from 1.05 billion in 2019 to 401 million in 2020, a drop of 62 percent and less than the total reported two decades earlier. Traffic rebounded in 2021 to about two-thirds of 2019's record-high enplanements.
  - Air freight has been a bright spot during the pandemic, increasing 16.5 percent from 2019 to 2021.
  - Over the last decade, runway pavement condition has been nearly constant, with 80 percent of pavements rated good, 18 percent fair, and 2 percent poor.
- **Passenger Rail:** In FY 2021 Amtrak carried more than five times as many riders between Washington and New York City as all of the airlines combined, and more than twice as many between New York City and Boston.
- **Freight Railroads:** The COVID-19 pandemic severely impacted freight railroad traffic and operations. As compared with 2019, in 2020 rail carloads were down 13 percent, revenue ton-miles down 10.8 percent, and total operating revenue dropped 11 percent. U.S. rail intermodal was down only 2 percent, due to a surge in imports and related port traffic.
- **Ports and Waterways:** The pandemic caused an overall drop of 6 percent in waterborne tonnage handled, which was less than the decrease in traffic experienced by other transportation modes. The average 2020 dwell time of container vessels at the top 25 U.S. container ports was 28.1 hours, down slightly from 28.2 hours in 2019.
- **Petroleum Pipelines:** The crude petroleum and products pipeline systems carried 3.3 billion barrels across the United States in the pandemic year of 2020, down 10 percent from 3.7 billion in 2019. Pipeline shipments recovered to 3.5 billion barrels in 2021.
- **Disruptions to the Transportation System:** In 2020, there were a record-high 22 weather and climate disaster events with losses exceeding $1 billion each across the United States. These events included 7 tropical cyclones, 13 severe storms, 1 related to drought, and 1 due to wildfires. Ten of the cyclone and severe storm events caused a total of 60 days of closure spread across 25 maritime ports. While too much water disrupted transportation along the coasts, too little water disrupted barge traffic on the Mississippi.

extreme weather delays at the Nation's ports and airports, as well as new disruptions, such as cybersecurity threats.

This chapter reviews the extent, usage, condition, and physical and economic performance of the transportation system. The condition of the system is affected by wear from use and damage from infrastructure age and environmental forces, all of which vary by modal components of the system. Performance is affected by the physical and operational capacity of infrastructure and services to handle demand, extreme weather, or human-caused disruptions. The relationships of capacity and demand translate into economic costs of transportation and affect the contribution of transportation to the economy, described at the end of this chapter as economic performance.

This chapter includes the latest transportation data on the extent, usage, condition, and performance of the U.S. transportation system. In most cases the latest data available are for the year 2020. A point of emphasis is the changes in the transportation system brought about by the COVID-19 pandemic, officially recognized as a national emergency in the United States on March 14, 2020.

Highways, Bridges, and Vehicles

Expansive Infrastructure Required to Meet Demand and Resiliency Needs

Roads

In 2020, the U.S. road system had about 4.2 million centerline-miles[1] and 8.8 million lane-miles,[2] both of which are virtually the same as in 2018, and more than 618,400 bridges, up by 0.4 percent since 2018. The mileage of non-expressway principal arterial streets and collector streets were also up by 0.4 and

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

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

Table 1-1 Public Roads, Streets, and Bridges: 2000, 2010, and 2018–2020

Road/street/bridge	2000	2010	2018	2019	2020
Public Road and Street Mileage by Functional Type (miles)	3,936,222	4,067,076	4,176,915	4,171,125	4,172,562
Interstate	46,427	46,900	48,440	48,481	48,472
Other freeways and expressways	9,140	14,619	18,603	18,631	18,656
Other principal arterial	152,233	157,194	156,614	156,680	157,210
Minor arterial	227,364	242,815	246,214	246,831	246,539
Collectors	793,124	799,226	814,585	815,118	819,025
Local	2,707,934	2,806,322	2,892,459	2,885,384	2,882,660
TOTAL lane-miles	**8,224,245**	**8,581,158**	**8,794,569**	**8,785,398**	**8,790,746**
TOTAL bridges	**587,135**	**604,460**	**616,096**	**617,084**	**618,456**
TOTAL registered vehicles	**225,821,241**	**250,070,048**	**273,602,100**	**276,491,174**	**275,924,442**
Vehicle-miles of travel (millions)	**2,746,925**	**2,967,266**	**3,240,327**	**3,261,772**	**2,903,622**

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

SOURCES: 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, and 1-35. Available at http://www.bts.gov/ as of August 2022.

0.5 percent, respectively, since 2018, indicating that road building during the pandemic tended to focus more on local needs than on interstate travel.

Local roads are by far the most extensive component of the highway system, amounting to 2.9 million miles (around 69 percent of total centerline-miles) in 2020 (Table 1-1). However, interstate highways, which accounted for about 48,000 miles (just over 1 percent of total system-miles), handled the highest volumes of traffic as measured by vehicle-miles traveled (VMT)—at about 25 percent in 2020 [USDOT FHWA OHPI 2021]. Rural highways comprise 70.3 percent of the centerline miles and 68.5 percent of the lane-miles and carry 31.1 percent of VMT.

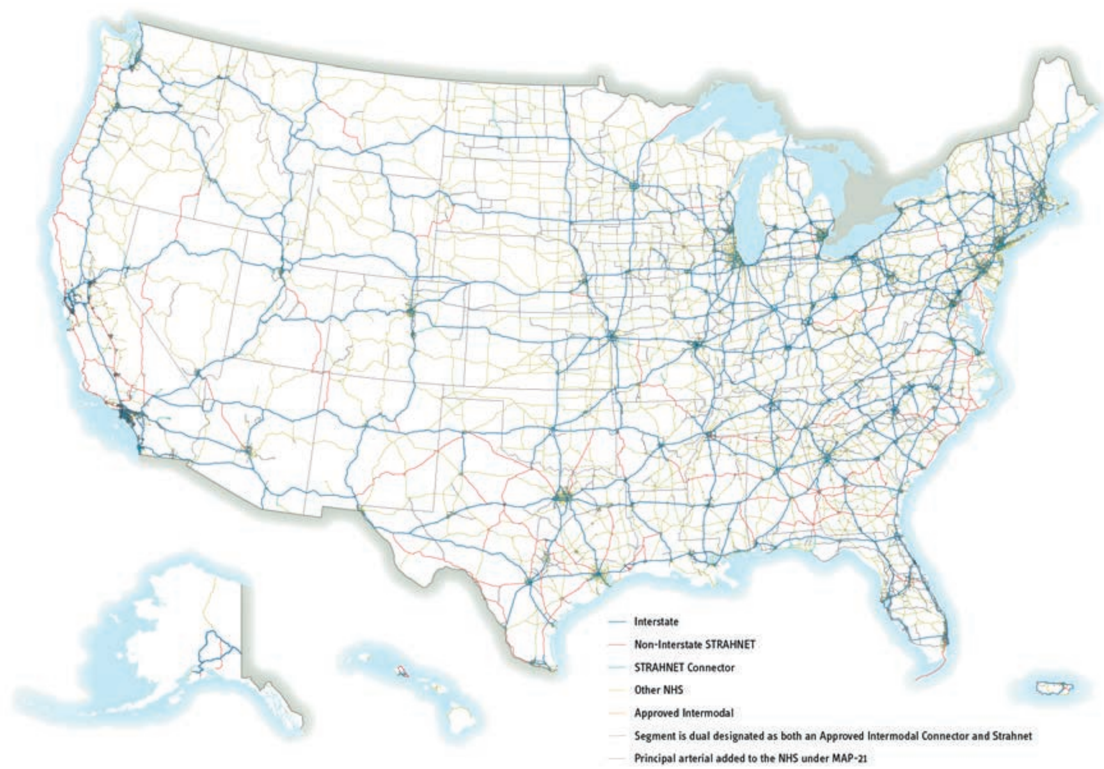
Figure 1-1 shows the National Highway System (NHS) and other principal arterials and intermodal connectors, comprising an extensive system of highways that supports densely populated urban centers in the northeast and parts of the Midwest, South, and West. The NHS includes interstate highways as well as other roads important to the Nation’s economy, defense, and mobility.

Condition of Roads and Highways

Interstate Highways Have the Best Pavement Condition

The U.S. Department of Transportation’s (USDOT’s) Federal Highway Administration

Figure 1-1 National Highway System, Intermodal Connectors, and Principal Arterials: 2022



KEY: NHS = National Highway System or the interstate highway system; STRAHNET = Strategic Highway Network or a network of highways which are important to the U. S. strategic defense policy. MAP-21 principal arterials = those rural and urban roads serving major population centers not already categorized above.

SOURCE: U.S. Department of Transportation (USDOT), Federal Highway Administration, Highway Performance Monitoring System, as cited in USDOT, Bureau of Transportation Statistics, National Transportation Atlas Database, available at www.bts.gov as of October 2022.

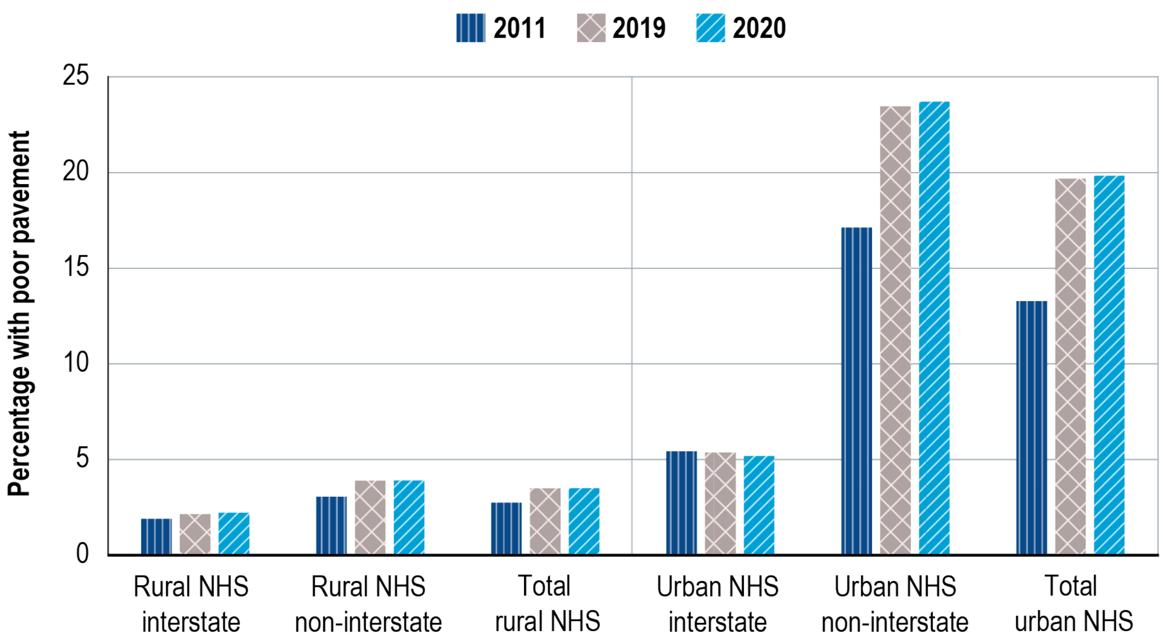
(FHWA) reports national statistics on pavement condition using International Roughness Index (IRI) measurements, which indicate the smoothness of pavement for three major categories:

1. Road-miles on the NHS, a network of strategic highways and roads in the United States that includes the interstate highway system;
2. Road-miles by functional classification, such as interstates, other freeway and expressways, other principal arterials, and minor arterials; and
3. National system performance measures of daily VMT by NHS road pavement condition.

The percentage of pavement in poor condition on the rural NHS has remained relatively stable (under 4.0 percent) since 2011,[3] with rural NHS interstate highways having the best pavement condition of all NHS roads (Figure 1-2). The percentage of urban NHS interstate highways with poor pavement improved slightly from 5.4 percent in 2011 to 5.1 percent in 2020. From 2011 to 2020, the portion of the NHS with the poorest pavement has consistently been the urban non-interstate portion of the system, with a percentage about 5 times greater than other portions of the NHS. The total rural and urban NHS categories are a summary of the statistics of both the NHS interstate highways and non-interstate highways in each category, including Puerto Rico. Poor condition is defined as any pavement with an IRI value greater than 170 inches/mile.

[3] No data were reported for 2010 due to a change in the data model, so data reported for 2011 were used in this section.

Figure 1-2 Percent Miles of the NHS with Poor Pavement: 2011, 2019, and 2020



KEY: IRI = International Roughness Index; NHS = National Highway System.

NOTE: Poor condition is defined as any pavement with an IRI value greater than 170 inches/mile.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, table HM-47, available at http://www.fhwa.dot.gov/policyinformation/statistics.cfm as of September 2022.

Looking at the pavement condition for all high function roads, including non-NHS federal and state roads that have high traffic volumes and densities, yields a broader and slightly different view of overall road condition than just examining the NHS (Figure 1-3). The mileage of rural higher function roads with poor pavement conditions increased between 2011 and 2020. The percentage of poor pavement miles in 2011 for rural interstates and other freeways/principal arterials was just under 5, increasing to just over 5 in 2020. The mileage of urban higher function roads with poor pavement conditions improved for all roadway classes, decreasing from 21.4 percent in 2011 to 19.8 percent in 2020.

Daily VMT were approximately 4.3 billion in 2020, of which 10.3 percent were over roads with pavement in poor condition. Poor pavement conditions can lead to bumpy rides, vehicle wear, and flat tires in addition to traffic congestion and crashes. Urban roads have a larger share than rural roads of VMT on roads with poor pavement conditions. The percentage of daily VMT on rural NHS roads with poor pavement condition increased from about 2 percent in 2011 to about 3 percent in 2018; for urban NHS travel on poor pavement, the percentage increased from about 11 to about 14 percent over the same period, as shown in Figure 1-4 [USDOT FHWA OHPI 2021].

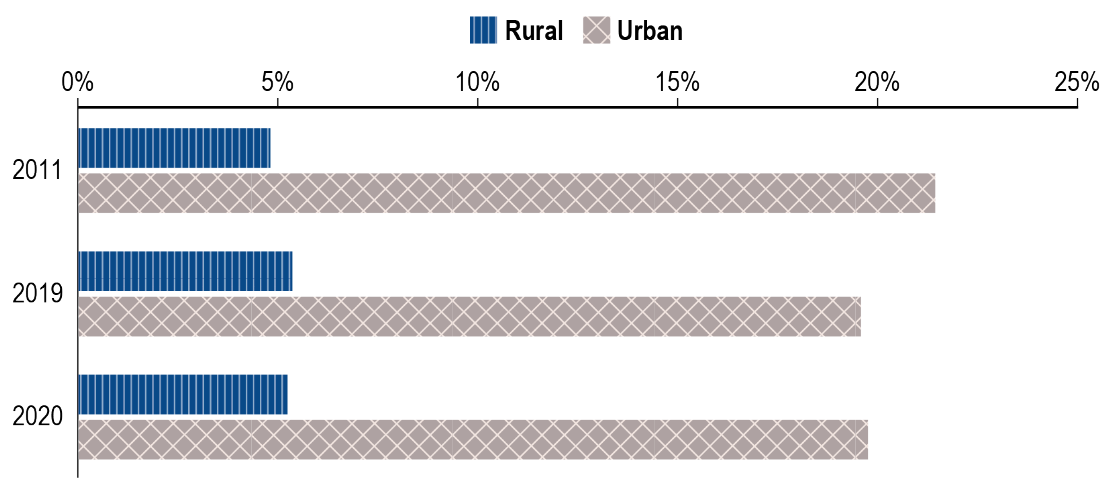
Bridges

In most cases, as stated above, 2020 data is the latest year available for complete and final datasets. FHWA has total bridge data that varies per bridge, based on lane miles, load restrictions, and bridge conditions.

A total of 618,456 highway bridges were in use in 2020 (Table 1-1), ranging in size from rural one-lane bridges crossing creeks to urban multilane and multilevel interstate bridges and major river crossings.

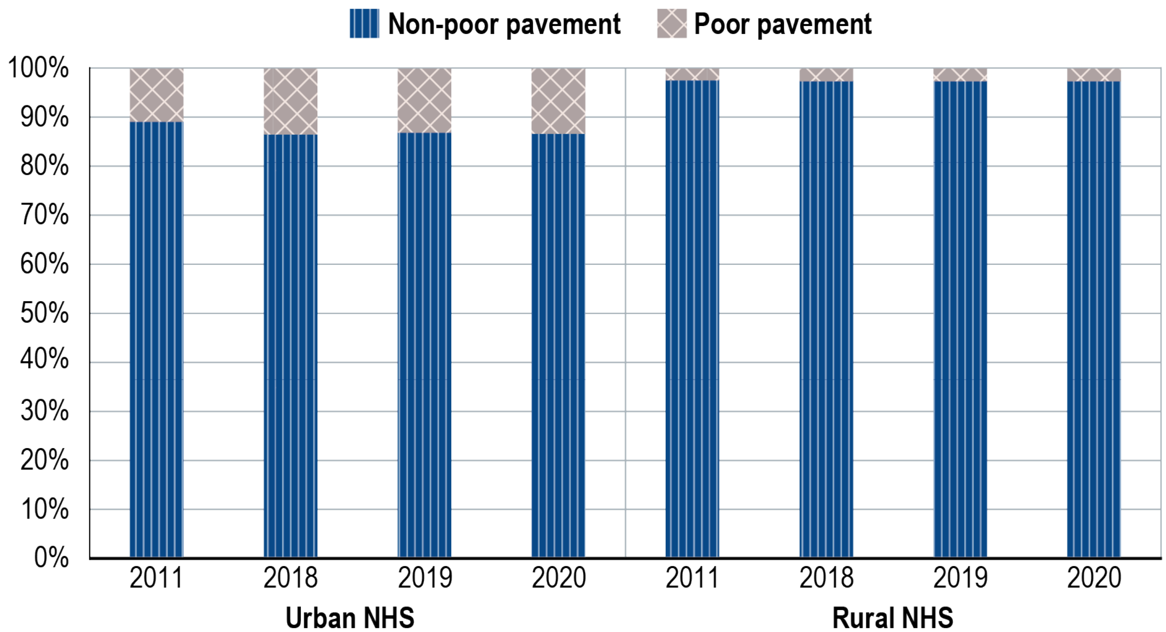
In the same year, rural bridges, including those on rural interstate highways, accounted for 70.9 percent of the total bridge network [USDOT FHWA OHPI 2021]. While the interstate highway bridges accounted for 9.5 percent of all bridges, they carried 45.5 percent of motor vehicle bridge traffic.

Figure 1-3 Rural vs. Urban High Function Roads with Poor Pavement Condition: 2011, 2019, and 2020



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, table HM-64, available at http://www.fhwa.dot.gov/policyinformation/statistics.cfm as of September 2022.

Figure 1-4 Daily Vehicle-Miles Traveled on NHS Roads With Poor Pavement Condition, Urban vs. Rural: 2011 and 2018–2020 (Daily VMT = 4.3 Billion in 2020)



KEY: NHS = National Highway System; VMT = vehicle-miles traveled.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *National Highway System Length – 2018, Daily Travel by Measured Pavement Roughness – Urban and Rural*, table HM-47A, available at https://www.fhwa.dot.gov/policyinformation/statistics/2020/pdf/hm47b.pdf as of September 2022.

Condition of Bridges

Bridge Condition Has Continued to Improve

The number of the Nation's bridges in poor condition[4] declined from 59,305 bridges (about 10 percent of all bridges) in 2010 to 42,966 in 2022 (6.9 percent) [USDOT FHWA 2022a]. Poor bridge conditions affect freight transportation and passenger travel, especially if detours around a closed bridge[5] or weight restrictions[6] are in place. Under extreme circumstances, poor bridge conditions can lead to headline grabbing catastrophic failures and collapses. The percent of bridges in poor condition has been two-and-a-half to almost three times greater for non-NHS bridges than for NHS bridges.[7,8]

As shown in Figure 1-5, the greatest percentage of poor bridges, determined by the lowest rating of the National Bridge Inventory (NBI) condition ratings for the bridge deck, superstructure, substructure, or culverts, are in rural and urban

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

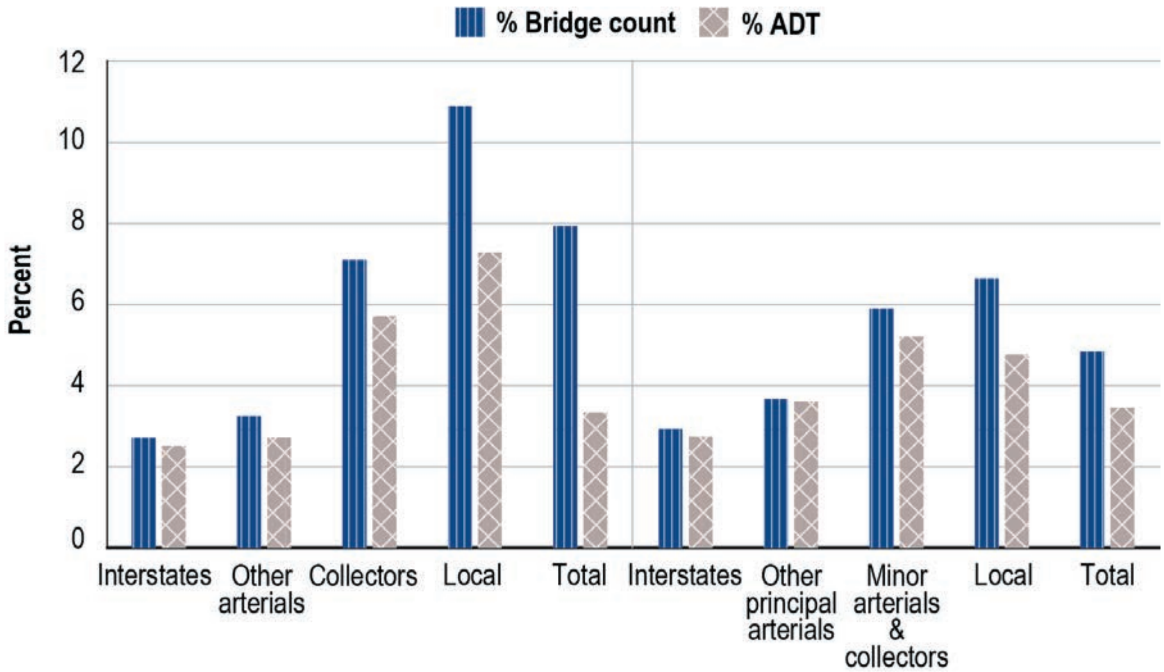
[5] Closed bridges are not open to public traffic.

[6] A weight-restricted bridge cannot safely support the weight of any vehicles that exceed the posted weight limit even if they are otherwise legal on the adjacent roadways.

[7] NHS bridges are those bridges located on the network of strategic highways and roads in the United States that comprise the NHS and includes the interstate highway system.

[8] 2012 is the first year available reflecting the Federal Highway Administration's new condition-based performance measures, such as "the percent of NHS bridges by deck area classified as in poor condition."

Figure 1-5 Number of and Average Daily Traffic on Poor Condition Bridges: 2021



KEY: ADT = average daily traffic.

NOTE: A "poor" bridge condition rating is determined by the lowest rating of the National Bridge Inventory (NBI) condition ratings for bridge deck, superstructure, substructure, or culverts.

SOURCE: U.S. Department of Transportation, Federal Highway Administration, Bridge Condition by Functional Classification, available at https://www.fhwa.dot.gov/bridge/fc.cfm as of September 2022.

areas are on local roads. Bridges in poor condition on rural roads in 2021 accounted for about 7.9 percent of the total number of rural bridges and 3.3 percent of the throughput (average daily traffic[9]) on rural highways.

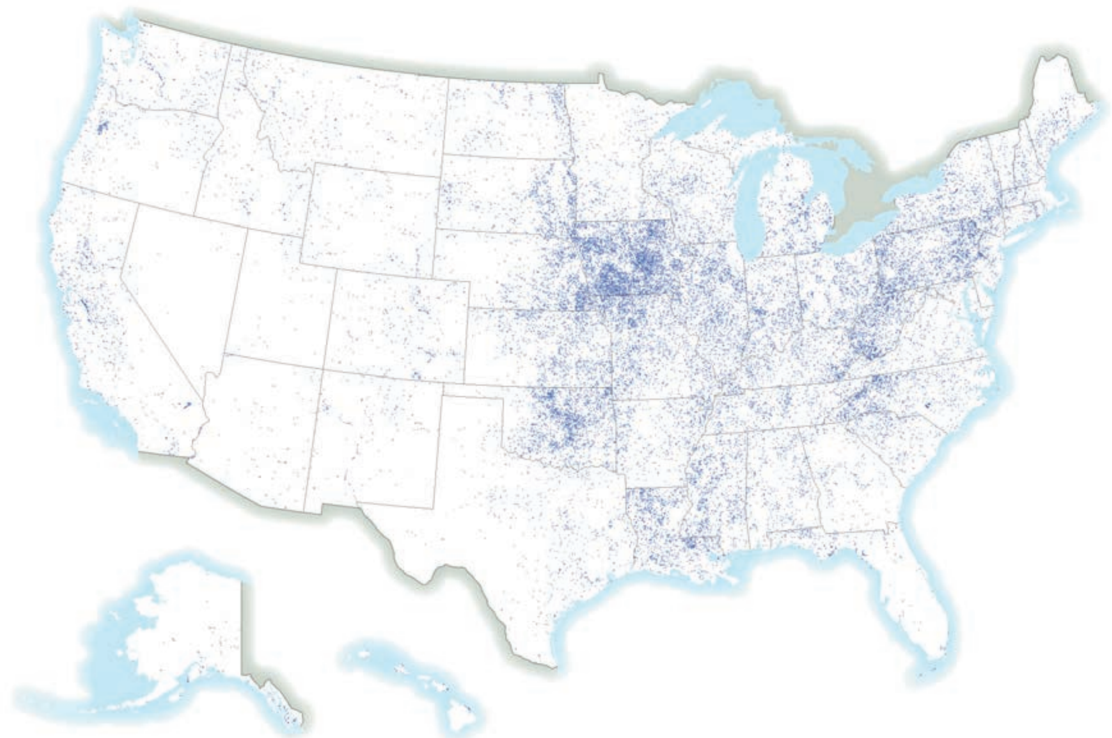
In comparison, bridges in poor condition on urban roads comprised approximately 4.8 percent of urban bridges and 3.5 percent of urban road throughput (average daily traffic) [USDOT FHWA 2021a]. The most used bridges are in better shape than their less-used counterparts, just as interstate and NHS bridges are in better shape than their smaller non-NHS counterparts.

Bridges are an important component of rural transportation infrastructure. Of the 43,586 bridges considered to be in poor condition nationwide in 2021,[10] about 80 percent of them are in rural areas [USDOT FHWA 2022d]. Bridges in poor condition are concentrated in rural areas in the Midwest and Northeast (Figure 1-6). Moreover, 4 out of 5 closed bridges and 9 out of 10 bridges with posted load restrictions are in rural areas. Load restrictions on bridges can increase costs

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

[10] Bridges in poor condition may have deficiencies, such as deck deterioration, section loss (loss of a cross-sectional area of a bridge member caused by corrosion or decay), spalling (depression in concrete), and scour (erosion of the stream bed or bank material around the bridge due to water flow).

Figure 1-6 Bridges in Poor Condition in Rural Areas: 2021



SOURCE: U.S. Department of Transportation, Federal Highway Administration, National Bridge Inventory, available at www.transportation.gov as of October 2022.

(e.g., delivery delays, costly detours, and the need for lighter trucks or loads). Detours around a closed bridge in rural areas averaged more than three times the distance of bridge detours in urban areas (17.75 vs. 5.55 miles) [USDOT FHWA OHPI 2021].

In 2021, 66,399 out of the 615,734 bridges open to traffic had some type of load restriction or a temporary bridge in place, comprising about 11 percent of all bridges [USDOT FHWA 2022c]. The percentage of the Nation's bridges open to traffic with restricted postings alone was about 11 percent in 2010 and 10 percent in 2021, showing some improvement in bridge condition. Of the 64,476 bridges having some form of posted restriction in 2021, about 29 percent (18,757 bridges) were in poor condition.

Concerning who owns and is responsible for the upkeep of the 43,586 bridges in poor condition in 2021, about 31 percent of these bridges (13,303) were owned by States, 51 percent (22,368) by counties, 7.1 percent (3,103) by towns, 7.3 percent (3,187) by cities, and 1.8 percent (770) by the Federal Government. The remaining bridges are owned by park agencies, tollways, railroads, and other entities [USDOT FHWA 2022b].

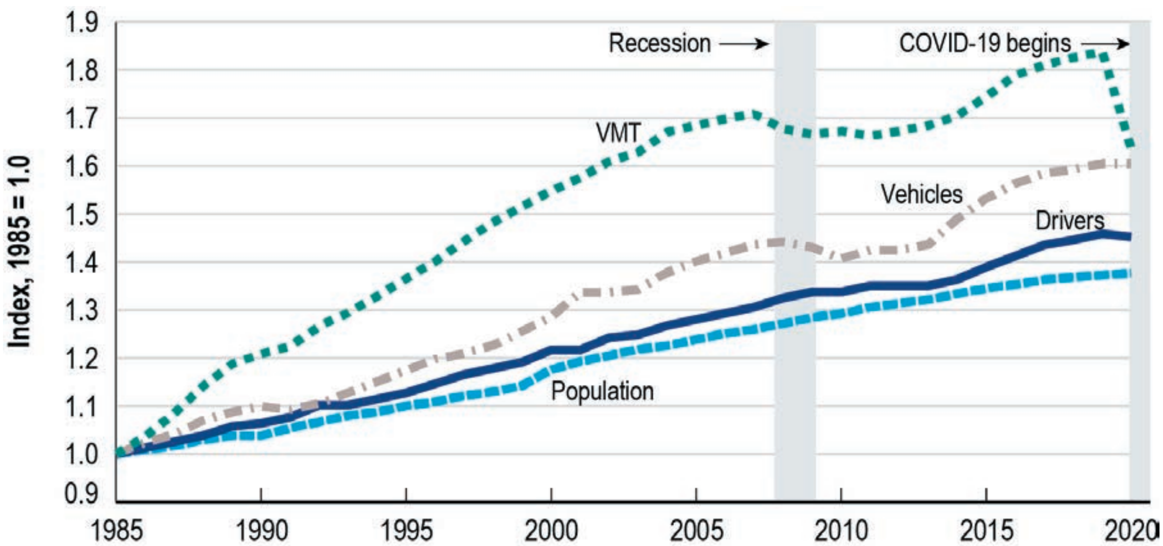
Vehicles

Government, businesses, private individuals, and nongovernmental organizations owned and operated about 275.9 million motor vehicles in 2020 and drove a total of more than 2.9 trillion miles. Although commercial vehicles (trucks and buses) comprised about 5 percent of registered vehicles, their use accounted for about 11 percent of VMT [USDOT FHWA OHPI 2021].

While highway system growth has stagnated in recent years, quite the opposite is true for the number of highway vehicles and the miles they are driven, both of which have grown at a faster rate than licensed drivers and the population since 1985 (Figure 1-7). Some noticeable changes in these trends occurred during the beginning of the COVID-19 pandemic in 2020. While vehicle ownership and licensed drivers continued to grow, but at a slower rate, VMT decreased 11 percent from 2019 to 2020, which was a notable drop from that which occurred during the 2008–2009 economic recession. VMT in 2020 was down to the same level as in 2003, which predated the recession years. Pandemic-induced changes in passenger travel and freight shipping are discussed further in Chapter 2 - Passenger Travel and Equity and Chapter 3 - Freight and Supply Chain. The pandemic was also largely responsible for the anemic growth in vehicle registrations (0.8 percent) from 2018 to 2020. Over that period, new passenger car sales in the United States declined from 5.3 million to 3.4 million vehicles [USDOT BTS 2022b] as shortages of labor and vehicle components (especially electronics) resulted in reduced vehicle production and increased vehicle prices. These factors are discussed further in Chapter 4 - Transportation Economics.

Most daily personal travel, particularly work commutes, is in privately owned vehicles. According to the National Household Travel Survey [USDOT FHWA 2022e], the average passenger vehicle was driven slightly more than 10,000 miles a year in 2017, which is about the same as in 2009. More recent usage, however, has likely declined due to the pandemic's effects. Comparable public data for commercial trucks are not available. The Vehicle Inventory and Use Survey (VIUS), formerly conducted every 5 years

Figure 1-7 Licensed Drivers, Vehicle Registrations, Vehicle-Miles Traveled, and Population: 1985–2020



KEY: VMT = vehicle-miles traveled.

SOURCE: Vehicles, Drivers, and Population: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2020. Table DV-1C and VM-1, available at https://www.fhwa.dot.gov/policyinformation/statistics/2020/ as of September 2022.

by the Census Bureau (the last survey was in 2002), provided further data on the physical and operational characteristics of the Nation's commercial truck population. An updated VIUS is being conducted by BTS in 2022 [USDOT BTS 2022f].

Condition of the Vehicle Fleet

Increasing Age of Vehicles

The average age of the Nation's light vehicles (which includes passenger cars and light trucks) has been increasing steadily over time and was 11.7 years in 2018, up from 10.6 years in 2010. The pandemic-induced drop in vehicle sales, noted above, increased the average vehicle age even further, reaching 12.1 years in 2021 [USDOT BTS 2022b]. Vehicle condition usually declines with use and age.

Various factors have been offered to explain the increasing age of the vehicle fleet: longer vehicle life due to improvements in vehicle manufacturing, an increase in the number of vehicles per household (e.g., older vehicles passed on to children of driving age when parents get a new car), changes in driving habits, and deferring vehicle purchases during economic recessions. As to the latter, the average age increase in the light-duty vehicle fleet was 12 percent between 2008 and 2013, a period of economic recession and recovery, compared with average age increases during the non-recession periods immediately before and after the recession of about 4 percent between 2002 and 2007 and 3 percent between 2015 and 2019 [USDOT BTS 2022b]. In comparison, the vehicle fleet has aged 3.4 percent from 2018 to 2021, which spans the COVID-19 pandemic years, extrapolating to an increase of nearly 6 percent by 2023 if the present trend continues.

Highway Congestion

Much Lower Urban Highway Congestion During the Pandemic

Congestion measures are reported for the 52 largest metropolitan statistical areas (MSAs)—those with a population over 500,000—in the FHWA *Urban Congestion Report* [USDOT FHWA 2021b] (UCR) based on vehicle probe data.[11] Three measures are used to gauge congestion, an excess of vehicles on the roadway is one of the factors resulting in speeds that are slower than normal (free flow) speeds:

1. Daily congested hours,
2. Travel Time Index (TTI) that compares peak period travel time to low-volume travel time, and
3. Planning Time Index (PTI) for freeways that calculates the time needed to arrive on schedule with a probability of 95 percent for any particular time of the day relative to the free-flow travel time (a measure of travel time reliability).

Each of these measures represents a different aspect of congestion. The effects of reduced driving during the pandemic are evident in the latest results. From 2019 to 2020, on average for the 52 urban areas studied, congested hours were down 39 percent, TTI was down 14 percent, and PTI dropped 24 percent [USDOT FHWA 2021b].

The Texas A&M Transportation Institute's *Urban Mobility Report* provides a comprehensive look at highway congestion [SHRANK, EISELE, LOMAX 2021]. This biennial report, which relies on INRIX[12] data, includes both NHS and non-NHS freeways and arterial roads. The *Urban Mobility Report* reports show metrics for

[11] Vehicle probe data consists of locational data collected from the global positioning systems on vehicles using the road network.

[12] INRIX data is collected every 15 minutes of the average day of the week for almost every mile of major road in urban America, resulting in about a billion data points on speed on about 1.5 million miles of U.S. streets and highways. More than 90 percent of the travel delay in the 2019 report is based on a measured traffic speed.

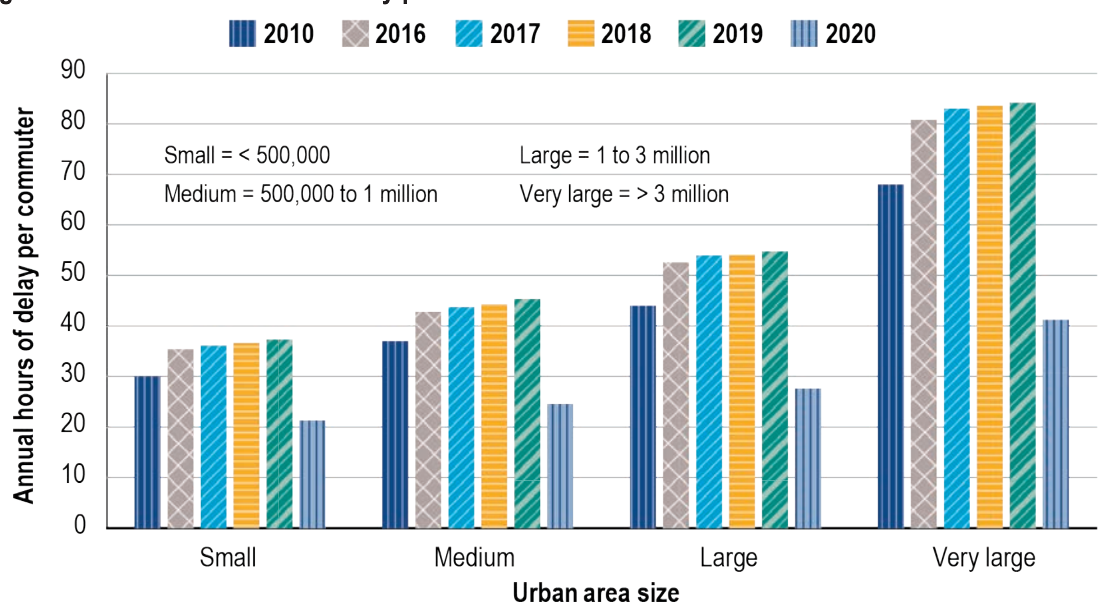
101 MSAs with additional data for another 393. The 2021 *Urban Mobility Report* shows that there were unprecedented reductions in highway congestion in urban areas in the COVID-19 initial pandemic year of 2020.

Figure 1-8 shows the average annual delay per commuter in the 101 largest urban areas for 2010 and 2016–2020. Overall, in urban areas annual hours of delay per commuter dropped from 54 hours in 2019 to 27 hours in 2020, a value not seen since 1989, more than three decades ago. Other congestion measures also recorded drops of historic proportions from 2019 to 2020. The average Travel Time Index decreased from 1.23 to 1.09, delay cost per commuter dropped from $1,170 to $605 (a 48 percent decline), and total motor fuel wasted due to congestion decreased from 3.5 billion gallons to 1.7 billion gallons (minus 51 percent) [SHRANK, EISELE, LOMAX 2021].

Truck congestion was different in some respects in 2020. Truck traffic did not decline as much as passenger vehicle traffic, as trucks made more business and home deliveries. As a result, the decrease in truck congestion was less than the decrease for passenger cars and was spread out over all sizes of urban areas, and over more hours of the day than the traditional commute hours. Truck congestion cost was $11 billion in 2020, down from $20 billion in 2019, but the truck share of total congestion cost increased from 11 percent of the total in 2019 to 12 percent in 2020. [SHRANK, EISELE, LOMAX 2021]

Figure 1-9 shows the peak-period congestion on high-volume truck routes on the NHS in 2020 and the projected peak-period congestion in the entire NHS in 2045. Not surprisingly, the major congested points are in metropolitan areas where truck traffic mixes with other traffic and along major interstate highways connecting major metropolitan areas. The rankings by peak average speed for the top 25 freight-significant congested locations (e.g., Fort Lee, NJ, Atlanta, and Nashville) in the Nation have stayed about the same over the past 10 years,

Figure 1-8 Annual Hours of Delay per Commuter: 2010 and 2016–2020



SOURCE: Schrank, Eisele, and Lomax. Texas A&M Transportation Institute, *Urban Mobility Report 2021*. available at https://mobility.tamu.edu/umr/ as of September 2022.

Figure 1-9 Peak-Period Congestion on the High-Volume Truck Routes on the National Highway System, 2020 and Projected to 2045

A. 2020

B. Projected to 2045

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.5, special tabulation as of October 2022.

although some locations have shown minor movements up or down the list [ATRI 2022]. In 2021, the average peak-hour truck speed for the top 100 truck bottlenecks was 38.6 mph, down 11.2 percent from 2020. Incremental efforts and system improvements have helped to mitigate congestion, but peak-period demand continues to exceed highway capacity. In 2022, BTS created a Supply Chain Indicators Dashboard that produces monthly average truck speed miles per hour (MPH) at 10 bottleneck locations that track data from January 2019 to October 2022, see Figure 1-10.

Public Transit

The COVID-19 Pandemic Caused Transit Ridership to Plummet

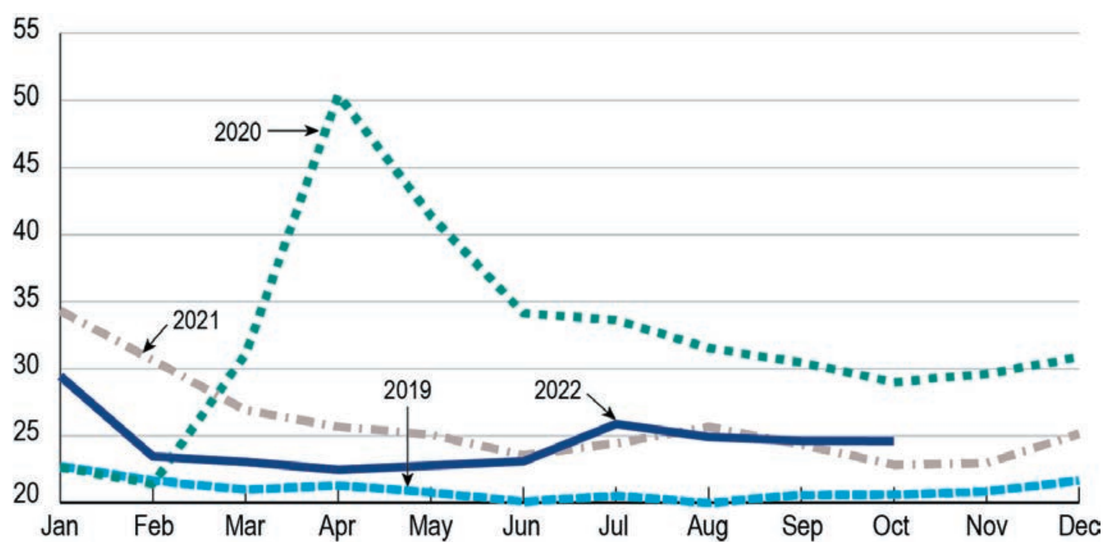
About 970 urban transit agencies and 1,270 rural and tribal government transit agencies offer a range of travel options, including commuter rail, subway, and light-rail; transit and trolley bus; demand-response services; and ferryboat. In 2020, these transit agencies operated over 5,700 stations.[13] There were 13,173 fixed-rail-transit track-miles and 5,000 fully controlled or limited-access bus lane-miles in 2020 [USDOT FTA 2021].

Transit agencies vary widely in size, ranging from social service agencies operating a single vehicle to the 13,000 vehicles[14] operated by the New York City Metropolitan Transportation Authority. While 2020 saw little change in public transit infrastructure, the COVID-19 pandemic caused transit ridership to plummet. Passenger trips dropped from 9.0 billion in 2019 to 5.4 billion in 2020, a reduction of 40 percent (Table 1-2). Monthly ridership losses during the onset of the pandemic were even more striking. April 2020 had 158.5 million unlinked passenger trips (UPT),—the lowest ridership on record since 2002. This was down from 835.1 million UPT in April of 2019, a decrease of 81 percent.

[13] With about 83 percent compliant with the Americans with Disabilities Act (Pub. L. 101-336).

[14] Includes commuter bus, demand response, heavy rail, bus, and bus rapid transit.

Figure 1-10 Average Truck Speed in MPH at Bottleneck Locations: 2019, 2020, 2021, and 2022



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Supply Chain Indicator Dashboard, available at https://www.bts.gov/freight-indicators#truck-speed, as of October 2022.

Table 1-2 Transit Vehicles and Ridership: Revenue Years 2000, 2010, and 2018–2020

Transit vehicle	2000	2010	2018	2019	2020
TOTAL, transit vehicles	**106,136**	**135,674**	**134,855**	**137,581**	**137,614**
TOTAL, rail transit vehicles	**17,114**	**20,374**	**20,515**	**21,153**	**21,387**
Heavy rail cars	10,311	11,510	10,763	11,198	11,064
Commuter rail cars and locomotives	5,497	6,768	7,023	7,144	7,524
Light rail cars	1,306	2,096	2,729	2,811	2,799
TOTAL, non-rail transit vehicles	**89,022**	**115,300**	**114,340**	**116,428**	**116,227**
Motor bus	59,230	63,679	63,284	64,000	63,830
Demand response	22,087	33,555	33,253	34,613	34,561
Ferry boat	98	134	171	183	204
Other	7,607	17,932	17,632	17,632	17,632
Rail Transit Stations	**2,595**	**3,124**	**3,448**	**3,632**	**3,665**
Person-Miles (millions)	**45,100**	**52,627**	**53,830**	**54,097**	**31,547**
Unlinked Passenger Trips (UPT in billions)	**7.95**	**9.30**	**8.96**	**8.96**	**5.42**
Rail transit UPT	**2.95**	**3.92**	**4.18**	**4.24**	**2.12**
Non-rail transit UPT	**5.00**	**5.38**	**4.78**	**4.72**	**3.30**

KEY: UPT = unlinked passenger trips.

NOTES: *Motor bus* includes bus, commuter bus, bus rapid transit, and trolley bus. *Light Rail* includes light rail, streetcar rail, and hybrid rail. Demand response includes demand response and demand response taxi. *Other* includes the Alaska railroad, automated guideway transit, cable car, inclined plane, monorail, and vanpool. *Unlinked passenger trips* are the number of passengers who board public transportation vehicles. Passengers are counted each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination.

SOURCES: ***Transit vehicles:*** U.S. Department of Transportation (USDOT). Federal Transit Administration (FTA). National Transit Database (NTD) as cited in USDOT. Bureau of Transportation Statistics (BTS). National Transportation Statistics (NTS). Table 1-11. Available at http://www.bts.gov/ as of August 2022. ***Person-miles traveled:*** USDOT/FTA/NTD as cited in USDOT/BTS/NTS. Table 1-40. Available at http://www.bts.gov/ as of August 2022. ***Transit Stations and Unlinked passenger trips:*** USDOT/FTA/NTD. Available at https://www.transit.dot.gov/ntd/ntd-data as of August 2022.

Eight months later, in December, ridership was still down by 62 percent compared to 2019 [USDOT FTA 2021]. While transit ridership is slowly increasing, it has yet to recover to pre-pandemic levels [USDOT BTS 2022j]. Figure 1-11 shows transit ridership in the top 50 urbanized areas in 2021.

Despite the ridership decline, the distribution of vehicles and activity across the different transit modes was roughly the same as in recent years. Rail transit (heavy, commuter, and light rail) comprised approximately 16 percent of the transit vehicles but 39 percent of transit trips and 53 percent of person-miles traveled (PMT) [USDOT FTA 2021]. Buses recorded the highest share of transit trips at 56 percent but only 40 percent of PMT. This can be attributed to the fact that bus passengers generally take shorter trips. Conversely, due to longer trips, rail carries 43 percent of all transit PMT. Demand-response or paratransit systems, which are largely social service agency trip providers in areas without fixed services or timetables, operated around 25 percent of transit vehicles in 2020 but carried only 2 percent of the trips and passenger miles. Demand-response and paratransit systems, which operate mostly in urban areas but also sometimes in rural areas, tend to service those with a disability or those who do not own a car.

Two rapidly growing travel services that affect both driving and transit usage in urban areas are ride-hailing and vehicle-sharing. These on-demand services have created new business models including transportation network companies (TNCs), mobility on demand (MOD), and mobility-as-a-service (MaaS), which rely on a digital platform that integrates various forms of transport services into a single on-demand service. The use of these new travel options is discussed further in Chapter 2—Passenger Travel and Equity.

Transit System Condition

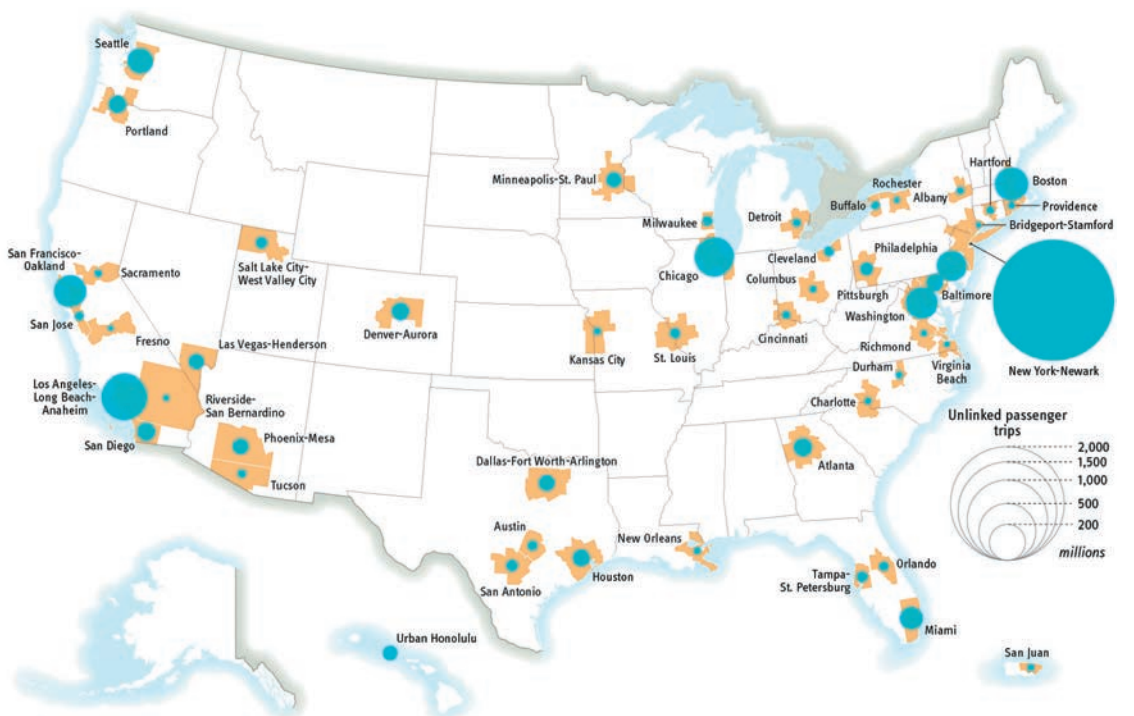
Most Transit Vehicles and Facilities Are in a State of Good Repair

Vehicle age is used as a surrogate for condition, with the average lifetime mileage by asset type[15] reflecting the respective condition of different transit modes, with older transit vehicles more likely to break down than newer ones. For the most part, the average age of the Nation's transit fleet increased between 2000 and 2020. Two exceptions include ferryboats, where investments in new vessels occurred in the late 2000s, which dropped their average age by about 5 years, and in articulated buses,[16] which have shorter useful life and thus a faster fleet turnover (Figure 1-12). The average age of heavy rail passenger cars, at about 23 years, makes them the oldest part of the Nation's transit system [USDOT BTS 2022b]. Motorbuses have

[15] Average lifetime mileage per active vehicle is the total miles accumulated on all active vehicles since date of manufacture divided by the number of active vehicles. Typically, this is found by taking the average of all odometer readings at the end of the fiscal year.

[16] Data on the average age of other types of transit buses have been unavailable since 2013. Over the period 2000 to 2013 the average age of large transit buses was 7.7 years, versus 6.1 years for articulated buses. The latter had an average age of 7.1 years from 2014 to 2020, so it appears that large transit buses are roughly a year older than articulated buses.

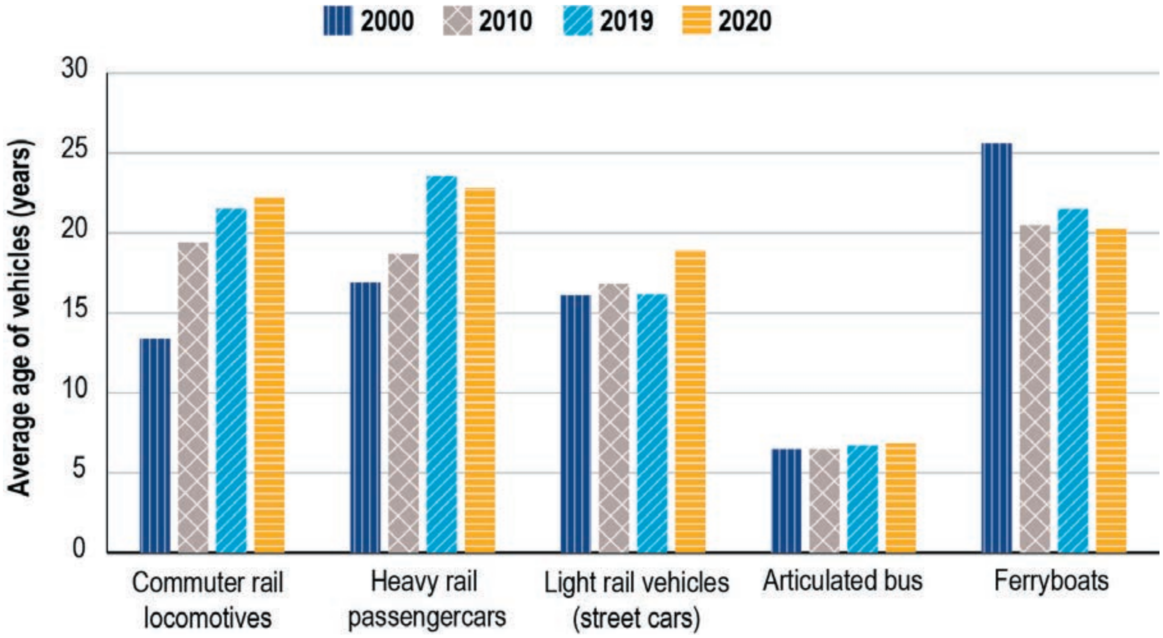
Figure 1-11 Top 50 Urbanized Areas of Transit Ridership: 2021



NOTE: Urban Areas (orange shaded)—built-up area or urban agglomeration with a high population density and significant infrastructure.

SOURCE: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, available at www.fta.dot.gov as of October 2022.

Figure 1-12 Average Age of Urban Transit Vehicles: 2000, 2010, 2019, and 2020



NOTE: An articulated bus is bus type with two sections joined by a vertical hinge, which allows for easier cornering.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 1-29, available at https://www.bts.gov/content/average-age-urban-transit-vehicles-years as of September 2022.

an average age of 7.5 years [USDOT FTA 2021]. In general, average vehicle age increases with the vehicle's replacement cost because agencies have an incentive to maintain their more expensive assets to extend their service lives.

The transit industry has made progress in improving the reliability of service, primarily through preventative maintenance and investments in state-of-good-repair. For example, the number of major mechanical failures[17] for buses decreased from about 248,000 in 2010 to 176,000 in 2020—a 29 percent decrease. Transit agencies also report state-of-good-repair information for fixed and mobile assets. Of all assets rated in 2020, 82 percent of revenue vehicles (those that carry passengers) and 88 percent of facilities (e.g., transit stations, maintenance facilities, parking lots, and structures) were deemed to be in a state-of-good-repair [USDOT FTA 2021].

Aviation

Air Travel Plummeted Due to the Pandemic

The main elements of aviation system infrastructure include airport runways and terminals, aircraft, and air traffic control systems. In 2021 the United States had about 20,100 airports (Table 1-3), ranging from rural grass landing strips to large paved multiple-runway airports. About a quarter of the airports are public-use facilities, which include large commercial airports and general aviation airports that serve a wide range of users. The remaining three-quarters are private airports, which tend to be relatively small. The stock of airports has been relatively stable over the past

[17] A major mechanical failure is one that that prevents the vehicle from completing a scheduled revenue trip or from starting the next scheduled revenue trip because movement is limited, or safety compromised.

two decades, the exception being a 6 percent increase in the number of private airports since 2000. Interestingly, the number of licensed pilots increased by 15 percent from 2010 to 2021. Despite the increase in air transport pilot licenses, air crew shortages have been a significant factor in flight cancellations and route reductions during the pandemic.

The COVID-19 pandemic caused major reductions in air travel in 2020 (Table 1-3). Total passenger enplanements at U.S. airports were down from 1.05 billion in 2019 to 401 million in 2020, a drop of 62 percent, and there were fewer enplanements than the total reported two decades earlier. Traffic rebounded in 2021 to about two-thirds of 2019's record high

Table 1-3 U.S. Air Transportation System: 2000, 2010, and 2018–2021

Air transportation system	2000	2010	2018	2019	2020	2021
TOTAL, U.S. airports	**19,281**	**19,802**	**19,627**	**19,636**	**19,919**	**20,061**
Public use	5,317	5,175	5,099	5,080	5,217	5,211
Private use	13,964	14,353	14,528	14,556	14,702	14,850
Military	U	274	305	308	312	313
TOTAL, aircraft	**225,359**	**230,555**	**219,224**	**218,609**	**210,862**	**U**
General aviation aircraft	217,533	223,370	211,749	210,981	204,140	204,405
Commercial aircraft	7,826	7,185	7,475	7,628	5,882	U
Pilots	**625,581**	**627,588**	**633,317**	**664,565**	**691,691**	**720,605**
TOTAL, load factor	**72.94**	**81.79**	**83.72**	**84.65**	**58.79**	**73.75**
Domestic flights	71.14	82.07	84.47	85.11	58.90	77.68
International flights	75.02	81.48	81.93	83.53	58.33	59.00
TOTAL, passenger enplanements (thousands)	**741,181**	**791,815**	**1,016,834**	**1,053,200**	**400,796**	**703,303**
Enplanements on domestic flights	599,844	632,141	780,034	813,887	336,937	608,208
Enplanements on international flights of U.S. carriers	70,476	89,198	111,910	115,552	34,797	60,773
Enplanements on international flights of foreign carriers	70,861	70,477	124,890	123,761	29,062	34,323
TOTAL, revenue passenger-miles, U.S. carriers (millions)	**691,853**	**795,128**	**1,010,573**	**1,054,798**	**378,052**	**687,824**
Domestic, revenue passenger-miles (RPM) (millions)	500,432	554,711	720,818	752,758	303,562	571,839
International on U.S. carriers,revenue passenger-miles (RPM) (millions)	191,422	240,418	289,755	302,041	74,490	115,985
TOTAL, Freight Enplaned (thousand tons)	**5,023**	**14,124**	**17,221**	**17,327**	**18,910**	**20,187**
Domestic, Freight Enplaned (thousand tons)	1,574	10,083	12,412	12,704	13,994	14,692
International on U.S. carriers, Freight Enplaned (thousand tons)	3,449	4,041	4,809	4,624	4,916	5,496

KEY: U = unavailable at time of publication.

NOTES: *General aviation* includes air taxis. Major U.S. carriers have annual operating revenue exceeding $1 billion. National carriers have annual operating revenues between $100 million and $1 billion. These carrier categories differ from the more commonly used business model categories. Total includes both scheduled and non-scheduled passenger enplanements. *Revenue passenger-miles* (RPM) are calculated by multiplying the number of revenue passengers by the distance traveled. *Load factor* is a measure of the use of aircraft capacity that compares the system use, measured in RPMs as a proportion of system capacity, measured by available seat miles.

SOURCES: ***Airports:*** U.S. Department of Transportation (USDOT). Federal Aviation Administration (FAA), special tabulation, November 2019. ***General aviation aircraft and Pilots:*** USDOT/FAA. FAA Aerospace Forecast, Fiscal Years (multiple issues). Available at www.faa.gov as of November 2019. ***Passenger enplanements:*** USDOT, Bureau of Transportation Statistics (BTS), Office of Airline Information (OAI), T1/DB20 (Green Book). Available at http://www.transtats.bts.gov/ as of November 2019. ***RPM and Freight Enplaned:*** USDOT, BTS, OAI, T-100 Segment data. Available at http://www.transtats.bts.gov/ as of November 2019.

enplanements. This lower traffic level meant that fewer planes were flying and that planes were flying with a lot of empty seats. Load factor, a measure of aircraft capacity utilization, was 59 percent in 2020 and 74 percent in 2021, as compared with 85 percent in 2019. The recovery in air passenger traffic continued into 2022, when the number of aircraft departures in the first 9 months were 90.4 percent of the departures in the first 9 months of 2019 [USDOT BTS 2022l]. Air freight has been a bright spot during the pandemic, increasing 16.5 percent from 2019 to 2021 (Table 1-3).

Figure 1-13 shows the U.S. airports with the most passenger enplanements on scheduled flights in 2021. Hartsfield-Jackson Atlanta International (36.7 million), Dallas/Fort Worth International (30.0 million), and Denver International (28.6 million) were the top three airports in 2021. The top 50 airports accounted for 83 percent (about 542 million) of the U.S. airport passenger enplanements in 2021.

U.S. airports handled about 5.7 million[18] commercial airline flights in 2020, 56 percent of the number of flights in 2019 (10.2 million). This rebounded to 7.6 million in 2022. Total pre-pandemic commercial flights on U.S. carriers have varied between 9.5 and 10.0 million since 2010 but remain below the high point of more than 10.5 million before the December 2007 to June 2009 recession [USDOT BTS 2022e]. At least some of this reduction is due to the trend for airlines to use larger aircraft and reduce the number of flights.

Condition

Runway Pavement Condition Remained Stable

The Nation's aviation system consists of numerous airport assets, including runways/taxiways, tarmacs, terminals, air traffic control systems, and support structures. The only regular national-level reporting of asset condition is for airport runway pavements. Runway pavement condition is classified by the FAA as follows [USDOT BTS 2022b]:

- *Good:* All cracks and joints are sealed;
- *Fair:* Mild surface cracking, unsealed joints, and slab edge spalling;
- *Poor:* Large open cracks, surface and edge spalling, vegetation growing through cracks and joints.

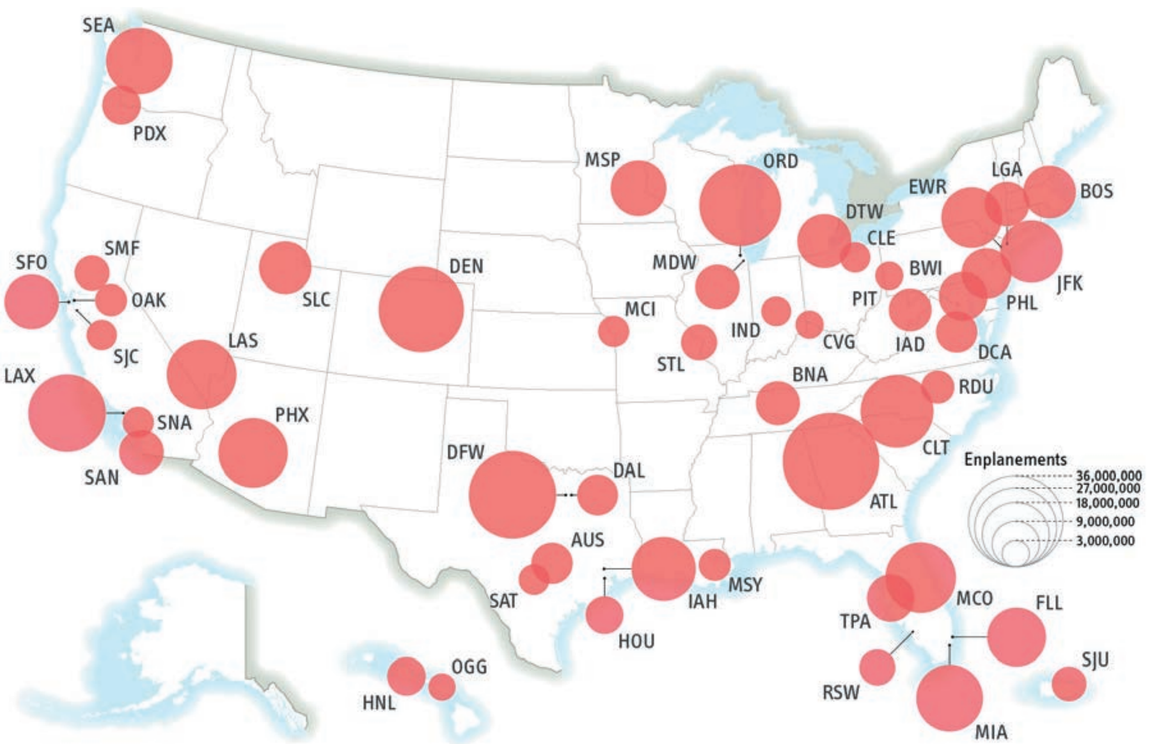
Over the last decade, runway pavement condition has been nearly constant with 80 percent of pavements rated good, 18 percent fair, and 2 percent poor.

The latest 5-year *National Plan of Integrated Airport Systems* (NPIAS)[19] estimates the need for approximately $43.6 billion in Airport Improvement Program (AIP)-eligible projects at 3,310 public-use airports during fiscal years 2021 to 2025 [USDOT FAA 2020]. This is an increase of $8.5 billion over the plan issued 2 years prior. Although there is some overlap in how the types of investments are categorized, about 72 percent ($31 billion) of the AIP-eligible projects are for reconstruction of or bringing assets into compliance with the latest best practices for safety, capacity, security, and environment [USDOT FAA 2020].

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

[19] The National Plan of Integrated Airport Systems (NPIAS) contains all commercial service airports, all reliever airports, and selected public-owned general aviation airports identified by FAA Order 5090.3C. An airport must be included in the NPIAS to be eligible to receive a grant under the Airport Improvement Program.

Figure 1-13 Enplanements at the Top 50 U.S. Airports: 2021



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, T-100 Data, as reported in National Transportation Statistics, table 1-44, available at www.bts.gov as of August 2022.

The average age of U.S. commercial airline aircraft increased slightly between 2018 and 2019, going from 13.5 to 13.7 years [USDOT BTS 2022b]. In 2019, the average aircraft age for the largest airlines (called majors[20]) was 13.4 years. For the next level of airlines (called nationals[21]), the average aircraft age was 12.7 years, and for regional airlines[22] 27.5 years—roughly twice the age of the larger planes used by major and national airlines. No public data are currently available to indicate the condition of the aircraft fleet.

Performance

Aircraft Delays Showing Gradual Improvements

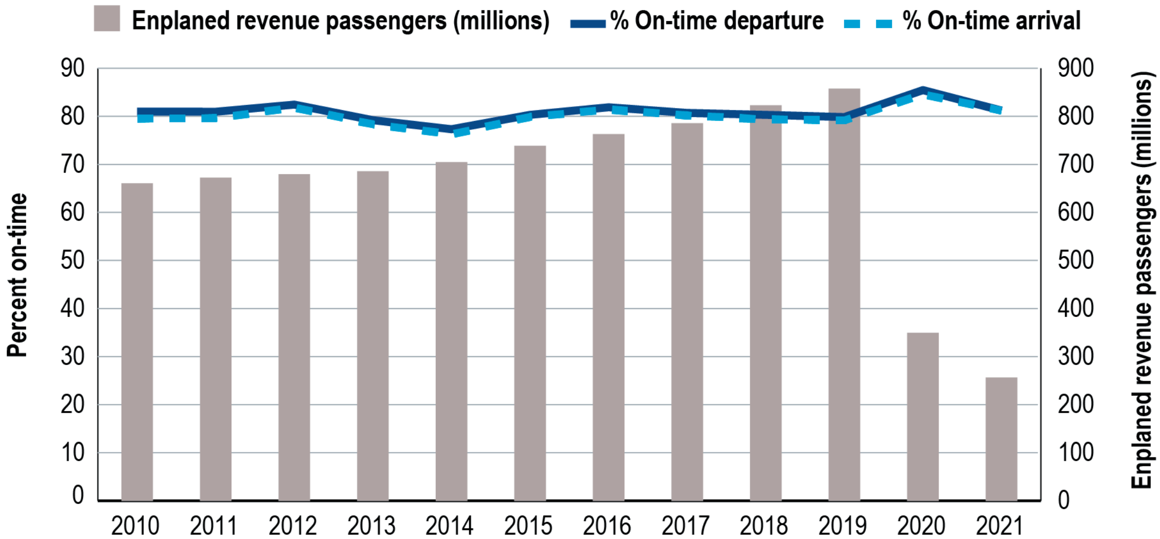
Flight delays can ripple through the U.S. aviation system as late arriving flights tend to delay subsequent flights throughout the day. Apparently, reduced air traffic during the pandemic resulted in improved on-time departure and arrival performance (Figure 1-14). The percent of on-time arrivals for the largest U.S. carriers increased from 79.2 percent in 2019 to 84.6 percent in 2020. The percentage

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

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

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

Figure 1-14 Percent On-Time Flight Departures and Arrivals: 2010–2021



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

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, On-time Percentage Arrivals and Departures, available at https://www.transtats.bts.gov/ as of October 2022.

of on-time departures experienced a similar increase, from 79.9 percent in 2019 to 85.5 percent in 2020 [USDOT BTS 2022b]. In 2021, as air traffic began to recover, both on-time values dropped a bit, to 81.2 percent. For the first 9 months of 2022 on-time arrivals were down to 78.3 percent and on-time departures fell to 79.0 percent [USDOT BTS 2022l].

In June 2022, DOT received 5,862 complaints about airline service from consumers, up 270 percent from the 1,586 complaints received in pre-pandemic June 2019 [USDOT BTS 2022m]. Of the 5,862 complaints received, 28.8 percent concerned cancellations, delays, or other deviations from airlines' schedules, and 24.5 percent concerned refunds. This large increase in consumer complaints led the Department to create an interactive dashboard before Labor Day 2022, to make it easier for the traveling public to determine which services, such as hotels and meals, would be provided to them when the cause of a cancellation or a lengthy delay was due to circumstances within the airline's control.

The causes for flight arrival delays (Figure 1-15) have remained relatively constant since 2010, with the notable exception of National Aviation System delay, which has declined steadily from 25 percent in 2017 to 17 percent in 2021. Operational changes due to the COVID-19 pandemic resulted in the two leading causes of flight delay swapping positions between 2019 and 2020. Due to reduced air traffic, aircraft arriving late as a delay cause dropped from 40 to 29 percent. Conversely, air carrier problems with staffing and other factors led to air carrier delay as a cause to increase from 31 to 42 percent. Extreme weather caused 7 percent of flight delays and security issues 0.3 percent.

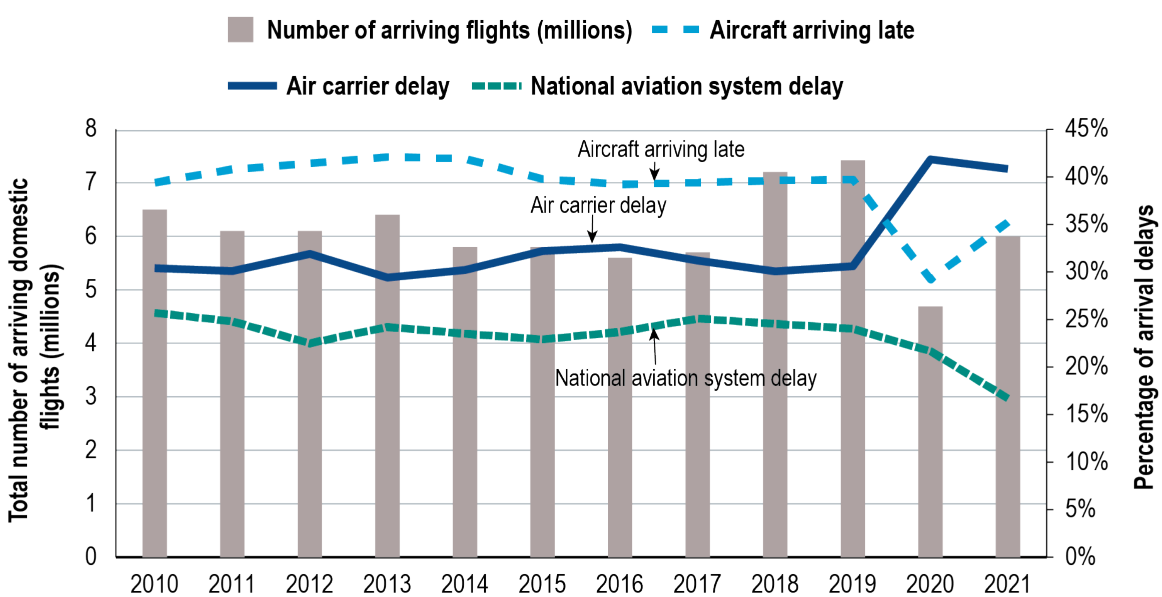
Wait times at terminal security checks are a necessary, and often lengthy, part of the air traveler experience. Although the Transportation Security Administration (TSA) provides real-time data on wait times at selected airports, no archival data are reported on security average wait times nationally or on trends over time. However, the number of passengers and airport crew going through airport security is reported. In 2014, about 654 million people passed through the Nation's security checks; by 2018 this number had increased to 814 million people, about a 25 percent increase. After the COVID-19 pandemic spread in 2020, TSA people screenings (which are used as a proxy for "throughput" or air travel demand) dropped to about 11,000 per day by April 2020, representing a drop of 2.2 million passenger screenings or 95 percent from the same month a year earlier [USDHS TSA 2020]. In September 2022, TSA screenings were 3 percent higher than in September 2019 as shown in Figure 1-16. The 2-year recovery of air traffic is clearly shown in Figure 1-16.

Passenger Rail

Amtrak Transports Passengers Across the United States with the Highest Ridership in the Northeast Corridor

The National Railroad Passenger Corp. (Amtrak) is the primary operator of intercity passenger rail service in the United States. Amtrak operated 20,787 route-miles in 2020 and more than 500 stations that served 46 states and Washington, D.C. (Table 1-4). On an average day, Amtrak operates more than 300 trains, using a fleet of approximately 1,400 passenger cars and nearly 400 locomotives. Amtrak has a particularly strong presence in the Northeast Corridor (NEC) between Boston, MA, and Washington, D.C. In FY 2021 Amtrak carried more than five times as many riders between

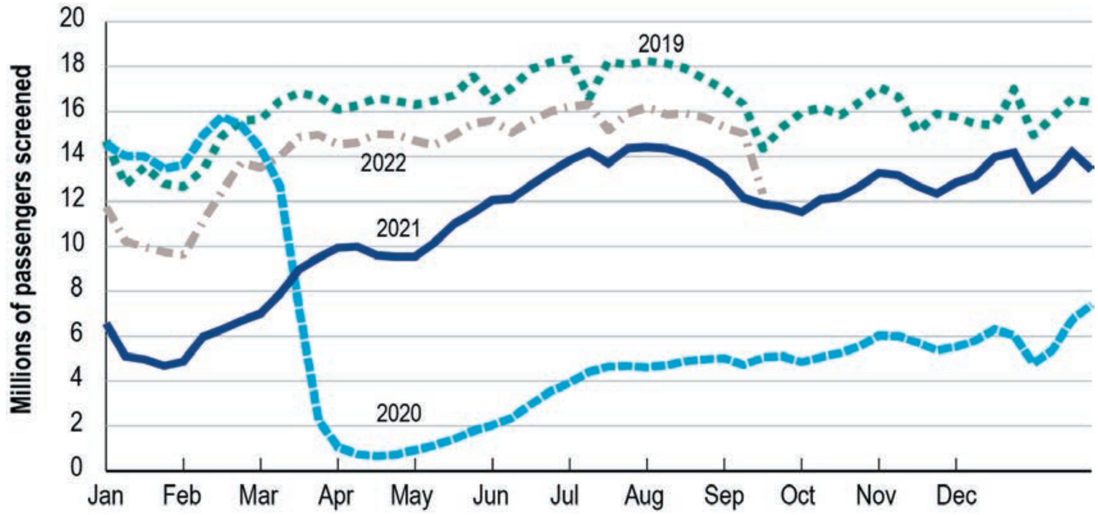
Figure 1-15 Percent of Flight Delay by Delay Cause: 2010–2021



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

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Airline On-Time Statistics and Delay Causes, available at https://www.bts.gov/ as of September 2022.

Figure 1-16 Average Daily Number of People Screened at TSA Checkpoints by Week: 2019–2022



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics Administration, COVID-19 Transportation Statistics, as of October 2022.

Table 1-4 Passenger Rail Transportation System: Fiscal Years 2000, 2010, and 2018–2021

Equipment and mileage operated by Amtrak	2000	2010	2018	2019	2020	2021
Locomotives	378	282	431	403	384	U
Passenger cars	1,894	1,274	1,403	1,415	1,313	U
System mileage	23,000	21,178	21,407	21,407	20,787	U
Stations	515	512	526	526	526	526
Passengers (millions)	20.9	28.7	31.7	32.0	16.8	12.2
Passenger-miles traveled (millions)	5,574	6,420	6,361	6,487	3,450	2,860

KEY: U = unavailable at time of publication.

NOTE: Fiscal year ending in September.

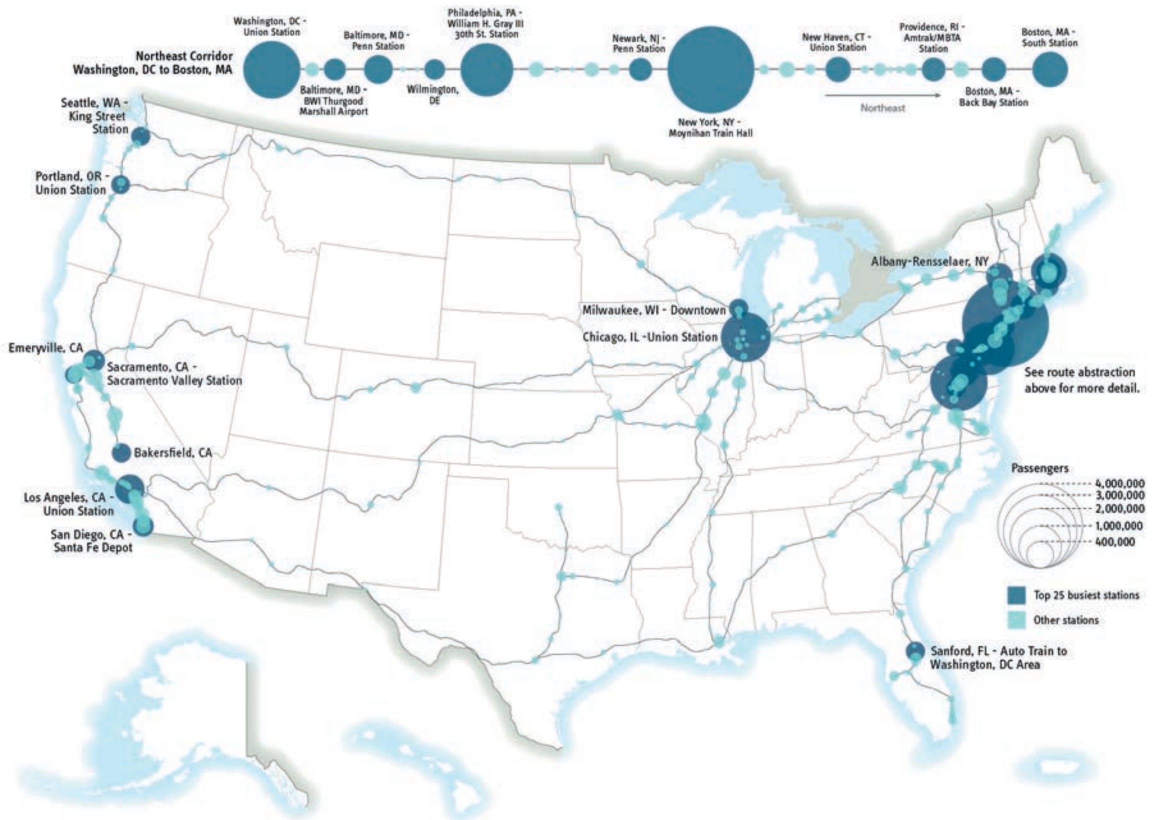
SOURCES: Association of American Railroads, *Railroad Facts* (Annual issues) as cited in U.S. Department of Transportation (USDOT). Bureau of Transportation Statistics (BTS). National Transportation Statistics (NTS). Tables 1-1,1-7, 1-11, 1-40. Available at http://www.bts.gov/ as of November 2022.

Washington and New York City as all the airlines combined, and more than twice as many between New York City and Boston [AMTRAK 2021].

Just as with the highway and air travel modes, the COVID-19 pandemic wreaked havoc on Amtrak's ridership. Amtrak's total ridership for all its routes in FY 2019 totaled 32 million, which was adjusted downward by the corporation from a higher and earlier estimate, compared to 12.2 million in FY 2021. This was a 62 percent reduction in total ridership between 2019 and 2021.

Figure 1-17 depicts where people ride Amtrak in the United States. The heaviest ridership is in the Northeast Corridor (NEC) between Boston and Washington, D.C. Ridership is also high around Chicago as well as at several locations in California and the Pacific Northwest. In FY 2021 the busiest Amtrak Station was Penn

Figure 1-17 Busiest Amtrak Stations: 2021



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, based upon the National Rail Passenger Corp. (Amtrak), State Fact Sheets, available at www.amtrak.com as of October 2022.

Station in New York City (4.1 million passengers) followed by Union Station in Washington, D.C. (1.8 million passengers) and Philadelphia's 30th Street Station (1.5 million passengers) [AMTRAK 2022].

Amtrak Condition

Amtrak owns a small fraction of its route-miles in the NEC plus three other shorter segments in the following corridors: New Haven, CT–Springfield, MA; Harrisburg, PA– Philadelphia, PA; and Porter, IN– Kalamazoo, MI [AMTRAK 2021]. Most passenger train services outside the NEC are provided over tracks owned by and shared with Class I (the Nation's largest) freight railroads—about 72 percent of Amtrak's train-miles. Hence, Amtrak is largely dependent on the host railroads for the condition of its infrastructure. Amtrak is responsible, however, for 2,408 track-miles and infrastructure within the NEC plus a few other locations used by both Amtrak and other users, including commuter rail and freight rail.

The average age of Amtrak locomotives in 2020 was 19.1 years, the same age as 10 years prior. The average age for Amtrak passenger cars was 33.6 years, 8 years more than in 2010 [USDOT BTS 2022b]. The increasing average age of the fleet has had an impact on fleet availability and vehicle reliability.

The Federal Infrastructure Investment and Jobs Act (IIJA) provides Amtrak with a $22 billion level of investment to advance state-of-good-repair capital projects and fleet acquisitions and $44 billion to the Federal Railroad Administration for grants to states, Amtrak, and others for rail projects. This represents the largest investment of its kind since Amtrak began operations in 1971 [AMTRAK 2021].

Amtrak Performance

The hours of delay experienced on Amtrak services trended upward from 2010 to 2019, from about 80,000 hours to 97,000 hours, then dropped to 73,000 hours in 2020, most likely due to the lower rail passenger traffic levels during the pandemic noted above (Figure 1-18). The percentage of on-time arrivals systemwide improved from 73 percent in 2018 to 80 percent in 2020. In the NEC, where Amtrak owns and operates 80 percent of the track on its routes, 87 percent of the arrivals were on-time in 2020. On-time arrivals, however, dropped to 59 percent on routes longer than 750 miles [USDOT BTS 2022b].

National databases report several sources of delay for passenger operations. These include delays caused by Amtrak itself (e.g., operational delays and breakdowns), those caused by the host freight railroad, and other non-railroad causes, such as customs inspections.[23] Delay caused by host railroads remains the major source of Amtrak delays, accounting for 57 percent of total delay in 2020, which is typical of recent years [USDOT BTS 2022b].

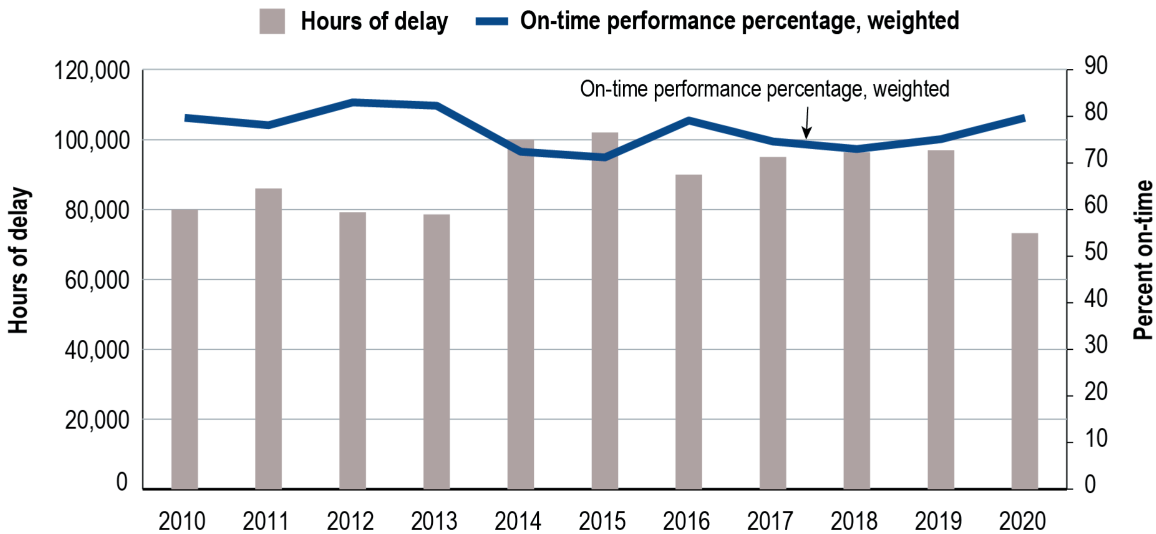
Freight Railroads

New Efficiencies Help Railroads Carry More Cargo in Fewer Cars

The United States had 136,729 railroad route-miles in 2019, including 92,190 miles owned and operated by the seven Class I railroads [AAR

[23] These are delays due to U.S. and/or Canadian customs and immigration procedures for trains crossing the U.S.-Canadian Border.

Figure 1-18 Hours of Delay and On-time Performance of Amtrak: 2010–2020



NOTE: On-time performance is weighted by distance category because a longer trip increases the probability of a delay when compared to a shorter trip.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Amtrak On-Time Performance, *National Transportation Statistics*, table 1-73, available at https://www.bts.gov/content/amtrak-time-performance-trends-and-hours-delay-cause as of September 2022.

Table 1-5 Rail Transportation System: Fiscal Years 2000, 2010, and 2018–2021

Item	2000	2010	2018	2019	2020	2021
Equipment and mileage operated by Class I						
Locomotives	20,028	23,893	26,086	24,597	23,544	23,264
Freight cars[a]	560,154	397,730	293,742	270,378	252,400	243,087
Average freight car capacity (tons)	92.7	101.7	104.6	103.3	105.1	104.9
System mileage	99,250	95,700	92,837	92,282	91,773	91,651
Revenue ton-miles (trillion)	1.47	1.69	1.73	1.61	1.44	1.53
Capital expenditures, $billion						
Roadway and structures	$4.55	$7.86	$9.33	$9.09	$8.35	$7.93
Equipment	$1.51	$1.91	$3.08	$3.88	$2.46	$2.31
Total	**$6.06**	**$9.77**	**$12.41**	**$12.97**	**$10.81**	**$10.24**

[a] Includes totals for Canada and Mexico.

NOTE: *Fiscal year* ending in September.

SOURCES: ***Class I railroads-Locomotives, Freight cars, and System Mileage:*** Association of American Railroads, Railroad Facts (Annual issues) as cited in USDOT/BTS/NTS. tables 1-1 and 1-11, Available at http://www.bts.gov/ as of December 2022. ***Capital expenditures:*** Association of American Railroads, Railroad Facts (Annual issues), as of November 2022.

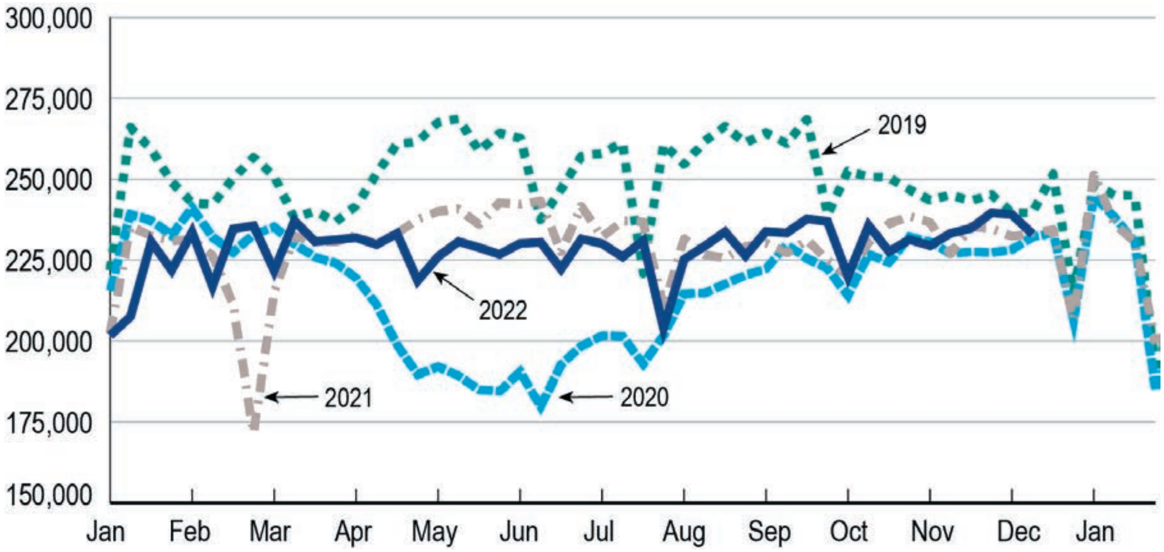
2021].[24] About 626 local and regional railroads operated the remaining 44,539 miles. In 2021, Class I railroads provided freight transportation using 23,264 locomotives (Table 1-5) and 1.66 million railcars [AAR 2021]. Average freight car capacity was about 102 tons in 2010 and gradually increased over the decade to 105 tons in 2021 due to construction of larger cars, particularly new hopper and tank cars.

The big news for 2020 was the impact of the COVID-19 pandemic on freight railroad traffic and operations [AAR 2021]. As compared with 2019, rail carloads were down 13 percent, revenue ton-miles 10.8 percent, and total operating revenue 11 percent. The reduction in traffic was not uniform across the commodities carried. U.S. rail intermodal was down only 2 percent, due to a surge in imports and related port traffic in the second half of 2020, and chemicals were down 3.5 percent. Grain carloads increased by 4.5 percent. Rail traffic has since rebounded to near-normal levels. Over the first three quarters of 2022, total rail non-intermodal carloads were at about 91 percent of the totals for the same months in 2019, and by November 2022 were at 97 percent of the carloads in November 2019 [USDOT BTS 2022k]. Rail intermodal traffic had a more varied path to recovery. In the early months of the pandemic (spring of 2020) intermodal units were running about 10 percent below the same months in 2019, but from summer 2020 through spring of 2021 intermodal traffic was 10 percent above that in 2019, and from July 2021 through November 2022 was about the same as in 2019 (Figure 1-19).

Over the past 50 years, Class I railroads and connecting facilities have developed increasingly efficient ways to carry and transfer cargo (e.g., larger cars as noted above, double-stack container railcars, and on-dock rail), allowing more cargo to be carried with fewer railcars. Figure 1-20 shows that the system mileage of Class I railroads in 2018 was less than

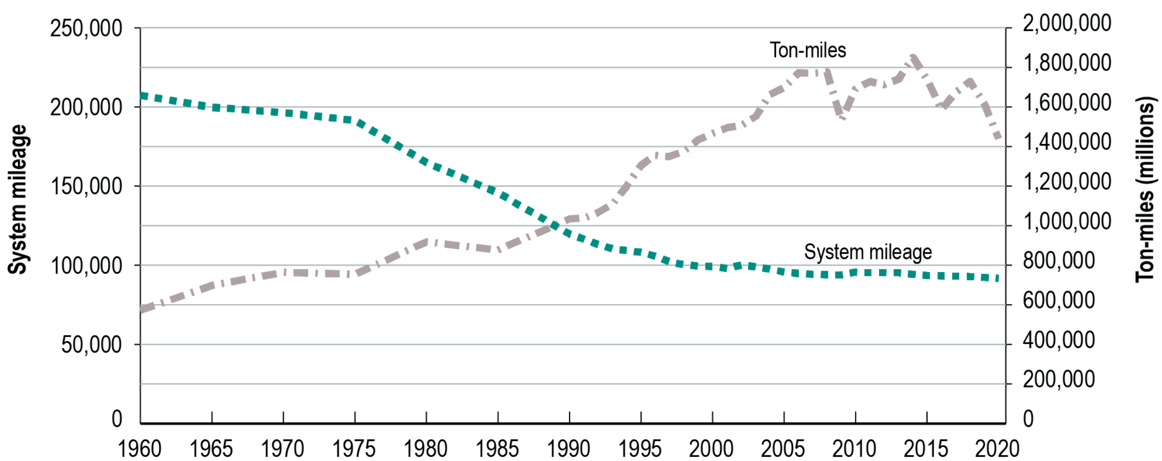
[24] According to the Association of American Railroads, Class I railroads had a minimum operating revenue of $900 million in 2020 (the latest year for which data are available). It includes BNSF Railway, CSX Transportation, Grand Trunk Corp. (Canadian National operations in the United States), Kansas City Southern, Norfolk Southern, Soo Line (Canadian Pacific operations in the United States), and Union Pacific.

Figure 1-19 U.S. Total Rail Non-Intermodal Carloads by Week: 2019–2022



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Supply Chain Indicator, as of November 2022.

Figure 1-20 Class I Railroad System Mileage and Ton-Miles of Freight: 1960–2020



NOTES: Data includes every 5 years until 1970. Data are yearly thereafter.

SOURCE: Association of American Railroads, Railroad Facts, Statistical Highlights (Washington, DC; annual issues), available at https://www.aar.org/ as of September 2022.

45 percent of the mileage in 1960.[25] However, freight rail ton-miles tripled to 1.7 trillion during the same period. Mileage has been down slightly since then and traffic has declined as noted above, but the basic conclusion about efficiency gains remains unchanged.

The railroads, which are private companies, invested $10.8 billion in 2020 to improve their facilities (Table 1-5). This is down 17 percent from that in 2019, in line with traffic and revenue reductions, but is higher than the investment as recently as 2010.

Freight Rail Condition

Track Inspection Improves Track Condition and Safety

Freight rail carriers are not required to report freight track conditions to public agencies. Thus, universal track condition reports are unavailable. However, railroads regularly inspect their track and perform necessary repairs to ensure track safety. Federal Railroad Administration (FRA) regulations do require railroads to maintain track inspection records and make them available to FRA or State inspectors on request. The FRA's rail safety audits focus on regulatory compliance and prevention and correction of track defects.

FRA publishes an annual enforcement report, summarizing the civil penalty claims for violations. In FY 2021 FRA inspectors or other railroad regulators reported 833 track violations, about half the number in 2018 and comparable to the number in the intervening years [USDOT FRA 2021a].

Ports and Waterways

About 8,300 water transportation facilities existed in the United States in 2020 (Table 1-6). Dams and navigation locks are two of the principal infrastructure features of the U.S. inland waterway transportation system,[26] with nearly two-thirds of locks situated along this system. They enable shallow draft operations on many major rivers.[27] This physical infrastructure has been largely unchanged for the past decade. Investment in navigation locks has mostly been directed to replacing aging structures, often with larger lock chambers.

In 2020, there were 44,500 U.S.-flagged maritime vessels operating on the waterways, an increase of 3 percent since 2018 and 10 percent since 2010 (Table 1-6). Recreational boats have numbered about 12 million since 2010.

From 2010 to 2019, waterborne commerce (Table 1-6) grew by 1.2 percent. Domestic tonnage decreased by 8.5 percent over that period, which was offset by a 7.2 percent increase in foreign commerce. Water is the leading transportation mode for U.S.-international freight trade by weight and value. From 2019 to 2020, waterborne tonnage decreased by 5.8 percent due to the pandemic, which was less than the decrease in traffic experienced by other transportation modes. This is due to the nature of the commodities handled—coal, chemicals, petroleum, grain, ores, sand and gravel, metal products, as well as a variety of consumer goods and containerized products imported from around the world. In 2022, low water conditions on the Mississippi River significantly reduced barge throughput (see Chapter 3 - Freight and Supply Chain).

[25] While some line segments have been abandoned, many former Class I miles have been sold or leased to non-Class I railroads [AAR 2021].

[26] The principal inland waterways are the Mississippi, Ohio, Tennessee, Cumberland, Kanawha, Upper Atchafalaya, Ouachita, Illinois, Arkansas, Black Warrior, Tombigbee, Alabama-Coosa, and Columbia-Snake River Basins, and the Gulf Intracoastal Waterway

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

Table 1-6 Water Transportation System: 2000, 2010, and 2018–2020

Item	2000	2010	2018	2019	2020
Infrastructure					
Waterway facilities (including cargo handling docks)	9,309	8,060	8,237	8,250	8,334
Ports (handling over 250,000 tons)	197	178	181	185	192
Miles of navigable waterways	25,000	25,000	25,000	25,000	25,000
Lock chambers	276	239	239	237	237
Lock sites	230	193	193	192	192
U.S. Flag Vessels					
TOTAL, Commercial Vessels	**41,354**	**40,512**	**43,170**	**43,752**	**44,501**
Barge/non-self-propelled vessels	35,008	31,906	33,266	33,600	34,168
Self-propelled vessels	10,410	10,775	9,904	10,152	10,333
Recreational boats, millions	12.8	12.4	11.9	11.9	11.8
TOTAL, Waterborne Commerce (million tons)	**2,462**	**2,334**	**2,438**	**2,363**	**2,226**
Domestic	1,070	894	849	818	743
Foreign	1,392	1,441	1,589	1,545	1,483

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

SOURCES: Fleet: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, Navigation Data Center, *Waterborne Transportation Lines of the United States* (Annual issues), available at http://www.navigationdatacenter.us/ as of August 2022. **Recreational boats:** U.S. Department of Homeland Security, U.S. Coast Guard, Recreational Boating Statistics as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 1-11, available at http://www.bts.gov/ as of August 2022. **Waterways Locks, Facilities, and Vessels:** U.S. Army Corps of Engineers, Institute for Water Resources, available at https://www.iwr.usace.army.mil/ as of August 2022. *The U.S. Waterway System: Transportation Facts and Information* (Annual issues), as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, tables 1-1 and 1-11, available at http://www.bts.gov/ as of December 2019. **Vessel calls:** U.S. Department of Transportation, Maritime Administration, Vessel Calls in U.S. Ports, Selected Terminals and Lightering Areas, available at https://www.marad.dot.gov/resources/data-statistics/ as of October 2018.

Waterway Condition and Performance

Time Delays at Navigation locks Increase By 3-Fold

Table 1-7 shows performance metrics for the 237 lock chambers at 192 lock sites for which the U.S. Army Corps of Engineers (USACE) has responsibility for lock operation and condition. From 2010 to 2019, the average delay in minutes increased three-fold and the percentage of vessels delayed rose by 44 percent. Due to less traffic during the pandemic, both measures improved in 2020 but were still well above the 2010 values.

When a lock or dam reaches a state of poor repair, waterborne traffic must stop to allow for scheduled maintenance or unscheduled repairs. Although scheduled delays impose a cost on industries that rely on waterborne commodities, an even greater cost is imposed when an unscheduled delay occurs. Unscheduled delays interrupt business operations for entire supply chains dependent on waterborne shipments. In 2020, locks experienced 9,147 periods of unavailability, of which 6,361 were scheduled shutdowns and 2,786 were not scheduled [USACE 2021].

The U.S. Army Corp of Engineers (USACE) is responsible for dredging navigation channels to foster safe and efficient use of the Nation's ports and waterways. USACE dredges removed about 265 million cubic yards in FY 2020. Eighty-seven

Table 1-7 Select Waterway Transportation Characteristics and Performance Measures: 2010 and 2018–2020

Year	Total lockages	Total number of vessels	Percent commercial lockages of all lockages	Average delay in minutes	Percent of vessels delayed
2010	641,846	855,121	74.5	79.8	36.0
2018	563,442	722,929	78.9	210.1	50.0
2019	506,838	662,314	78.7	246.9	52.0
2020	497,285	638,602	77.2	172.2	46.8

NOTES: A lockage is the movement through the lock by one or more vessels or extraneous matter, such as man-atees, debris, ice, etc. through a single lock cycle. Commercial lockages are all those that service vessels operated for purposes of profit and include freight and passenger vessels.

SOURCES: U.S. Army Corps of Engineers. Public Lock Usage Report Files. Calendar Years, 1993-2020. Institute for Water Resources (IWR). Updated July 29, 2021, available at https://www.iwr.usace.army.mil/ as of September 2022.

percent of this removal was done for navigational maintenance purposes [USACE 2020].

Ports

The BTS Port Performance Freight Statistics Program provides nationally consistent performance measures on the capacity and throughput for the Nation's largest tonnage, container, and dry bulk ports. A total of 192 ports handled at least 250,000 short tons annually in 2020 (Table 1-6). The top 25 U.S. ports by tonnage handled 68 percent of the short tons in 2020 [UDOT BTS 2022d]. The average 2021 dwell time of container vessels at the top 25 U.S. container ports was 32 hours, up 3.9 hours from 28.1 hours in 2020. Average container vessel dwell times for individual ports are shown in the online *Port Profiles*, which is available at www.bts.gov/ports.

In late 2020 and early 2021, many vessels waited to load and unload containerized cargo in anchorages in San Pedro Bay, in Southern California, and elsewhere due to port congestion. In late December 2021, the ports of Los Angeles and Long Beach had 91 container vessels waiting to berth, spending in some cases many more days at anchor than dockside. In total, U.S. container ports had about 112 container vessels at anchor waiting to berth in December 2021. [USDOT BTS 2022d] By November 2022 that number was down to 55 vessels [USDOT BTS 2022k]. Chapter 3 - Freight and Supply Chain discusses container vessel port operations in more detail.

U.S. coastal ports are dealing with the increasing size of the container vessels calling, due to their greater economies of scale and the elimination of physical constraints (e.g., the new Panama Canal locks). Many of the coastal seaports are served by large megaships as well as smaller Neo-Panamax (also known as New Panamax) ships—sized for the expanded Panama Canal locks that opened in 2016. Serving these large vessels efficiently calls for the port to have the requisite complement of large container cranes. The capacity and throughput of coastal and inland ports are described in Chapter 3 and in the BTS annual reports to Congress [USDOT BTS 2022d].

U.S.-Flagged Vessels

The U.S. Army Corps of Engineers classifies U.S.-flagged vessels primarily as self-propelled vessels or non-self-propelled vessels.[28] The age distribution of the self-propelled versus the

[28] Self-propelled vessels include dry cargo, tanker, and offshore supply vessels, ferries, and tugboats and towboats. Non-self-propelled vessels primarily include barges.

non-self-propelled fleets is notable (Figure 1-21), with just under 60 percent of the self-propelled fleet over 25 years of age, while 26 percent of the non-self-propelled fleet are that old. Self-propelled vessels require greater initial investments and periodic repair or overhaul, which allows them to remain economically viable and stay in service longer.

Ferries

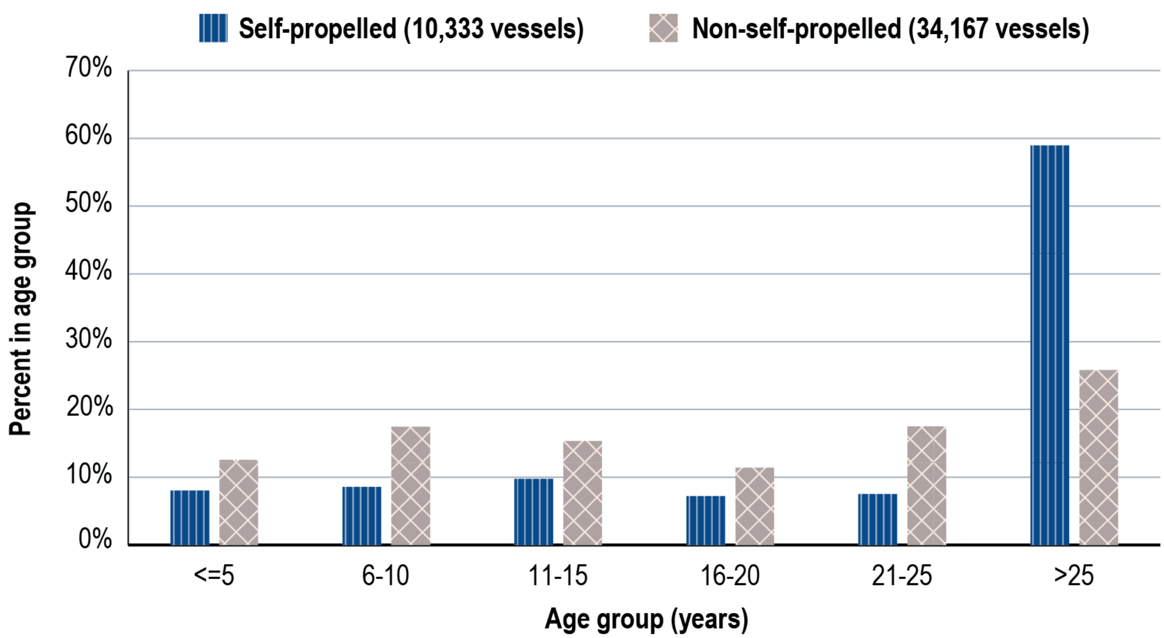
Based on those ferry operations that responded to the 2020 National Census of Ferry Operators (NCFO) [USDOT BTS 2020c], a reported total of 112.1 million passengers and 26.3 million vehicles were transported by ferry in 2019. Figure 1-22 shows that New York and Washington, the top two states for total passenger boardings, together reported transporting a combined total of 69.2 million passengers (38.7 and 30.5 million passengers, respectively). Ferry operators in Washington state alone transported about 58 percent of all reported vehicles by ferry (15.2 million vehicles) in 2019.

A ferry segment is the direct route that the boat takes between two terminals with no intermediate stops. The assigned state of the segment is that of the origin terminal. The reported ferry segments were concentrated in the northeast, on the west coast, and in Alaska. Nearly half (49.5 percent) of the total reported ferry segments came from just the top five states—Alaska (120 segments), New York (119 segments), California (96 segments), Washington (76 segments), and Michigan (52 segments).

Pipelines

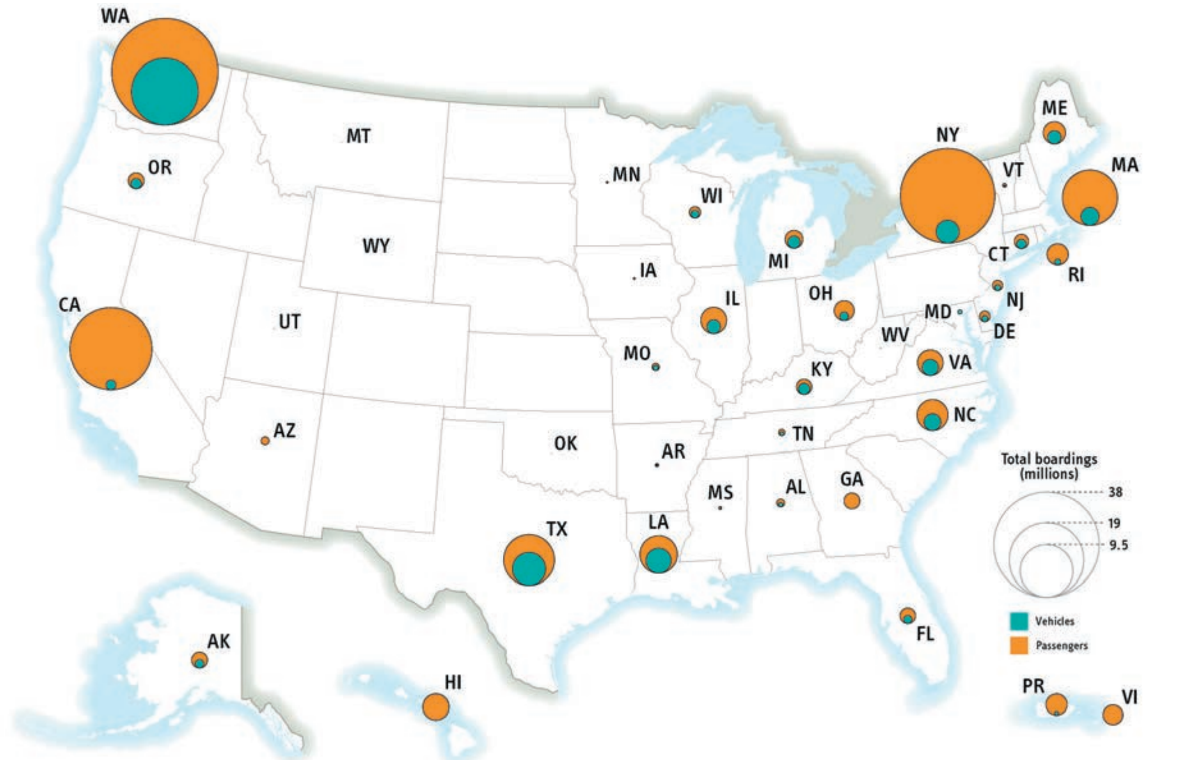
Pipelines include separate systems for natural gas, crude petroleum, and petroleum products. Typically, natural gas pipelines connect sources of supply with end consumers (both households and businesses), while crude petroleum

Figure 1-21 Number of U.S.-Flagged Vessels by Age Group and Propelled Type: 2020



SOURCE: U.S. Army Corps of Engineers. *U.S. Flagged Vessels by Type and Age*, table 4, vols. 1–3 consolidated, available at available at https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll2/id/7438 as of August 2022.

Figure 1-22 Ferry Passenger and Vehicle Boardings: 2019



NOTE: Boarding counts may be suppressed due to the data being considered proprietary by some ferry operators. For more information on the NCFO, please go to www.bts.gov/ncfo.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Census of Ferry Opera-tors, available at https://www.bts.gov/NCFO as of November 2022.

pipelines connect oil fields and marine terminals with refineries and product pipelines connect refineries with distribution centers.

The U.S. natural gas terminal and pipeline system extends across the lower 48 states, with higher concentrations in Louisiana, Oklahoma, Texas, and the Appalachia region (Figure 1-23). In 2021, natural gas was transported via about 319,000 miles of gathering[29] and transmission[30] pipelines and over 1.3 million miles of distribution lines[31] [USDOT BTS 2022b]. These pipelines connect to 65 million households and 5 million commercial and industrial users [AGA 2022].

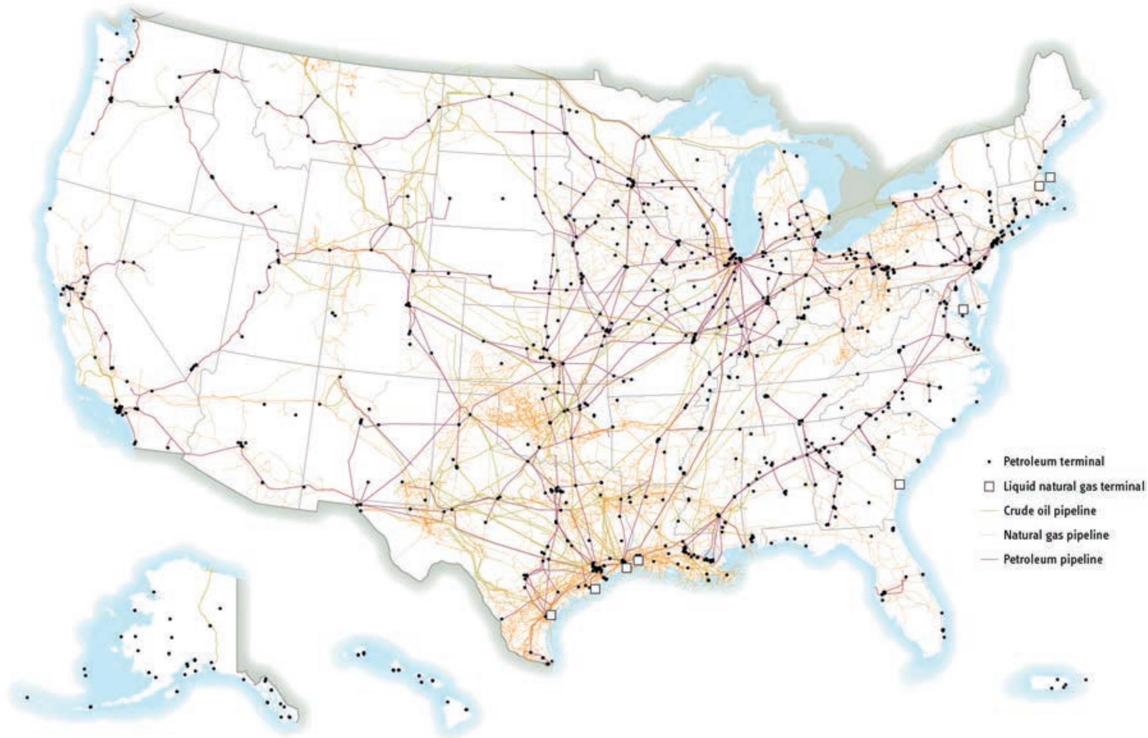
Petroleum terminals and crude oil and petroleum pipelines form a system that transports crude and refined petroleum to markets across the country (Figure 1-23). The Trans-Alaska Pipeline System is a major instate crude-oil pipeline that extends from Prudhoe Bay to Valdez. There were over 230,000 miles of crude/refined oil and hazardous liquid pipelines in 2021, up 26 percent since 2010 due almost entirely to construction

[29] Gathering pipelines are used to transport crude oil or natural gas from the production site (wellhead) to a central collection point.

[30] Transmission pipelines are used to transport crude oil and natural gas from their respective gathering systems to refining, processing, or storage facilities.

[31] A distribution line is a line used to supply natural gas to the consumer.

Figure 1-23 U.S. Petroleum and Natural Gas Pipelines: 2021



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, based on the U.S. Department of Energy, Energy Information Administration, U.S. Energy Mapping System, available at www.bts.gov as of October 2022.

of new crude petroleum pipelines.[32] This system carried 3.3 billion barrels across the United States in the pandemic year of 2020, down 10 percent from 3.7 billion in 2019. Pipeline shipments recovered to 3.5 billion barrels in 2021 [USDOT BTS 2022b].

Passenger Intermodal Facilities

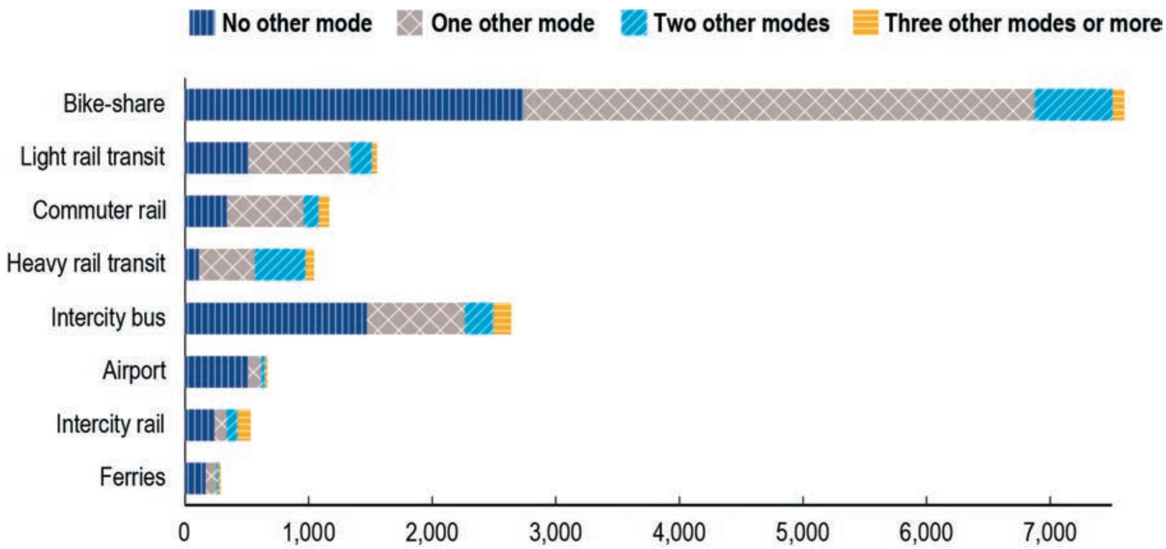
Of the approximately 15,500 intercity and transit rail, air, intercity bus, ferry, and bike-share stations in the United States in 2022, about 61 percent offer travelers the ability to connect to other public passenger transportation modes [USDOT BTS 2022c]. Of this 61 percent, 46 percent connect to one other mode, 11 percent connect to two other modes, and 4 percent connect to three or more other modes (e.g., bus, air, rail, ferry, or bikeshare).

After bikeshare, the transit modes that have the highest percent of intermodal connections are heavy rail transit (approximately 89 percent of 1,043 facilities), commuter rail (71 percent of 1,167 facilities), and light rail transit (67 percent of 1,554 facilities) (Figure 1-24). Of the intercity modes,[33] intercity rail terminals have the highest level of connectivity (approximately 55 percent of the 530 facilities) to other modes, followed by intercity bus stops (44 percent of the 2,639 stops), and airports (24 percent of the 666 airports).

[32] For example, the EPIC Crude Pipeline in Texas (732 miles) and the Dakota Access pipeline from North Dakota to Illinois (1,172 miles) [USDOE EIA 2019b].

[33] These include intercity rail, bus, and ferries.

Figure 1-24 Intermodal Passenger Facilities by Mode: 2022



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

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Intermodal Passenger Connectivity Database. Available at www.bts.gov as of September 2022.

Automated and Connected Highway Transportation Systems

Many new vehicles offer advanced driver assistance technologies, such as forward collision warning, automatic emergency braking, lane departure warning, lane keeping and lane centering assist, blind spot monitoring, rear cross-traffic alert, and adaptive cruise control, which assist drivers and help improve highway safety. Since 2018 the National Highway Traffic Safety administration (NHTSA) has required backup cameras on all new vehicles [USDOT NHTSA 2022a].

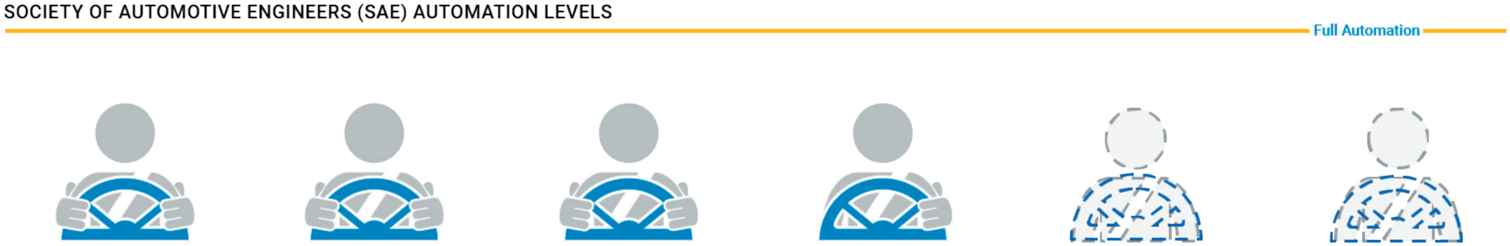
Research and testing to develop automated and connected transportation systems are proceeding at a fast pace. Automated systems improve many functions presently performed by human operators, taking advantage of sensors and computers to avoid collisions, improve traffic flow, and aid the long-term goal of increasing safety.

The Society of Automotive Engineers classifies an automated vehicle's complexity using six levels of automation, which range from zero to full automation (Figure 1-25). While specific to highway vehicles, similar concepts apply to other travel modes. There currently is no timeline in the United States for requiring some level of automation, but these technologies are rapidly being adopted. However, a broad array of federal agencies have programs in place devoted to the development of automated vehicles [USDOT OST 2022].

Automated vehicles (AVs), also known as self-driving, driverless, or robotic vehicles, are those in which varying levels of vehicle control are automated (AV levels 1–5). Level 0 means the vehicle has no automation; thus, the driver is performing all functions. As noted earlier in this chapter, most new vehicles in the United States have some level 1 (and even level 2) features as standard or optional equipment. At AV level 5, the highest level of automation, hands-off driving

Figure 1-25 Levels of Automation

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) AUTOMATION LEVELS



0	1	2	3	4	5
No Automation	**Driver Assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Zero autonomy; the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Automated Vehicles for Safety*, available at https://www.nhtsa.gov as of October 2022.

of the AV on all types of roads in a full range of traffic and weather conditions would be possible.

In 2021, NHTSA issued a Standing General Order on Crash Reporting for incidents involving vehicles equipped with level 2 or higher automation technology [USDOT NHTSA 2022b]. The intent is to allow NHTSA to respond to crashes that raise safety concerns about vehicle automation through further investigation and enforcement. From July 2021 to August 2022, NHTSA received reports on 522 incidents involving vehicles with level 2 automation and 176 involving vehicles with some higher automation level. The initial data from the standing order are discussed in Chapter 5 - Transportation Safety.

Automated vehicle testing is occurring across the United States. NHTSA established the Automated Vehicle Transparency and Engagement for Safe Testing (AV TEST) Initiative to assist in tracking the locations and characteristics of these testing activities (Box 1-A). Vehicles tested include not only automobiles but also transit vehicles [MASS TRANSIT 2022], airport shuttles and similar vehicles [GINDRAT 2021], over-the-road and delivery trucks [NYT 2022], and drayage vehicles [USDOT FHWA 2021c].

California is host to the most autonomous vehicle test sites and is the only state known to collect data on the test programs. The California Department of Motor Vehicles requires the test operators to report annually on the numbers of vehicles, miles driven, and autonomous system disengagements—the moment the system hands back control to a safety driver or when the safety driver intervenes [CA DMV 2022]. Analysis of the Disengagement Report for 2020 shows that the 29 companies doing autonomous vehicle testing in California operated their test vehicles for a total of 1,955,2083 miles in autonomous mode and encountered 3,695 disengagements, resulting in a mean distance of about 529 miles between disengagements [HERGER 2021]. This is a remarkable improvement over the average of 14 miles experienced in 2018. The better performing AVs did markedly better than average in 2020. The top five performing companies' vehicles all drove at least 10,000 miles between disengagements and the top performer almost 30,000 miles. Preliminary data for 2021 look even better. Test vehicles drove over 4 million miles with 2,676 disengagements, an average of 1,529 miles between events.

As automated vehicle on-road testing in traffic mixed with non-equipped vehicles has become more widespread, many states are considering regulations to address the potential effects of these vehicles on their roads. As of 2022, 38 states along with the District of Columbia have enacted legislation or issued executive orders regarding Autonomous Vehicles. Of these 39 jurisdictions, 5 states simply authorize a study, define key terms, or provide state contacts, or authorize funding; 4 states regulate truck platooning; 12 states authorize testing; and 16 states and the District of Columbia authorize full deployment. Of these, 18 states now allow testing or deployment without a human operator in the vehicle (Figure 1-26).

Automation Beyond Highways

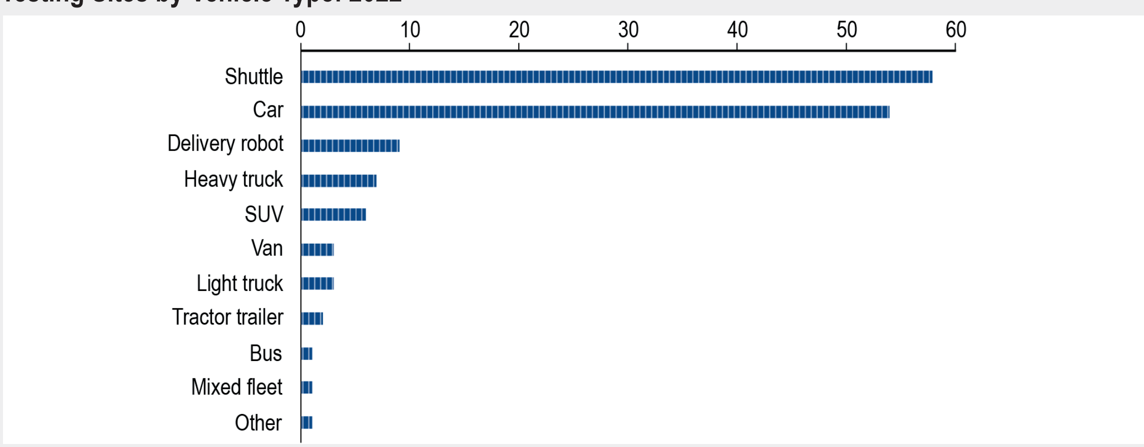
Autonomous vehicle development is not limited to highways. The Federal Transit Administration (FTA) has a Transit Automation Research Program [USDOT FTA 2022]; the maritime industry is investigating port automation and autonomous vessels; and railroads are building on long-standing experience with Automatic Train Control (ATC) to implement Positive Train Control (PTC) systems [USDOT FRA 2021b]. Pipeline operators are also building on experience with instrumented capsules (sometimes called smart pigs) and supervisory control and data acquisition (SCADA) systems to develop new technologies to detect leaks and inspect and repair lines [USDOT PHMSA 2022].

Box 1-A NHTSA AV TEST Initiative

The National Highway Traffic Safety Administration (NHTSA) launched the Automated Vehicle Transparency and Engagement for Safe Testing (AV TEST) Initiative in June 2020 with states, local governments, and private-sector stakeholders throughout the driving automation community. The goal of the initiative is to provide the public with direct and easy access to information about testing of vehicles equipped with Automated Driving Systems (ADS) technology. ADS are defined as systems capable of performing the entire driving task on a sustained basis, regardless of whether it is limited to a specific operational design domain, this term is used specifically to describe SAE levels 3, 4, or 5. The testing sites in 2022 showed the type of automated vehicles tested at locations displayed on the map.

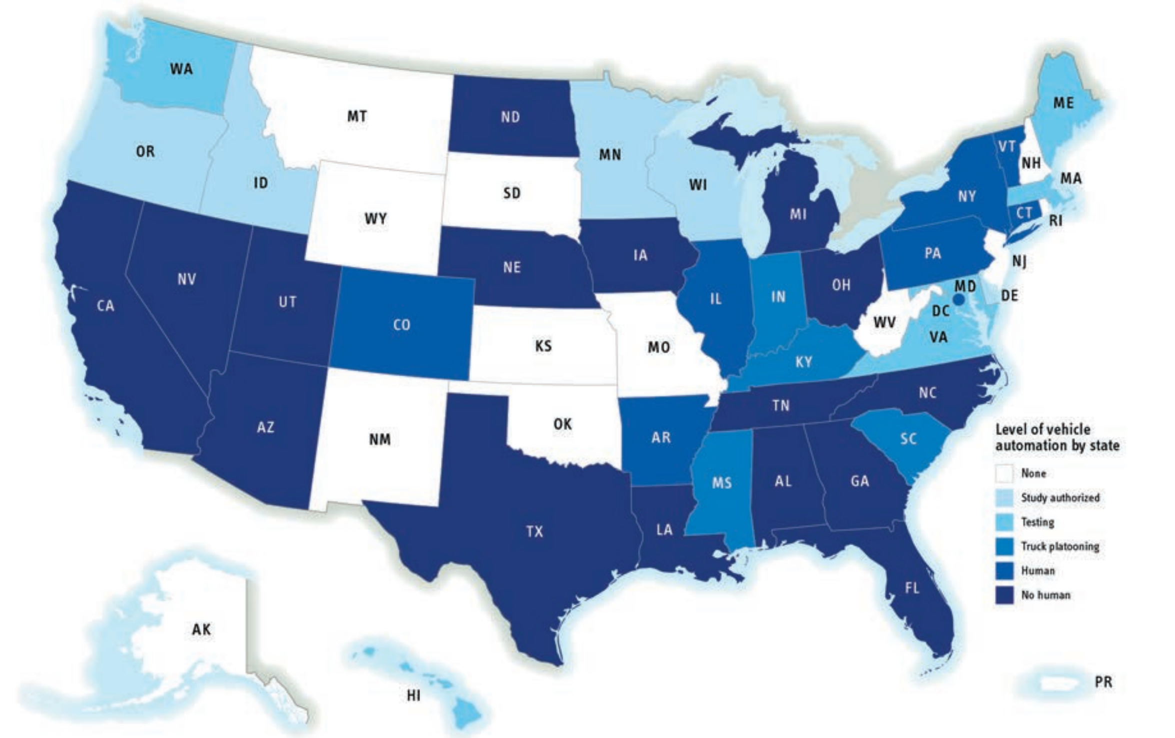
Automated Vehicle Testing Locations

Testing Sites by Vehicle Type: 2022



SOURCES: *Automated Vehicle Transparency and Engagement for Safe Testing (AV TEST) Initiative*. Available at https://www.nhtsa.gov/automated-vehicle-test-tracking-tool as of October 2022. U.S. Department of Transportation (USDOT). Office of the Secretary of Transportation (OST). 2021. *Automated Vehicles Comprehensive Plan*. Available at https://www.transportation.gov/sites/dot.gov/files/2021-01/USDOT_AVCP.pdf as of October 2022.

Figure 1-26 Automated Vehicle Legislation and Regulation by State: 2022



SOURCE: National Council of State Legislatures, Autonomous Vehicles, Self-Driving Vehicles Enacted Legislation, as published in Governors Highway Safety Association, Autonomous Vehicles, available at https://www.ghsa.org/state-laws/issues/Autonomous%20Vehicles as of October 2022.

Perhaps the quickest advance in adoption of automated transportation systems has been the increasing use of unmanned aircraft systems, or drones. Decades ago, drones were confined to science fiction and other future fantasies. Today drones are rapidly becoming a part of our everyday lives. They are quickly increasing in numbers and complexity. The way we use drones ranges from recreation to commercial and military applications.

The FAA requires drone operators to register their aircraft and, in some cases, obtain a remote pilot certification. In 2022 there were 865,500 drones registered with the FAA, and over 280,000 remote pilots have been certified. While 62 percent of the registered drones are for recreational use, the remaining 38 percent are dispatched for commercial tasks. Typical applications are for agriculture, forestry, mining, construction, and land management [USDOT FAA 2022].

System Resiliency

There were 22 billion-dollar natural disasters in 2020

The U.S. Department of Commerce (USDOC), National Oceanic and Atmospheric Administration

(NOAA) tracks weather and climate disasters, including hurricanes, tornadoes, floods, droughts, and wildfires where overall damages reached or exceeded $1 billion. In 2020, there were a record-high 22 weather and climate disaster events with losses exceeding $1 billion each across the United States. These events included 7 tropical cyclones, 13 severe storms, 1 related to drought, and 1 to wildfires [USDOC NOAA 2021]. The 22 events cost the Nation a combined $95 billion in damages. Part of the physical recovery costs and overall economic impact were due to damage and disruption of the transportation system.

Cyclone and severe storm events caused a total of 60 days of closure spread across 25 maritime ports [USDOT BTS 2022d]. Some ports were closed for more than one storm. New Orleans, Plaquemines, and South Louisiana were each closed for a total of 6 days by three different storms, and Lake Charles, LA, was closed twice for a total of 10 days. Hurricane Laura, a powerful Category 4 hurricane, closed Lake Charles for 8 days, which was the longest port shutdown in 2020. Most storm-related port closures were of short duration, from 1 to 3 days, which speaks to the resilience of the transportation system. There were 20 extreme weather events in 2021, second to 2020 (22) and third in total damages cost of $145 billion (behind 2017 and 2005) [USDOC NOAA 2022b].

The U. S. was hit with 15 separate billion-dollar weather and climate disasters in the first 9 months of 2022. Hurricane Ian, with 150 mph sustained winds, made landfall in southwest Florida as a strong Category 4 hurricane on September 28, resulting in major flooding and damage [USDOC NOAA 2022a]. In total, 7 top ports[34] had operations suspended due to Hurricane Ian, which caused widespread disruption in trade and transportation along both the Atlantic and Gulf coasts [USDOT BTS 2022]. While hurricanes brought disruption from too much water, drought has left the lower Mississippi River with too little water for normal navigation. Low water levels, especially on the vital stretch between Cairo, Illinois and Memphis, Tennessee, have caused groundings and the need for dredging that have closed sections of the river and halted barge movements for intermittent periods. U.S. Coast Guard District 8 (New Orleans) reported a backup of over 2,000 barges on the Lower Mississippi in early October. Low water also restricts the loads each barge can carry, and the narrower channel restricts the number of barges in a single tow [USDOT BTS 2022i]. These restrictions affect the ability to transport cereal grain and other bulk products by water, which account for over half of the 165.5 million tons of freight that moved in 2020 between states touching the Upper Mississippi System and Louisiana.[35]

Cybersecurity

Vulnerabilities for Transportation Infrastructure and Vehicles

The Nation's transportation system is also vulnerable to cyber and electronic disruptions. This is particularly true in the aviation system, which is dependent on electronic and digital navigation aids, communication systems, command and control technologies, and public information systems. All the surface transportation modes are similarly vulnerable as advanced technologies are deployed, as noted above.

State and local governments face growing threats from hackers and cybercriminals, including those who use ransomware software that hijacks computer systems, encrypts data,

[34] The affected ports were Tampa, Jacksonville, Savannah, Charleston, Wilmington, NC, Port of Virginia, and Baltimore.

[35] States touching the Upper Mississippi System include Minnesota, Wisconsin, Iowa, Illinois, and Missouri along the Mississippi north of its confluence with the Ohio River, plus Kansas and Nebraska along the navigable portion of the Missouri River and Indiana, Ohio, Kentucky, West Virginia, and Pennsylvania on the Ohio River.

and locks machines, holding them hostage until victims pay a ransom or restore the data on their own. In February 2018 hackers struck the Colorado Department of Transportation in two ransomware attacks that disrupted the agency's operations for weeks. State officials had to shut down 2,000 computers, and transportation employees were forced to use pen and paper or their personal devices instead of their work computers. Fortunately, the two cyber-attacks didn't affect traffic signals, cameras, or electronic message boards. In 2016, a ransomware attack struck San Francisco's light rail system, disrupting its computer system and email, and in 2017 Sacramento's regional transit agency was hit with a ransomware attack demanding it pay to get control of its website back. [BERGAL 2018].

Federal agencies have initiatives underway to counter the cyber threat. The Transportation Security Administration has made available the Surface Transportation Cybersecurity Resource toolkit, comprising a collection of documents designed to provide cyber risk management information to surface transportation operators [USDHS TSA UNDATED]. Because transportation is becoming more connected and dependent on advanced computing and communication systems and software, the USDOT has several research programs dedicated to ensuring a secure connected transportation environment, covering topics such as vehicle and infrastructure cyber security, and Dedicated Short-Range Communications (DSRC) Security focusing on ensuring trusted communications between vehicles and between infrastructure and vehicles [USDOT ITS UNDATED]. NHTSA promotes a multilayered approach to cybersecurity by focusing on a vehicle's entry points, both wireless and wired, which could be potentially vulnerable to a cyberattack. A layered approach to vehicle cybersecurity reduces the possibility of a successful vehicle cyberattack and mitigates the potential consequences of a successful intrusion [USDOT NHTSA UNDATED].

Cybersecurity will be a critical component of future transportation safety and security standards, especially since transportation systems, devices, components, and communications must be protected from malicious attacks, unauthorized access, damage, or anything else that might interfere with safety functions.

Data Gaps

Needs for the Future

The principal data gaps related to system extent, usage, condition, and performance are:

- Condition of vehicles, all modes;
- Deployment of traffic control devices and systems and connected vehicle infrastructure at a national level;
- Comprehensive data on the intercity bus travel mode;
- Connected and autonomous vehicle data at the national level;
- Freight intermodal facilities;
- Usage of passenger and freight intermodal facilities;
- Parking capacity; and
- Dedicated infrastructure for bicycles and other forms of active transportation.

The Vehicle Inventory and Use Survey (VIUS), resumed in 2022, will provide much needed data on the physical and operational characteristics of the Nation's commercial truck population, which has been a longstanding data gap.

Data gaps exist where transportation data are in the hands of private operators and are not readily available to the public. For example, private roads built by developers and maintained by homeowners associations seem to be a fast-growing category of local roads, yet there are no data on these facilities. Also freight rail carriers are not required to report freight track conditions nor are marine terminal operators required to report on their operations to the Federal Government. Even if the private operators publicly report data, the data are not nationally consistent or standardized. Operators may report data by different periods of time (e.g., calendar vs. fiscal years, which may begin and end in different months from others). Also, operators may use different or unique metrics or units of measures. For example, private marine terminal operators may use different throughput measures, such as container volumes, tonnage, or twenty-foot equivalent units. Data are also missing to relate asset condition to performance.

There is also a need for improved timeliness and completeness of financial data of all types and an effective framework for including public–private partnerships that avoids double counting.

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CHAPTER 2
Passenger Travel and Equity

Introduction

The recent story of passenger travel is a dramatic reversal of long-term growth followed by uneven recovery and an uncertain future due to factors such as the growth in working at home. During 2020—the first COVID-19 pandemic year—passenger travel across all transportation modes plummeted in the United States and around the world as businesses and industries either shut down or curtailed their activities and households sheltered in place. Passenger travel rebounded somewhat in 2021, but the growth in work at home and the increase in the retirement-age population contributed to dramatic shifts that will affect future passenger travel.

This chapter examines changes in passenger travel during and beyond the pandemic and explores the impacts of those changes on matters of equity. White House Executive Order 14301 defines equity as "the consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong

Highlights

- Dramatic changes happened in passenger travel in the United States in 2020 and 2021 due to the sudden impact of COVID-19. Comparing 2021 with pre-pandemic 2019 there were sharp losses with some recovery.
  - Highway travel was the first to recover, reaching 2019 levels by November of 2021.
  - Air travel reached parity in early September of 2022 and long-distance rail a week later.
  - Urban transit has not returned to pre-pandemic ridership with levels ranging from 30 to 40 percent of 2019 levels.
- The aging population of the United States will affect travel patterns as retirees replace commuting to jobs during peak congestion periods with travel for other purposes at other times of the day.
- For the remaining workforce, commuting behavior has changed significantly:
  - Working at home grew by 18.6 million, exceeded carpooling to become second to driving alone as a way to access work.
  - Driving alone to work, the most common way by far to get to work, lost 14.5 million users to levels not seen for decades.
  - Transit lost about 4 million of its 7.8 million users, just about half of its ridership, and commuter rail lost about two-thirds of its ridership.
  - Carpooling lost only one percentage point in share, as some carpool members dropped out to work at home.

Continued »

Highlights Continued

- Intercity and international travel reached all-time highs just before the onset of COVID-19. After first reaching a billion passengers in 2018, U.S. and foreign commercial air carriers operating in the United States served 4 percent more passengers in 2019, and passenger growth continued through January 2020. Amtrak also reached its peak year for passengers.
- In 2021, the United States fell from third to sixth in the world in arrivals from other countries. Despite that decline, the United States still led the world in tourism receipts with 13.2 percent of world receipts (excluding air fares), more than twice that of second place France.
- As in so many cases in the COVID-19 period, there was a sharp drop in transportation spending by consumers from the pre-pandemic baseline year of 2019 to the COVID-19 year of 2020 and then partial recovery in 2021. Transportation's 17.0 percent share of total spending in 2019 dropped to 16 percent in 2020 and then recovered partly to 16.4 percent in 2021.
- On a per-vehicle or per-worker basis, transportation spending is very similar for workers in different income quintiles, despite major differences in income.

to underserved communities that have been denied such treatment" [White House 2021]. Available statistics related to passenger travel provide a limited understanding on whether or not transportation has equitable consequences.

Population Change: A Driver of Long-Term Travel Trends

Local and long-distance travel generally increase with population growth, especially with growth in the working-age population defined as between 18 and 65 years of age. In November 2022, the United States population reached a third of a billion persons [USDOC CENSUS 2022]. As illustrated in Figure 2-1, the over age 65 population dominates projected growth in population change in the 2020–2030 period, and notably the substantial increase in aging of the remaining labor force age group in the 2030–2040 period. The last members of the baby boom generation will reach age 65 in 2029, with most entering retirement [VESPA et al 2020].

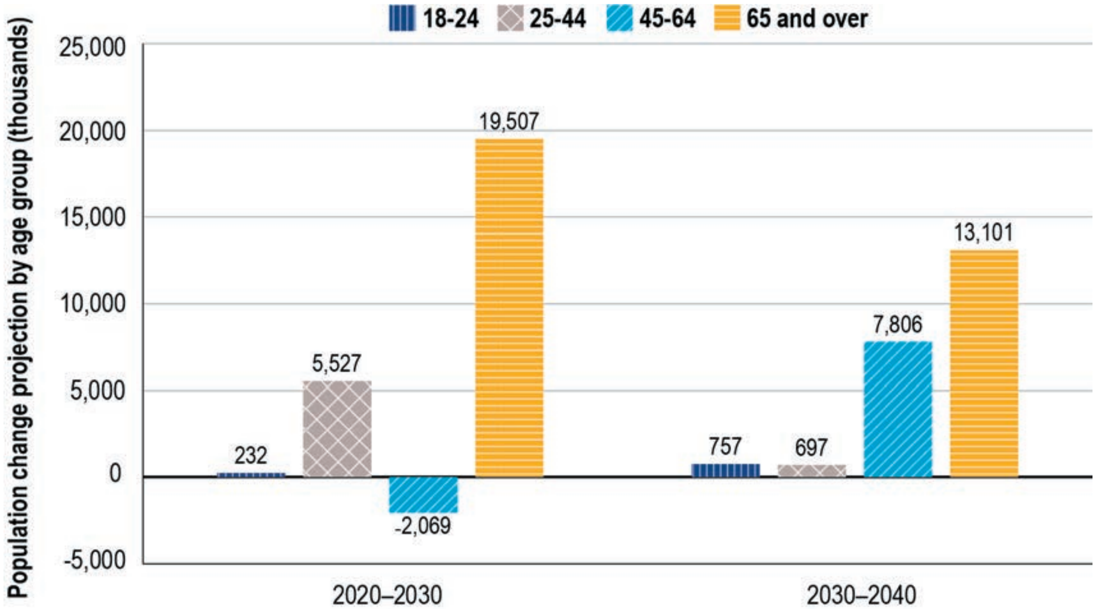
By 2034 the Census Bureau projects the post-working-age population, those over the age of 65, will exceed the pre-working-age population, those under the age of 18, for the first time in our Nation's history. Thus, the dependency ratio, the ratio of those too young or too old to work that have to be supported by the working-age population will shift sharply [VESPA et al 2018].

The working-age population is the predominant generator of personal travel in our society, not just because of work trips but also because of other trips that support household activities, which comprise about two-thirds of person trips each day, according to the 2017 National Household Travel Survey (NHTS) [USDOT FHWA 2018]. The retired population has significantly different travel demands, such as the replacement of work trips in peak congestion periods with travel for services throughout the day.

Population change and the consequences for travel are not even across the Nation. In 2019–2020, the Northeast and Midwest regions continued to suffer migration losses to the South and West. In 2020–2021, however, the West also recorded migration losses to the South while the Midwest showed a reduction in losses (Table 2-1).

Population shifts from 2020 to 2021 indicated that principal cities of metro areas lost approximately 4.9 million persons, most of whom

Figure 2-1 Population Change Projection by Age Group by Decade: 2020–2030 and 2030–2040



SOURCE: U.S. Department of Commerce, Census Bureau, 2017 Projections, available at https://www.census.gov/data/tables/2017/demo/popproj/2017-summary-tables.html. Table 2 Projected age and sex composition of the population as of September 2022.

(4.5 million) went to metro suburbs, while the remainder, about 8 percent, went to non-metro areas. On balance, about 2.5 million left the suburbs for so-called principal cities (some of which are in suburbs), and the remainder, about 13 percent, shifted to non-metro areas. Only about a million were outmigrants from non-metro areas, about 60 percent of whom went to metro suburbs (Table 2-2). Shifts from center cities to suburbs exacerbated by COVID-19 concerns were apparent in the 15 largest cities in the Nation, independent of region [USDOC CENSUS 2021]. These population shifts leave fewer people in the higher density principal cities of metro areas where alternatives to the personal motor vehicle have the best chance of serving mobility needs.

The 2020 T*ransportation Statistics Annual Report* featured travel demands of rural America, which is a small and shrinking portion of the Nation's population. The 1,976 rural counties in America had 46 million U.S. residents in 2020, constituting roughly 14 percent of the U.S. population. Many of these counties were among almost 73 percent of all U.S. counties that had a negative natural population change (births minus deaths) in 2021 as deaths exceeded births. This compares with more than 45.5 percent of all counties in 2019 and 55.5 percent in 2020.

Table 2-1 Net Domestic Migration by Region: 2019–2020 and 2020–2021

Region	2019–2020	2020–2021	Numeric change
Northeast	-315,166	-389,638	-74,472
Midwest	-207,685	-123,103	84,582
South	503,502	657,682	154,180
West	19,349	-144,941	-164,290

NOTE: Migration periods represent July 1 to June 30 of specific years.

SOURCE: U.S. Census Bureau, *Net Domestic Migration Increased in Many U.S. Counties in 2021*, available at https://www.census.gov/library/stories/2022/03/net-domestic-migration-increased-in-united-states-counties-2021.html.

In fact, all counties in Delaware, Maine, New Hampshire, and Rhode Island experienced natural population decreases [VESPA et al 2020]. The decline in natural population change reflects the overall birth rate in the 2010–2020 decade that was the lowest since the depression decade of 1930–1940 and part of a long-term trend since the 1980s toward lower birth rates [FREY].

Future growth in local travel will increasingly depend on attracting visitors from distant locations and on local population growth from foreign immigration and domestic migration. Immigrant arrivals are projected to contribute more to population growth than natural population change beginning in 2030 [VESPA et al 2020]. With respect to domestic migration, about 9 percent of the U.S population moved in 2019–2020, most of whom (61 percent) stayed within their original county. The percentages were similar in the 2020–2021 period, suggesting that future growth for travel in most counties will be from visitation from outsiders or from people just passing through the county.

COVID-19 and the Disruption of Travel Trends

The long-term expansion in travel with population growth was severely disrupted by the COVID-19 pandemic starting in March 2020. Figure 2-2 summarizes the disruptions following the last pre-pandemic "normal" year of 2019. Travel by all passenger transportation modes collapsed in early 2020, followed by some recovery in 2021, and a return to near normal levels in 2022 for some modes (primarily personal vehicles and commercial aviation) but a weaker recovery rate for other modes (especially transit and intercity bus). Even where passenger volumes are close to the 2019 "normal," their characteristics have changed appreciably. As described in last year's *Transportation Statistics Annual Report*, personal vehicle travel has shifted in terms of usage times and directions and air travel has seen an increase, although airlines report that most returning customers are not business travelers who typically pay higher ticket prices. The impacts of these pandemic-induced pattern shifts go well beyond transportation, affecting downtown offices and

Table 2-2 Population Shifts: 2020–2021 (Numbers in Thousands)

		To		
Outmigrants from	**Total**	**Principal cities of metro areas**	**Balances of metropolitan areas**	**Nonmetropolitan areas**
Principal cities of metropolitan areas[1]	4,889	NA	4,505	384
Balances of metropolitan areas[1]	2,889	2,496	NA	393
Nonmetropolitan areas[1]	998	392	606	NA

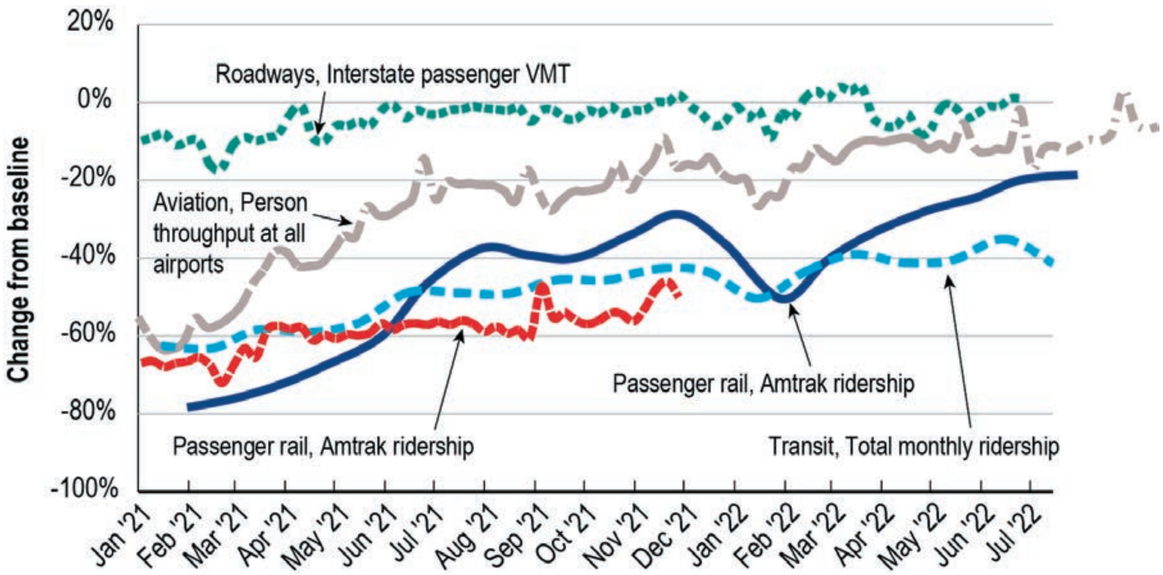
[1] Principal cities and balances are those within metropolitan areas. Metropolitan areas do not include Micropolitan Statistical Areas. Micropolitan Statistical Areas are included in Nonmetropolitan areas. Information about metropolitan status is available at https://www.census.gov/programs-surveys/metro-micro/about/glossary.html. Beginning in 2018, the description of a location in a metropolitan area but not in the principal city reads "balances of metropolitan areas" instead of "suburbs." Reference corresponding user note for more information.

KEY: NA = not applicable.

NOTES: Estimates may not sum to totals due to rounding. Migration estimates from the Current Population Survey Annual Social and Economic Supplement (CPS ASEC) exclude persons less than one year old. The sample includes noninstitutionalized persons currently living in the United States (50 states and the District of Columbia) and living in a household with at least one civilian adult (at least 15 years old). Movers from Puerto Rico and the United States Island Areas are counted as movers from abroad. Information on confidentiality protection, sampling error, nonsampling error, and definitions is available at https://www.census.gov/programs-surveys/cps/technical-documentation/complete.html.

SOURCE: U.S. Census Bureau, Current Population Survey, 2021 Annual Social and Economic Supplement (CPS ASEC), available at https://www.census.gov/data/tables/2021/demo/geographic-mobility/cps-2021.html as of September 2022.

Figure 2-2 COVID-19 Passenger Impact



KEY: Baseline = January 2020.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *Latest Weekly COVID-19 Transportation Statistics*, available at https://www.bts.gov/covid-19/week-in-transportation as of October 2022.

services, home arrangements and locations, and the use of technology and communications as substitutes for travel, although the duration of these shifts is uncertain.

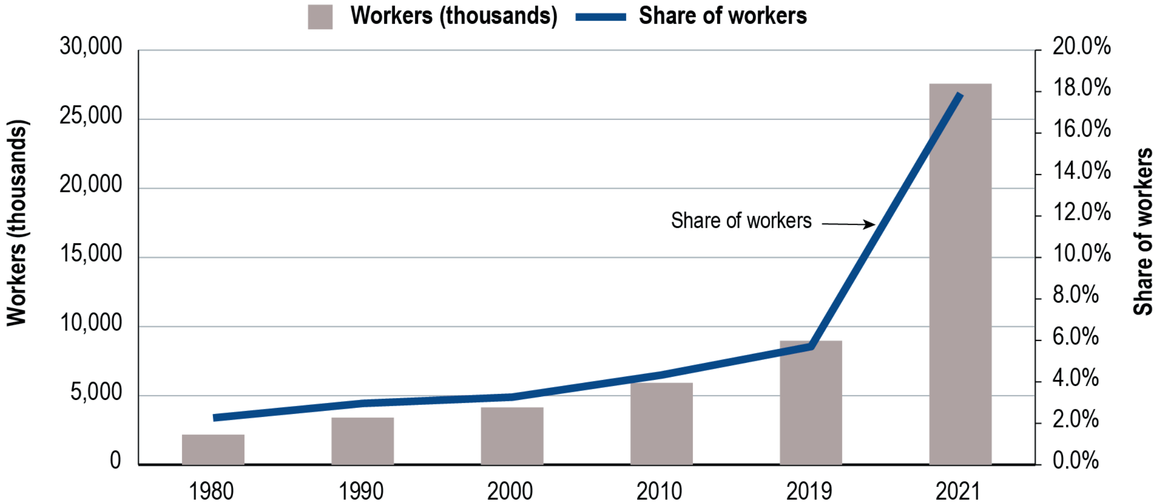
Changes in Local Commuting

Journeys-to-work traditionally account for a fifth of local travel, but that fifth is the major source of recurring urban congestion and a major source of ridership for public transit. Working at home has been replacing a share of journeys-to-work since at least 1980, and COVID-19 has dramatically increased that share (Figure 2-3). In 2021, the 28 million working from home surpassed the 12 million workers carpooling and was second only to the 105 million workers driving alone (Table 2-3).

Working at home is one of the most dramatic changes in travel behavior since World War II, and recent increases may not recede given shortages of workers, the benefits of reduced commuting time and costs, reduced costs of office space for employers, and the availability of more effective electronic tools to support those who are able to perform their job without face-to-face relationships. While some people who work at home are in a lower income range, the main trend in the recent period has been among those in higher income brackets (Figure 2-4). Repercussions from the working from home go beyond travel demand characteristics into broader influences on land-use, office space needs, and home arrangements as well as a likely change in the times, directions, and modal choices of trips.

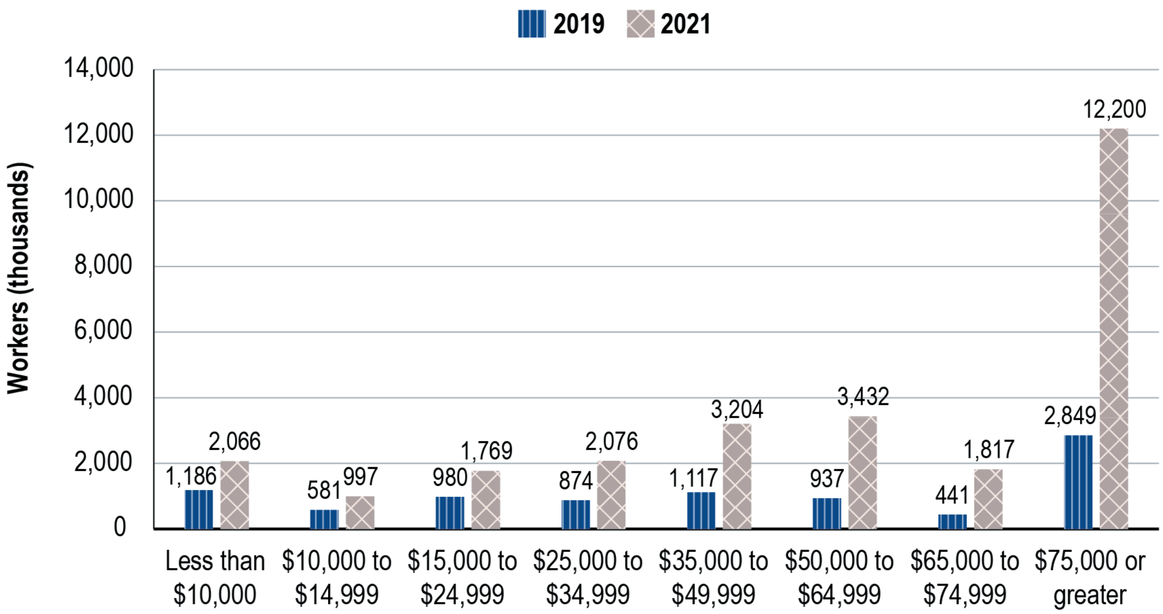
Table 2-3 provides a detailed mode choice tabulation for the base year 2019 and the most current full year 2021, showing the values in numbers of commuters and the percentages modal share for each. The most immediate measure of change is in the final column, which shows the change in the number of commuters from 2019 to 2021. All of the alternative modes

Figure 2-3 Long-Term Trend in Working at Home: 1980, 1990, 2000, 2010, 2019, and 2021



SOURCE: U.S. Department of Commerce, Census Bureau, Decennial Census 1980-2000 and 2010-2021 American Community Survey, Table S0801, available at https://data.census.gov/cedsci/ as of September 2022.

Figure 2-4 Workers Working at Home by Income: 2019–2021



SOURCE: U.S. Department of Commerce, Census Bureau, 2019-2021 American Community Survey, Table B08119, available at https://data.census.gov/cedsci/ as of September 2022.

Table 2-3 Mode of Transportation to Work Change: 2019–2021

Mode of transportation	2019 Count	2019 Share	2021 Count	2021 Share	Change from 2019 to 2021
TOTAL	156,941,346	100.00	154,314,179	100.00	-2,627,167
Car, truck, or van	133,054,328	84.78	116,668,475	75.60	-16,385,853
Drove alone	119,153,349	75.92	104,650,121	67.82	-14,503,228
Carpooled	13,900,979	8.86	12,018,354	7.79	-1,882,625
In 2-person carpool	10,469,892	6.67	9,050,049	5.86	-1,419,843
In 3-person carpool	1,982,471	1.26	1,776,397	1.15	-206,074
In 4-person carpool	765,777	0.49	683,451	0.44	-82,326
In 5- or 6-person carpool	421,798	0.27	353,122	0.23	-68,676
In 7- or-more-person carpool	261,041	0.17	155,335	0.10	-105,706
Public transportation	7,778,444	4.96	3,793,329	2.46	-3,985,115
Bus	3,601,403	2.29	1,971,235	1.28	-1,630,168
Subway or elevated rail	2,935,633	1.87	1,400,185	0.91	-1,535,448
Long-distance train or commuter rail	921,391	0.59	294,566	0.19	-626,825
Light rail, streetcar, or trolley	242,776	0.15	82,915	0.05	-159,861
Ferryboat	77,241	0.05	44,428	0.03	-32,813
Taxicab	385,756	0.25	296,457	0.19	-89,299
Motorcycle	221,923	0.14	166,676	0.11	-55,247
Bicycle	805,722	0.51	616,153	0.40	-189,569
Walked	4,153,050	2.65	3,399,405	2.20	-753,645
Other means	1,571,323	1.00	1,805,586	1.17	234,263
Worked from home	8,970,800	5.72	27,568,098	17.86	18,597,298

SOURCE: U.S. Department of Commerce, Census Bureau, 2019-2021 American Community Survey, Table B08301, available at https://data.census.gov/cedsci/ as of September 2022.

decline substantially, drawn down by the switches of commuters to working at home.

Working at home grew by 18.6 million, while driving alone lost 14.5 million users. Carpooling lost one percentage point in share. Transit lost about 4 million out of 7.8 million users, totaling a shift of half of its ridership. The largest shift in share was long-distance commuter rail. which resulted in a loss of about two-thirds of ridership. There is a small positive shift of about one-tenth of one percent in so-called Other Means of Transportation, which can include such things as e-scooters and personal boats.

Two of the features of the new commuting world are the share of workers whose work trip is under 20 minutes or over 60 minutes and those who must leave home at certain times to reach work sites. Almost 43 percent of workers have a work trip under 20 minutes. Adding those working at home to the group of workers with a commute under 20 minutes pushes the share above 60 percent in 2021. Figure 2-5 supports the observation that the growth of working at home is among longer distance commuters. The trend in the increased share of workers leaving their home county to work reversed after six decades of growth in 2020–2021 and returned to levels seen last in the 1990s.

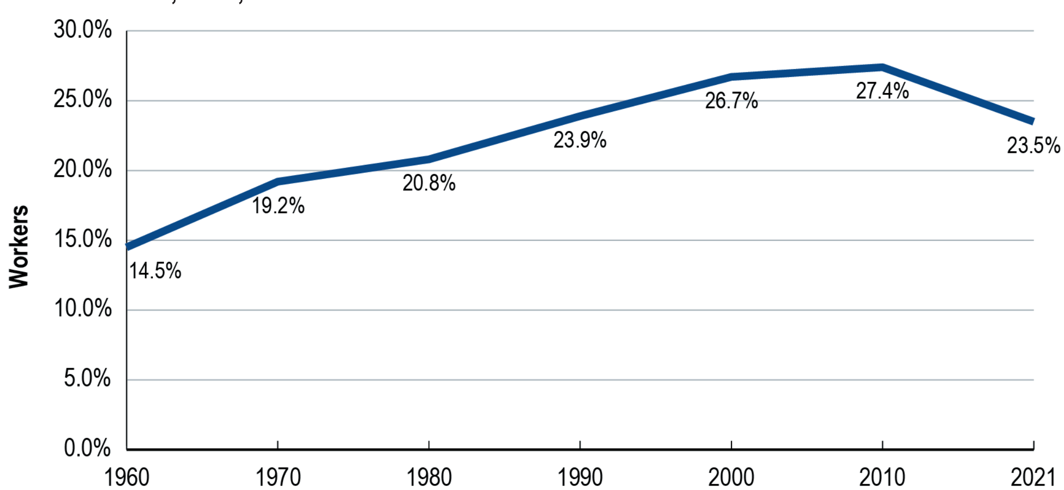
Changes in Intercity and International Travel

As described in the 2020 *Transportation Statistics Annual Report*, the United States seemed to be on the verge of a major expansion in long-distance travel and tourism in 2019. (Long-distance trips are defined in the National Household Travel Survey as trips of 50 miles or more from home to the farthest destination traveled.) After first reaching a billion passengers in 2018, U.S. and foreign commercial air carriers operating in the United States served 4 percent more passengers in 2019, and passenger growth continued through January 2020, showing a 6 percent increase over January 2019 just prior to the onset of COVID-19 [USDOT BTS 2020]. Amtrak also reached its peak year for passengers [ANDERSON 2019]. The intercity bus industry was instituting new approaches to intercity services and providing links to colleges, airports, and new destinations. All of that collapsed as COVID-19 emerged nationally in early 2020. With demand constrained both domestically and at many countries' borders, supply responded with dramatic curtailment of services.

The U.S. Travel Association (USTA) estimates that U.S. travel had made a partial recovery in 2021, with domestic leisure travel exceeding the 2019 base year, but domestic business travel lagged badly at less than half of 2019 spending. In addition, international inbound passenger spending was less than a quarter of 2019 spending as some countries foreclosed visitor travel due to COVID-19 lockdowns (Table 2-4). USTA estimates that 2.3 million jobs remain lost in the 2021 period, with 1.4 million of that loss in business travel employment [USTA 2022].

National Parks remain a popular destination for long distance trips, although the number of visits still has not recovered to pre-pandemic levels. According to the National Park Service (NPS), national parks received 297.1 million recreation visits in 2021, up 60 million visits (25.3 percent) from 2020 levels when park facilities were closed for at least part of the year due to COVID-19 concerns [USNPS 2022]. The NPS also reported more than 12.7 million overnight stays in 2021.

Figure 2-5 Percentage of Workers Leaving Their Home County to Work: 1960, 1970, 1980, 1990, 2000, 2010, and 2021



SOURCES: Pisarski, Alan, *NCHRP Report 550: Commuting in America III*, Figure 3-5, available at https://onlinepubs.trb.org/onlinepubs/nchrp/ciaiii.pdf as of September 2022. U.S Department of Commerce, Census Bureau, 2010 - 2021 American Community Survey, Table B08007 and Table B08203, available at https://data.census.gov/cedsci as of September 2022.

Table 2-4 Intercity Travel Spending: 2019, 2020, and 2021

Spending (USD, Billions)	2019	2020	2021
Domestic Leisure	722	555	751
Domestic Business	270	88	118
International Inbound	181	38	40
Total Direct Spending	**1200**	**680**	**910**

SOURCE: U.S. Travel Association, *U.S. Travel Answer Sheet*, May 2022, available at www.ustravel.org as of September 2022.

In comparison, a total of 327.5 million recreation visits were made in 2019. The increase from 2020 to 2021 is attributed largely to the Park Service's evolving COVID-19 protocols, which allowed more park facilities to be open and available for visitors in 2021 than in 2020.

Cruise ships are another aspect of long-distance travel. An estimated 29.7 million cruise passengers sailed from the United States in 2019, which accounted for an estimated half of the global cruise passengers [CLIA 2022]. The U.S. global cruise industry has been the mode of travel perhaps most affected by the COVID-19 pandemic. Compared to 2019, 2020 cruise travel declined 81 percent to 5.8 million passenger embarkations with a 51 percent decrease in cruise supported jobs and a 59 percent decrease in economic contributions. The Cruise Line International Association's baseline forecast expects passenger volumes to reach and exceed 2019 levels by the end of 2023 [CLIA 2022].

International Travel

Major components of international travel to the United States are the land border crossings, much of which are local trips made on a daily basis. This is distinguished from tourism stays that involve longer distances and usually overnight stays. The typically massive number of pedestrians from Mexico dropped substantially in 2020 and made only a very limited increase in 2021.

In 2019, the number of persons per vehicle from Mexico and Canada entering the United States averaged 1.9 persons per vehicle. In 2020, the average dropped to 1.6. In 2021, Mexico recovered somewhat, averaging 1.65 persons per vehicle, whereas Canada declined further to an average of 1.44 (Table 2-5).

Canada was ranked first in visits to the United States in 2019 with 20.7 million arrivals [USTA], but in 2021 those arrivals dropped to 2.53 million as reported by the U.S. Department of Commerce, National Travel and Tourism Office (NTTO) (Table 2-6). This represents a decrease of about 87.8 percent from 2019 as international

Table 2-5 U.S. Border Land-Passenger Gateways: Entering the U.S.: 2019–2021

	2019			2020			2021		
Land-passenger gateway	**Total**	**Mexico**	**Canada**	**Total**	**Mexico**	**Canada**	**Total**	**Mexico**	**Canada**
TOTAL land passengers	**241,926**	**188,229**	**53,697**	**116,911**	**106,589**	**10,322**	**132,374**	**125,864**	**6,510**
Personal vehicle passengers	188,067	136,890	51,177	90,647	80,591	10,056	102,952	96,562	6,389
Pedestrians	49,699	49,176	523	25,046	24,999	48	27,972	27,935	37
Bus passengers	3,866	2,153	1,713	1,153	992	161	1,385	1,350	35
Train passengers	294	10	285	64	7	57	65	17	47
Personal vehicles	99,818	73,085	26,733	56,833	50,605	6,229	62,979	58,548	4,431
Buses	436	152	77	147	90	10	143	96	4

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Border Crossing/Entry Data, Annual Data, as reported in *National Transportation Statistics*, Tables 1-47 and 1-48, available at https://www.bts.gov/topics/national-transportation-statistics as of October 2022.

travel declined 75.8 percent from 2019 to 2020 but rose by 15.0 percent in 2021 [USDOC NTTO].

Mexican travel to the United States was not as negative, with four times as many visitors as Canada in 2021, ranking first in visits to the United States that year. The top 10 international visitors to the United States from 2019 to 2021 by country of origin are ranked in Table 2-6. Mexico and Canada have been the dominant sources of international visitors to the United States for years, accounting for 58.5 percent of the 2021 total. It is interesting to note that the United Kingdom is the only European country listed, and India the only Asian country in 2021. In comparison, three European and four Asian countries were among the top 10 international visitors to the United States in 2019.

Overall flights per day from U.S. airports declined from over 26,000 in 2019 to 16,000 in 2020, recovering somewhat to just under 20,000 in 2021[USDOT BTS 2022]. In 2022, the levels averaged about 22,000 flights per day, 16 percent below 2019 levels. Carriers are flying larger aircraft and as a result scheduled seats per day have recovered better than overall flights, from 3.16 million seats per day in 2019 to 2.93 million seats per day in 2022, 8 percent below their pre-pandemic level. A long-standing airline measure of the share of the U.S. population that flew in the previous 12 months had grown to a level of 45 percent in 2019 dropping to 37 percent in 2021[A4A].

Overall trips, by air and non-air, are expected to reach 2019 levels by 2023 at 2.2 billion trips compared to 2.13 billion in 2019. Further, the number of international arrivals of foreign visitors is not expected to reach 2019 levels of about 80 million until 2025 [USTA].

Completing the picture of U.S. world tourism, the United Nations' World Tourism Organization (UNWTO) had placed the United States third in the world, behind France and Spain, in tourism arrivals, at 80 million visitors, and first in the world in tourism receipts, at $214 billion, in 2018 [UNWTO 2019]. In 2020, international visitor arrivals and spending declined by 76 and 65 percent, respectively. In 2021, there was a 15 percent increase in arrivals but a further

Table 2-6 Top Ten International Visitors to the United States: 2019, 2020, and 2021

	2019		2020		2021	
Rank	**Country**	**Arrivals (millions)**	**Country**	**Arrivals (millions)**	**Country**	**Arrivals (millions)**
1	Canada	20.72	Mexico	6.81	Mexico	10.40
2	Mexico	18.33	Canada	4.81	Canada	2.53
3	United Kingdom	4.78	United Kingdom	0.73	Colombia	1.06
4	Japan	3.75	Japan	0.70	United Kingdom	0.46
5	China	2.83	South Korea	0.44	India	0.43
6	South Korea	2.30	Brazil	0.42	Ecuador	0.41
7	Brazil	2.10	China	0.38	Dominican Republic	0.41
8	Germany	2.06	India	0.34	Peru	0.40
9	France	1.84	France	0.30	Argentina	0.30
10	India	1.47	Germany	0.29	Guatemala	0.28
	All Countries	**79.44**	**All Countries**	**79.44**	**All Countries**	**79.44**

SOURCE: U.S. Department of Commerce, International Trade Administration, National Travel and Tourism Office, Form I-94, available at www.trade.gov as of September 2022.

4 percent decline in spending. Visitor arrivals in 2021 had increased to nearly 22.1 million, but spending declined to $81.0 billion [UNWTO 2021]. In 2021, the United States dropped to 6th in world arrivals [UNWTO 2022]. Despite those losses, the United States still led the world in tourism receipts with 13.2 percent of world receipts (excluding airfares), more than twice second place France. Among the sharpest declines in receipts in 2021 was that of Canada, which restricted travel due to COVID-19 concerns, dropping to about a third of Mexican spending and below that of China and India.

The NTTO identified the trends in both arrivals of international visitors and outbound travel by U.S. citizens (Table 2-7). The values indicate only slight increases in 2021 from the substantial declines registered in 2020. Overall, 2021 international arrivals were more than 57 million behind the base year of 2019—a 72.2 percent drop. In 2020, arrivals rebounded by 15.0 percent, from about 19.2 million in 2020 to 22.1 million in 2021. Similarly, departures by U.S. citizens also declined substantially by nearly 51 percent in 2021 compared to 2019.

Equity Aspects of Local and Long-Distance Travel

Several initiatives to measure the equity aspects of passenger travel are underway, such as the cost burden placed on different populations for mobility to jobs, services, and other needs. Until current studies are completed and integrated into a comprehensive picture, national statistics on the equity aspects of travel by socio-economic groups are limited to Census data on vehicle availability and commuting by racial, ethnic, and income groups and data from the Bureau of Labor Statistics (BLS) on transportation spending by consumers in those groups. Census and BLS data generally distinguish only the largest racial and ethnic groups, especially when tabulations of sampled data are crossed with other characteristics of interest, such as income and worker status and push the limits of statistical reliability.

Vehicle Availability and Commuting

Long-term trends in vehicle availability for U.S. households appear to have continued despite pandemic and supply chain issues of recent years. Figure 2-6 displays the key trends of the continuing decline in both one- and no-vehicle households and the rise of multiple-vehicle households since 1980. The pertinent changes have been in zero vehicle households (down one percentage point per decade) and in three or more vehicle households.

More than half of the households with no vehicle are also households with no workers (Figure 2-7). Workers in households with no vehicle either work at home, walk, or use an employer's vehicle, transit, or other means to reach the place of work.

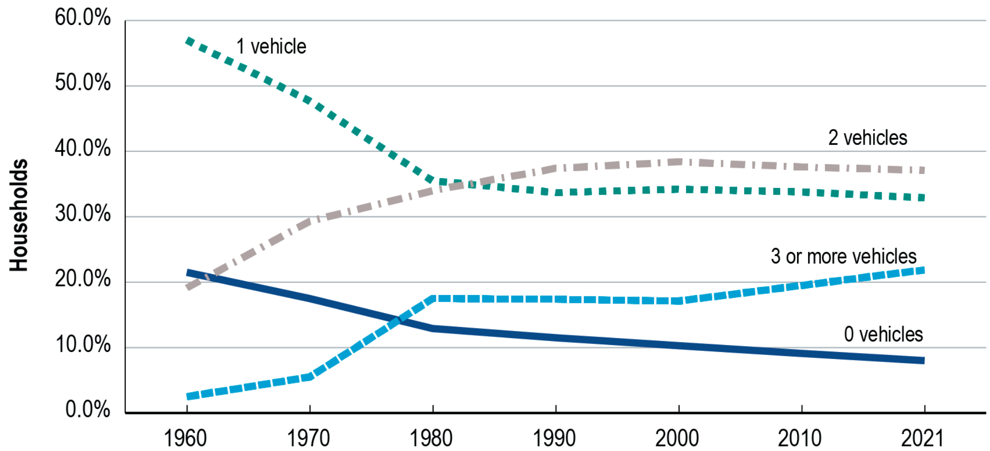
Figure 2-8 documents vehicle availability trends for the two largest racial and ethnic groups. Vehicle availability has been increasing among

Table 2-7 International Inbound and Outbound Travel: 2019–2021 (Millions)

	Passengers			Percent change from 2019	
Inbound/outbound	**2019**	**2020**	**2021**	**2020**	**2021**
Arrivals	79.44	19.21	22.10	-75.8%	-72.2%
Outbound	99.27	33.16	49.10	-66.6%	-50.5%

SOURCE: U.S. Department of Commerce, International Trade Administration, National Travel and Tourism Office, Forms I-92 and I-94, available at www.trade.gov as of September 2022.

Figure 2-6 Share of Households by Vehicles Owned 1960–2021



No. of vehicles owned	1960	1970	1980	1990	2000	2010	2021
0 vehicles	21.5%	17.5%	12.9%	11.5%	10.3%	9.1%	8.0%
1 vehicle	57.0%	47.7%	35.5%	33.7%	34.2%	33.8%	32.9%
2 vehicles	19.1%	29.3%	34.0%	37.4%	38.4%	37.6%	37.1%
3 or more vehicles	2.5%	5.5%	17.5%	17.4%	17.1%	19.5%	21.9%

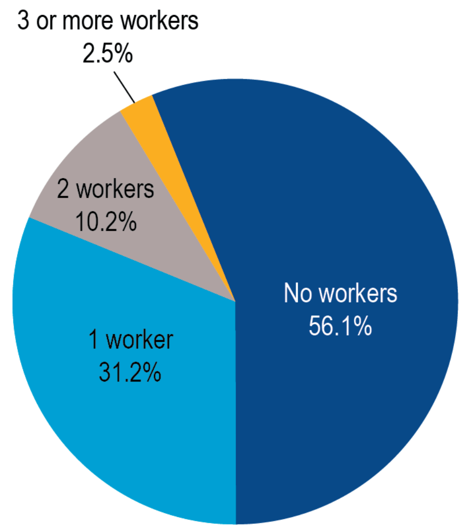
SOURCE: U.S. Department of Commerce, Census Bureau, Decennial Census 1960-2000 and 2010-2021 American Community Survey, Table DP04, available at https://data.census.gov/cedsci/ as of September 2022.

the major minority households, with Hispanics closing on the national average.

Commuting by the largest racial and ethnic groups is illustrated in Table 2-8 and Table 2-9. Percentages of African-Americans and Hispanics who drive alone closely match the total population, while Hispanics have a higher share of carpooling than the total and both African-Americans and Hispanics have a higher percentage of transit use to work. A lower percentage of Hispanics than the total population or African-Americans work at home, while Asian-Americans have a substantially higher percentage of working at home.

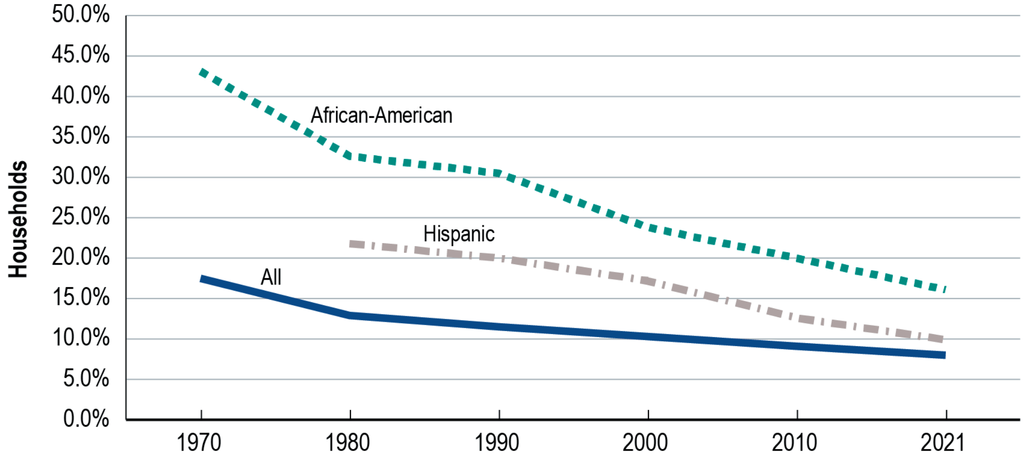
Commuting data reveal gender differences that may reflect equity aspects of labor force participation more than equity aspects of transportation. While the differences in mode choice are small and shrinking (Table 2-10), differences in travel time remain (Table 2-11).

Figure 2-7 Workers in Households Without Vehicles by Number of Workers: 2021



SOURCE: U.S. Department of Commerce, Census Bureau, 2021 American Community Survey, Table B08203, available at https://data.census.gov/cedsci/ as of September 2022.

Figure 2-8 Long-Term Trend in Zero Vehicle Households: 1970, 1980, 1990, 2000, 2010, and 2021



Type of household	1970	1980	1990	2000	2010	2021
All	17.5%	12.9	11.5	10.3	9.1	8.0
African-American	43.1%	32.6	30.5	23.8	20.0	16.1
Hispanic	NA	21.8	20.0	17.2	12.6	9.9

KEY: NA = not applicable.

SOURCE: U.S. Department of Commerce, Census Bureau, Decennial Census 1970-2000 and 2010-2021 American Community Survey, Table S0201, available at https://data.census.gov/cedsci/ as of September 2022.

Table 2-8 Comparisons of Major Racial and Ethnic Groups Using Traditional Major Modes: 2000, 2010, 2019, and 2021

Major mode and group	2000 (%)	2010 (%)	2019 (%)	2021 (%)
Drove alone				
Hispanic	60.6	67.8	71.6	66.8
African-American	67.0	72.0	72.9	66.5
TOTAL population	75.7	76.5	75.9	67.8
Carpool				
Hispanic	22.7	16.0	13.2	12.9
African-American	16.0	10.0	8.9	7.9
TOTAL population	12.2	9.7	8.9	7.8
Transit				
Hispanic	8.6	7.8	6.3	3.9
African-American	12.0	10.9	9.6	5.7
TOTAL population	4.6	4.9	4.9	2.5

SOURCE: U.S. Department of Commerce, Census Bureau, Decennial Census 2000 and 2010-2021 American Community Survey, Table S0802, available at https://data.census.gov/cedsci/ as of September 2022.

Women tend to work closer to home and have shorter travel times, while commutes over 60 minutes are more likely to be by men traveling to more distant jobs. Men predominate in those leaving home to work before 7 a.m. and women have the major share of travel after 7 a.m. The shares of commuters traveling more than 60 minutes to work declined sharply during the pandemic, reflecting a probable effect of travel time on the desire to work at home.

Consumer Spending on Transportation: The Aggregate View

Consumer spending on transportation reflects both the consumption of transportation for personal travel and the burden that travel costs place on household budgets. An understanding of consumer spending across all groups is pre-requisite to understanding racial and ethnic differences in consumer spending.

Figure 2-9 presents the broadest view of transportation spending during the 2000–2021 period, expressed as the transportation share

Table 2-9 Non-Motorized Commuting: 2021

Commute	All	Black or African-American	Hispanic or Latino	Asian Alone
Walked	2.2%	2.1%	2.3%	2.9%
Other non-motorized means	1.9%	2.5%	2.4%	2.1%
Worked from home	17.9%	15.3%	11.6%	27.5%
Mean travel time to work (minutes)	25.6	27.2	26.9	27.1

SOURCE: U.S. Department of Commerce, Census Bureau, 2021 American Community Survey, Table S0201, available at https://data.census.gov/cedsci/ as of September 2022..

Table 2-10 Means of Transportation to Work by Gender: 2021

Transportation	All	Male	Female	F/M Ratio
Workers 16 years and over	154,314,179	81,813,405	72,500,774	88.6%
Car, truck, or van	75.6%	76.9%	74.1%	96.4%
Drove alone	67.8%	69.4%	66.0%	95.1%
Carpooled	7.8%	7.5%	8.1%	108.0%
In 2-person carpool	5.9%	5.7%	6.1%	107.0%
In 3-person carpool	1.2%	1.1%	1.2%	109.1%
In 4-person carpool	0.8%	0.8%	0.7%	87.5%
Workers per car, truck, or van	1.06	1.06	1.06	100.0%
Public transportation (excluding taxicab)	2.5%	2.3%	2.6%	113.0%
Walked	2.2%	2.2%	2.2%	100.0%
Bicycle	0.4%	0.5%	0.3%	60.0%
Taxicab, motorcycle, other means	1.5%	1.6%	1.4%	87.5%
Worked from home	17.9%	16.4%	19.5%	118.9%

SOURCE: U.S. Department of Commerce, Census Bureau, 2021 American Community Survey, Table S0801, available at https://data.census.gov/cedsci/ as of September 2022.

Table 2-11 Travel Time to Work by Gender: 2019 and 2021

Travel time	All	Male	Female
Travel time to work (minutes)			
2021	25.6	27.3	23.7
2019	27.6	29.1	25.8
Overall travel time			
2021			
Under 20 minutes	42.5%	39.5%	46.0%
Over 60 minutes	7.7%	9.3%	5.9%
2019			
Under 20 minutes	39.8%	37.3%	42.5%
Over 60 minutes	9.8%	11.4%	8.1%
Time left home to work			
2021			
Before 7 AM	32.8%	38.8%	25.9%
After 7 AM	67.2%	61.3%	74.0%
2019			
Before 7 AM	32.4%	38.2%	25.8%
After 7 AM	67.6%	61.8%	74.2%

SOURCE: U.S Department of Commerce, Census Bureau, 2019 - 2021 American Community Survey, Table S0801, available at https://data.census.gov/cedsci as of September 2022.

of consumer spending in this century. Early in this century the transportation share of consumer spending was in the 18–19 percent range. In the 1990s it had occasionally ranged around the 20-percent level. Fuel prices could push spending into the 17 percent range in 2022, possibly back to the 2019 spending level (Table 2-12). It is important to note that this spending does not include spending paid for by an employer or by any other source outside the household, which clearly also dropped appreciably in the 2020–2021 COVID-19 period.

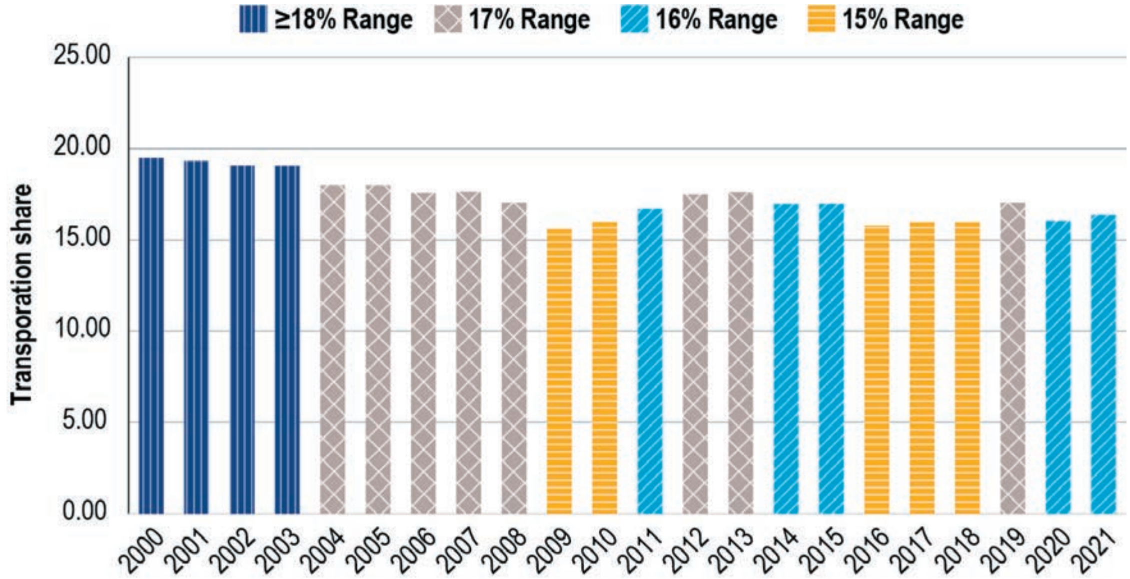
As in so many cases observed in the COVID-19 period, there is a sharp drop in consumer expenditures from the baseline year of 2019 to the COVID year of 2020 and then a partial recovery in 2021. Also, changes in consumer expenditure areas outside of transportation can affect transportation's spending share.

Table 2-12 provides recent detail of all spending from the pre-COVID base year of 2019 and into the subsequent COVID-19 years. The drop in transportation expenditures from 2019 to 2020 is heavily affected by a decline in fuel purchases and purchased transportation. Other pandemic-related changes were the sharp declines in food purchases away from home along with a decline in apparel purchases and a drop in educational spending.

Transportation spending is affected by the number of workers in a household, shown in Figure 2-10. The Consumer Expenditure Survey (CEX) statistics for 2021 estimated that there were 31,664,000 households, almost 24 percent of all households, containing more than 50 million people, about 15 percent of the population, in zero-worker households. This reflects the increasing numbers of retirees [USDOL BLS CEX 2021].

While spending increases with number of workers in the household, Table 2-13 shows that spending on a per-vehicle or per-worker basis is almost constant across different income quintiles. Total transportation spending per person rises with income but stabilizes when evaluated on a per worker basis. Spending on vehicle fuel (when analyzed on a per vehicle basis) is quite similar among workers of different incomes. The overall effect of all purchased transportation (e.g., transportation one buys a ticket to use) on a worker basis is also relatively stable. COVID-19 seemed to have affected all about the same on a per worker basis. The effects by incomes and race and ethnicity of purchased transportation for intercity travel will be examined in detail later in the intercity segment of this chapter. The local part of purchased transportation is transit and taxi use. The expenditures for transit among the income groups are quite stable in which the spending by the highest income level actually exceeds that by the lowest income group. But on a per worker basis, transit spending is greatest among

Figure 2-9 Transportation Share of Consumer Spending: 2000–2021 (Percent)



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Surveys, available at https://www.bls.gov/cex/tables/top-line-means.htm as of September 2022.

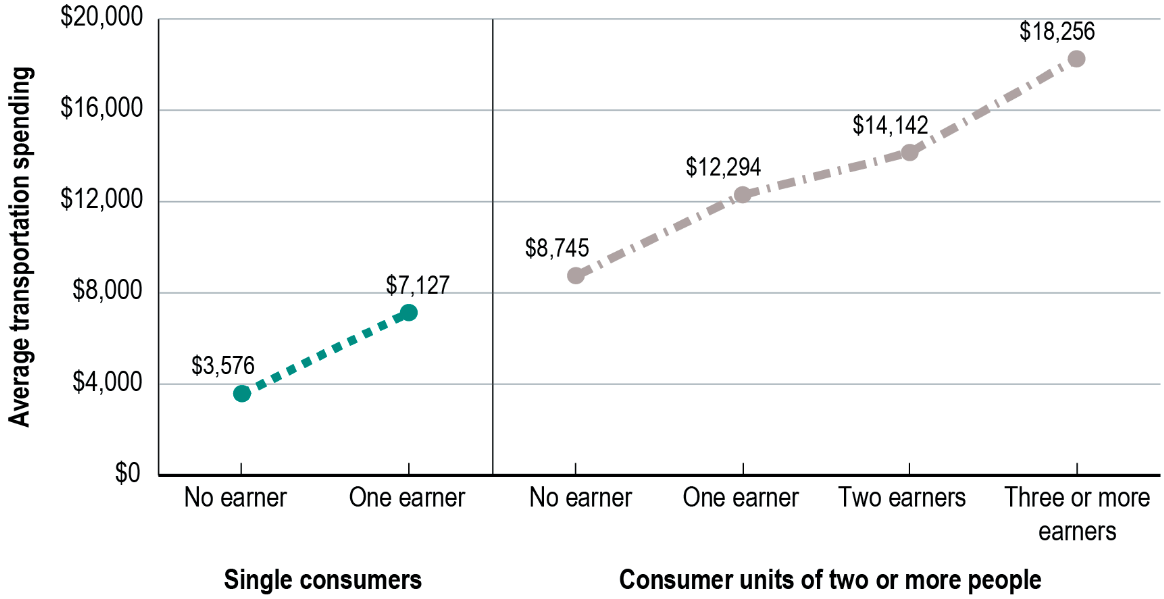
Table 2-12 Selected COVID-19-Related Trends in Overall Spending (Spending per Consumer Unit): 2019–2021

				Percent change		
Expenditure type	**2019**	**2020**	**2021**	**2019–2020**	**2020–2021**	**2019–2021**
Average annual expenditures	**$63,063**	**$61,332**	**$66,928**	**-2.70%**	**9.12%**	**6.17%**
Food	$8,169	$7,310	$8,289	-10.52%	13.39%	1.47%
Food at home	$4,643	$4,935	$5,259	6.29%	6.57%	13.27%
Food away from	$3,526	$2,375	$3,030	-32.64%	27.58%	-14.07%
Housing	$20,679	$21,417	$22,624	3.57%	5.64%	9.41%
Apparel	$1,883	$1,434	$1,754	-23.84%	22.32%	-6.85%
Transportation	$10,742	$9,826	$10,961	-8.53%	11.55%	2.04%
Vehicle purchases	$4,394	$4,523	$4,828	2.94%	6.74%	9.88%
Gasoline other fuels	$2,094	$1,568	$2,148	-25.12%	36.99%	2.58%
Purchased transportation	$781	$263	$452	-66.33%	71.86%	-42.13%
Healthcare	$5,193	$5,177	$5,452	-0.31%	5.31%	4.99%
Entertainment	$3,090	$2,909	$3,568	-5.86%	22.65%	15.47%
Education	$1,443	$1,271	$1,226	-11.92%	-3.54%	-15.04%

NOTES: All values have been rounded, and as a result some cell values have been rounded to zero. This is particularly evident in the characteristic section. When data are not reported or are not applicable (i.e., missing values), tabulated cell values have been set to zero. Purchased transportation includes tickets for airline and trail travel, transit fares, and other payments for for-hire transportation.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Surveys, available at https://www.bls.gov/cex/tables/top-line-means.htm as of September 2022.

Figure 2-10 Transportation Spending by Earners: 2021



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, Table 1600, available at www.bls.gov/cex/tables.htm as of September 2022.

Table 2-13 Transportation Spending Per Person, Per Worker, Per Vehicle by Income: 2021

Transportation spending type	All consumer units	Lowest 20 percent	Second 20 percent	Third 20 percent	Fourth 20 percent	Highest 20 percent
TOTAL transportation spending	**$10,961.18**	**$4,273.08**	**$7,987.72**	**$10,285.33**	**$12,983.60**	**$19,204.24**
Per Person	4,567.16	2,513.58	3,803.68	4,114.13	4,637.00	6,001.33
Per Worker	8,431.68	10,682.70	9,984.65	7,911.79	7,637.41	9,144.88
Gasoline, other fuels, and motor oil	**2,147.55**	**1,110.70**	**1,701.73**	**2,184.39**	**2,656.86**	**3,074.43**
Per Vehicle	1,130.29	1,110.70	1,134.49	1,149.68	1,155.16	1,138.68
"Public and other transportation (all purchased transportation)"	**451.54**	**148.76**	**194.10**	**329.93**	**450.89**	**1,129.15**
Per Worker	347.34	371.90	242.63	253.79	265.23	537.69
Intracity mass transit fares	45.36	47.41	39.89	39.31	45.97	54.16
Per Worker	34.89	118.53	49.86	30.24	27.04	25.79
Taxi fares and limousine services*	24.60	22.63	11.06	17.03	20.79	51.45
Per Worker	18.92	56.58	13.83	13.10	12.23	24.50

* Diary item.

NOTE: Reimbursed business travel is not included in these data.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, Table 1101, available at www.bls.gov/cex/tables.htm as of September 2022.

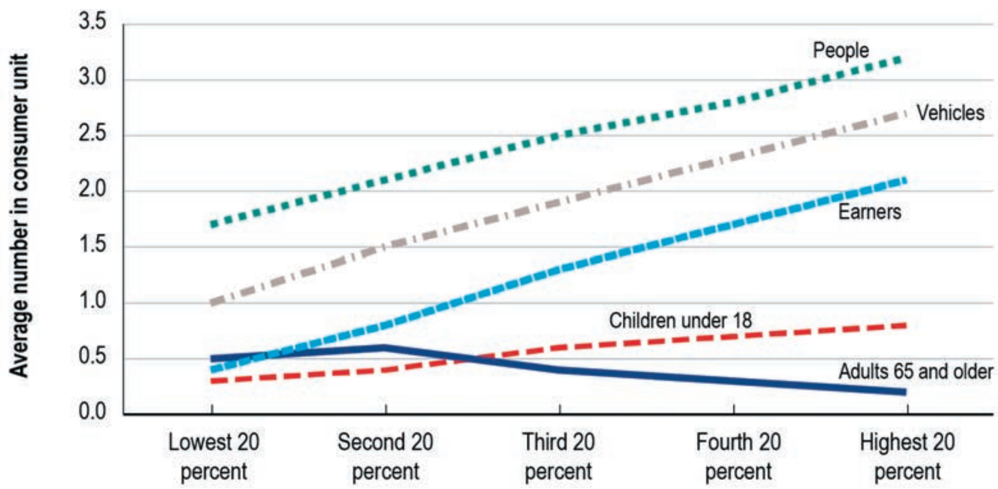
the lowest income group. For comparison, taxi and limo spending is shown with a significant revelation that the lowest income group is the highest in spending on taxis and second only to the highest income group in spending on cab usage per worker. This may be the product of the use of cabs among the carless, as well as the small number of workers in the lowest income quintile.

When examined by quintiles of income, transportation spending shifted sporadically from 2020 to 2021. Only the lowest quintile showed a decline of about 2 percent. The changes in spending exhibited growth in other quintiles but were varied with growth in the second quintile of 28.5 percent, 11.9 in the third, 3 percent in the fourth, and an increase of 14.3 percent in the highest quintile [USDOL BLS CEX 2021].

These overall consumer unit demographic patterns tend to remain relatively stable over time, for example, the variations between the 2019 and 2021 data are not more than one-tenth of one percent for any characteristic. The most apparent observation is the close pattern relationship between population, earners, and vehicles. The general sense of auto ownership over the years began with the concept of one vehicle per household, then one vehicle per worker (every quintile group now has more vehicles than workers) and now, nearly one vehicle per adult in every quintile except the lowest (Figure 2-11).

Vehicle ownerships rises, as expected with increasing workers, the lower two income quintiles have a larger ratio of vehicles to earners than the higher quintiles, explained largely by retirees in the lower groupings.

Figure 2-11 Demographic Patterns by Income Quintile: 2021



Measure	Lowest 20%	Second 20%	Third 20%	Fourth 20%	Highest 20%
People	1.7	2.1	2.5	2.8	3.2
Children under 18	0.3	0.4	0.6	0.7	0.8
Adults 65 and older	0.5	0.6	0.4	0.3	0.2
Earners	0.4	0.8	1.3	1.7	2.1
Vehicles	1.0	1.5	1.9	2.3	2.7

SOURCE: Sources U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, Table 1101, available at www.bls.gov/cex/tables.htm as of September 2022.

Another profile statistic identifies the share of households with no vehicles versus at least one. At the national level, 89 percent of units have at least one vehicle. But, in the lowest quintile only 71 percent have at least one, jumping sharply in the second and third group and reaching 96 percent in the highest two quintiles. This varies from the findings of the American Community Survey but may simply be a function of the distinct definitions of the BLS consumer unit versus the ACS definition of a household.

Consumer Spending on Transportation by Racial and Ethnic Categories

Differences among racial and ethnic groups in spending on transportation are shown in Table 2-14. The standout is perhaps that of Asians with the highest levels of spending (and highest incomes) of all groups. Both Asian and Hispanic incomes benefit from large numbers of workers in the unit as noted above. Asian incomes are also associated with the highest

Table 2-14 Annual Expenditures for Major Economic and Transportation Categories: 2021

			Not Hispanic or Latino			
Expenditure	**"All consumer units"**	**"Hispanic or Latino"**	**Total**	**"White and all other races"**	**"Black or African-American"**	**Asian**
"Average annual expenditures (major categories)"	**$66,927.83**	**$57,954.80**	**$68,475.68**	**$71,640.67**	**$51,013.20**	**$78,726.38**
Food	8,289.28	8,157.54	8,312.18	8,716.11	6,123.98	10,526.82
Housing	22,623.55	20,832.27	22,931.28	23,617.25	19,141.70	28,377.90
Apparel	1,754.39	2,186.06	1,681.25	1,698.71	1,585.83	2,303.12
Transportation	10,961.18	11,505.41	10,867.22	11,190.59	9,072.40	10,494.04
Health care	5,451.61	3,326.71	5,818.35	6,215.73	3,614.71	4,967.89
Entertainment	3,567.89	2,233.69	3,797.55	4,162.81	1,787.40	2,661.57
Education	1,226.14	554.54	1,342.04	1,435.07	826.13	3,114.91
Transportation expenditures	**$10,961.18**	**$11,505.41**	**$10,867.22**	**$11,190.59**	**$9,072.40**	**$10,494.04**
Vehicle purchases, new	2,210.00	2,269.00	2,200.00	2,418.00	991.00	2,864.00
Vehicle purchases, used	2,555.00	2,753.00	2,520.00	2,473.00	2,782.00	1,426.00
Gasoline, other fuels, and motor oil	2,148.00	2,432.00	2,098.00	2,150.00	1,812.00	2,028.04
Vehicle finance charges	272.00	280.00	270.00	278.00	231.00	227.33
Maintenance and repairs	975.00	982.00	974.00	1,014.00	748.00	777.75
Vehicle rental, leases, licenses, and other charges	760.00	666.00	776.00	817.00	545.00	947.96
Vehicle insurance	1,528.00	1,678.00	1,502.00	1,491.00	1,560.00	1,478.33
Public and other transportation	452.00	412.00	459.00	470.00	393.00	698.27
Vehicles owned	1.9	1.7	1.9	2	1.4	1.6
"Transportation expenditures per vehicle (selected items)"						
Fuel expenditures per vehicle	$1,130.53	$1,430.59	$1,104.21	$1,075.00	$1,294.29	$1,267.53
Maintenance and repairs per vehicle	$513.16	$577.65	$512.63	$507.00	$534.29	$486.09
Insurance per vehicle	$804.21	$987.06	$790.53	$745.50	$1,114.29	$923.96

KEY: NA = not applicable.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, Table 2100 and Table 2200, available at www.bls.gov/cex/tables.htm as of September 2022.

levels of education among all groups. Also, theirs is the highest level of spending on education, more than double the closest other race category in spending.

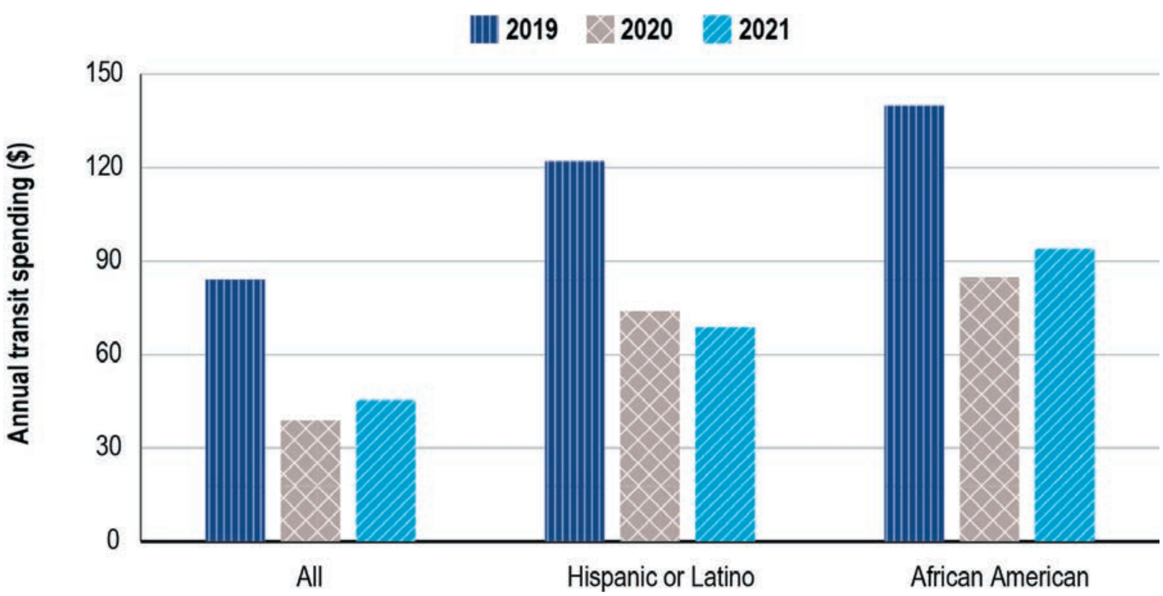
Hispanics and African-Americans live in center cities in general and in large metropolitan areas as well. This affects automobile ownership costs, transit usage (Figure 2-12), and housing costs, among others. This shifts the share of spending going to housing and transportation with overall shares for all at about 50 percent of spending, but with a greater share of that 50 percent going to housing versus transportation.

Rural populations tend to have similar, but slightly lower total spending shares of housing and transportation, but with greater transportation costs and lower housing costs even though their home ownership levels are higher than metropolitan residents. There tends to be few Hispanics and African-Americans in rural areas, so the low-income groups there tend to be White, non-Hispanics [USDOL BLS CEX 2021.

Asians comprise only 5 percent of the population, thus sampling statistics tend to be less available on their characteristics. Asians have the highest incomes, with a large number of persons and workers per unit. They also have relatively low vehicle ownership and high-transit spending [USDOL BLS CEX 2021].

Table 2-15 shows racial and ethnic differences in spending on public and other purchased transportation (e.g., air, taxi, train) [USDOL BLS CEX 2021]. It provides valuable insight into the intercity travel of selected minorities via examination of their spending patterns. Intercity travel was greatly affected by COVID-19 shutdowns and the fact that so much of that travel is discretionary, so risk avoidance was a preeminent concern of many potential travelers. The following highlights are averaged across all consumer units not just those actually incurring the expenses:

Figure 2-12 Annual Transit Spending in the COVID-19 Period: 2019–2021



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, available at www.bls.gov/cex/tables.htm as of September 2022.

- African-American bus usage was small in 2019—averaging just under $9 a year per consumer unit, and dropped to almost to zero in 2020; bus usage returned to about $2.50 in 2021.
- Hispanic usage followed a similar pattern; $14 in 2019, $4 in 2020, and recovering somewhat to $5 in 2021.
- African-American airline fares were somewhat more positive at $275 in 2019, dropping to $79 in 2020, and then rising to $237 in 2021.
- Hispanic air usage was similar, with $338 in 2019, dropping to $151 in 2020, and returning somewhat to $258 in 2021.

The overall population had total intercity travel spending in the 2019 base year of $780, then dropped to $263 in 2020, recovering somewhat to $450 in 2021. It is notable that the usage of local transportation, cabs, and transit were heavily affected by the declines of the intercity public modes and personal vehicle travel.

Table 2-15 Purchased Intercity Transportation: 2019–2021

Transportation purchased	All Consumer Units	Hispanic or Latino	Black or African-American	Ratio Hispanic or Latino	Ratio Black or African-American
2019 public and other transportation	780.55	609.20	534.20	78.05%	68.44%
Airline fares	513.14	337.80	274.69	65.83%	53.53%
Intercity bus fares	15.28	14.29	8.86	93.52%	57.98%
Local trans. on out-of-town trips	20.33	12.38	11.00	60.90%	54.11%
Taxi fares and limousine services on trips	11.94	7.27	6.46	60.89%	54.10%
Intercity train fares	30.24	19.24	18.26	63.62%	60.38%
Ship fares	56.39	37.91	43.09	67.23%	76.41%
2020 public and other transportation	263.46	264.63	199.11	100.44%	75.58%
Airline fares	159.89	150.80	69.70	94.31%	43.59%
Intercity bus fares	2.23	4.23	0.38	189.69%	17.04%
Local trans. on out-of-town trips	6.89	4.21	3.55	61.10%	51.52%
Taxi fares and limousine services on trips	4.05	2.48	2.08	61.23%	51.36%
Intercity train fares	7.96	4.89	2.75	61.43%	34.55%
Ship fares	11.24	9.63	1.65	85.68%	14.68%
2021 public and other transportation	451.54	411.54	393.33	91.14%	87.11%
Airline fares	321.99	257.83	236.74	80.07%	73.52%
Intercity bus fares	4.18	4.94	2.57	118.18%	61.48%
Local trans. on out-of-town trips	14.21	8.82	9.47	62.07%	66.64%
Taxi fares and limousine services on trips	8.35	5.18	5.56	62.04%	66.59%
Intercity train fares	11.20	6.92	8.45	61.79%	75.45%
Ship fares	19.51	10.14	10.17	51.97%	52.13%

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Surveys, available at https://www.bls.gov/cex/tables/top-line-means.htm as of September 2022.

Data Gaps

This chapter provides a brief perspective on the events that unfolded in passenger transportation during the COVID-19 years and an assessment of their implications. A fuller treatment should be made but will best occur in the future when the implications have stabilized somewhat and the assessment is less speculative. Long-term monitoring is critical.

It is often the case that when totally unexpected public policy challenges arise, they must be addressed with the statistical capabilities at hand. This argues for constructing the basic statistical system to comprehensively address all aspects of transportation activity. The current challenges forced by COVID-19 and public and private changes reacting to it are a massive demonstration of that need. In that light, assessments are needed of the historical gaps uncovered and the new challenges to the statistical system that have arisen.

On the positive side, one of the bright spots has been the ability of statistical agencies to shift quickly to rapid turnaround data collection to support the almost daily policy and operations challenges that arose. New technologies that permitted rapid real-time reporting proved powerful enhancements. Monthly, weekly, and daily reporting became a norm with proper warnings about their preliminary nature or potential statistical weaknesses.

While new data sources, such as cell phone tracks and other location-based services data, provide a wealth of timely observations on the volume and patterns of travel, these sources rarely indicate socio-economic characteristics associated with the observed travel behavior. Much is known about travel, but little is known about the traveler or the purpose of the travel. These missing characteristics are essential to understanding the effectiveness of transportation in serving the Nation’s mobility needs, especially through the lens of equity.

While our understanding of travelers and local travel is informed by 60 years of travel surveys in major metropolitan areas, by nationwide data on journeys-to-work collected by the Census Bureau since 1970, and by several iterations of the National Household Travel Survey and its predecessors, our understanding of long-distance travel is limited to airline passenger counts and itineraries and to sporadic national surveys last conducted in 1995. As a consequence, we do not know how much travel on local transportation infrastructure is by people traveling through the area or visiting from a distant place. Such travel has different characteristics and requires different transportation management strategies to accommodate effectively.

While information on airline passenger counts and itineraries is extensive, airport managers and aviation planners lack basic information on the demographics and trip purposes of their customers, which limits forecasting and effective understanding of airport markets. The same is true for long-distance rail travel.

Statistics on intercity, charter, and school bus travel are far more limited. Anecdotal evidence suggests that the bus industry carries substantial amounts of travel, but little is known about the number of travelers and characteristics of those travelers. Ridership counts are consistently collected only for buses operated by or for publicly supported transit systems. Although buses are heavily used by minorities, young people, and the elderly, limited data about their travel characteristics are available. Our understanding of equity concerns is limited to data on consumer expenditures that lack geographic detail.

Statistics on recreational travel are increasingly important, especially as retirees become a larger portion of the population. There is a need for annual statistical reporting of travel to and from national parks and other important recreation areas. Existing data are fragmentary in coverage and scope. At a minimum, an inventory of state statistics would permit a basis for better design of ongoing reporting. Since the last long-distance travel survey was conducted in 1995, cruise ships have grown into a major generator of long-distance travel. Information is limited to vessel and passenger counts by port. As the industry recovers from the pandemic, information on the demographic and economic characteristics of cruise ship patrons will become an important element in port planning and marketing.

With respect to local travel, better understanding is needed on the use of micromobility modes, typically found in the urban environment and include bicycle and scooter rentals. These modes are small and were severely impeded by COVID-19 effects, but have growth potential in some specific locations. Given their interactions with other more traditional modes as both a support tool and a competitor, at least annual reporting is required, beyond the anecdotal, to establish the nature of opportunities and roles that can be played by these providers.

The challenge in addressing equity concerns often comes down to recognizing service level characteristics by neighborhood, which is extremely difficult to establish, and linking it to the socio-economic characteristics of the same neighborhood. Data challenges are even greater for understanding the special mobility needs of disabled residents within the neighborhood and the attributes of transportation facilities and services required to meet those needs. Equity analysis is hindered by the lack of sample frames and unaffordable sample sizes of general surveys to represent small groups of concern, such as Native Americans.

A major statistical challenge is to develop measures of working-at-home populations. Several agencies sought to address this during the pandemic but used varying definitions. The American Community Survey has used the definition of working at home that was developed for the decennial census as far back as 1980, and is limited to individuals who work at home a majority of the days of a usual week. The transportation profession needs statistics on occasional telework, recurring telework by day of week, and work at multiple locations during the day or week to understand and serve new temporal and geographic variations in travel demand.

A change in labeling geographic areas Census Bureau products has been challenging to transportation planners and policy analysts. For example, the Census Bureau has combined both central cities and important suburban centers into principal cities that masks important population changes and combines statistics on commuting flows between a city center and its constituent neighborhoods with flows between spatially separated city centers. Separating the two groups by renaming the central cities as such and then labeling suburban centers as principal cities where appropriate would at least resolve much of the lost data utility.

Finally, there is little information available regarding different levels of accessibility to or levels of service by mode available for a given geography or sociodemographic group. As analysts seek to better understand equity and mobility opportunities it will be incumbent to develop systematic databases that capture measures of mobility opportunities. While existing data sets can give some insights, there is not a comprehensive multimodal framework for reporting on transportation availability. Work towards developing these measures is underway on many fronts.

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CHAPTER 3
Freight and Supply Chain

Introduction

U.S. economic competitiveness is dependent on efficient freight movement. Manufacturers procure raw materials and intermediate goods, process them in the production operation, and ship their products to customers, all thanks to logistics activities. Companies rely on goods being hauled from their suppliers to their business establishments and from their establishments to their customers; they handle a myriad of paperwork that governs freight flows; they package, store, and ship their products as a key part of managing their supply chains. It is the transport and logistics industry that links all supply chain actors together.

COVID-19 caused extensive pandemic-related consumer purchases and supply chain disruptions, drawing public attention to supply chain issues. More recent global changes, such as the war in Ukraine, drought-induced

Highlights

- Thirty-eight percent of U.S. gross output in 2020, equivalent to $12.44 trillion, depended on the Nation's Transportation and Logistics sector, which itself contributed an output of $565 billion.
- After the COVID-19-year of 2020, U.S. trade surged to $4.6 trillion, a 22 percent increase from 2020 to 2021.
- In 2021, Canada reemerged as the United States' leading trade partner in terms of trade value, with Mexico and China ranked second and third, respectively.
- In 2020, over 17 billion tons of domestic freight worth $14.5 trillion moved through about $7 trillion of assets consisting of ports, highways, rail systems, airports, and pipelines.
- Trucks transported 12 billion tons in 2019, or 67 percent of total domestic freight volume — about 10 times more than that of rail, the United States' third-ranked mode by freight volume.
- In 2020, e-commerce's share of total retail sales increased to 14.6 percent from 10.5 percent in the previous year.
- In terms of freight value, John F. Kennedy International Airport and Chicago airports were ranked as the top two international freight gateways in 2020. Ranked 3rd and 4th were the U.S.-Mexico land border post in Laredo and the Port of Los Angeles.
- Improved U.S. East Coast connectivity to liner shipping networks have enabled the diversion of some Asian trade volumes from the U.S. West Coast to U.S. East Coast ports; in 2021 U.S. East Coast Asian container volumes exceeded U.S. West Coast Asian freight volumes.

Continued »

Highlights Continued

- Pipelines dominated U.S.-Canada trade in 2021, carrying about 37 percent of total freight weight. Carrying 35 percent of freight weight, trucking is the dominant mode in U.S.-Mexico trade. Vessels are the second mode of choice for U.S.-Mexico trade, carrying nearly 30 percent of freight weight.
- Substantial foreign direct investment in Mexico in 2022, particularly from the nearshoring of U.S. companies, will likely mean an increase in cross border trade flows, with trucking continuing its modal dominance. This will likely mean a shifting of freight flows from U.S. coastal ports to the U.S.-Mexico border.
- In 2019 and 2020, the container port average dwell time was 28.2 and 28.1 hours, respectively; this increased to an average of 32.1 hours in 2021 and to 35.5 hours for the first half of 2022, reflecting increasing congestion from COVID-induced demand.

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navigation constraints on the Ohio and Upper Mississippi River systems, and labor unrest in significant parts of the freight transportation system, have underscored the impact supply chains have on day-to-day life.

This chapter first describes U.S. production, referred to as gross output, and international trade as principal factors affecting transportation demand. Sectors that rely most on transportation and warehousing are identified and the value of their gross output provided, as is the gross output for the transportation and warehousing sector. The dominance of China, Mexico, and Canada among U.S. top 10 trading partners in terms of value is then described.

The chapter then addresses the characteristics of the U.S. freight transportation system that enables the movement of U.S. gross output between domestic origins and destinations as well as international trade. The chapter also explores domestic freight demand and highlights the dominance of trucking in the freight markets, including the top 10 domestic commodity markets. The distribution of gateway trade to other states is then addressed, using Texas and Michigan as examples, and notes the U.S. Asian trade supply chain shift from the U.S. West Coast to U.S. East Coast ports. Data on U.S. container port performance are presented, and the chapter concludes with the identification of data that, when made available, can be useful for planning and performance monitoring purposes.

Much of the data reported were based on the Freight Analysis Framework (Box 3-A), which integrates data from a variety of sources in downloadable formats and visualizations.

Low Water on the Mississippi Slows Critical Freight Flows

The Mississippi River provides a vital link for freight movement in the United States. In 2020, the river carried more than half of the 165.5 million tons of freight that moved between the 12 states touching the Upper

Mississippi System[1] and Louisiana (Figure 3-1). The percentage of freight carried by the river to Louisiana is notably higher for some states: 92 percent for Indiana, 81 percent for Missouri, 80 percent for Illinois, and 75 percent for Kentucky. Today, that flow of freight has been hampered by low water levels on the Lower River.

Agricultural Product Movement by Water

Of the 12 states, Illinois shipped the most freight to Louisiana in total (55 million tons) and by water (44 million tons) in 2020 (Figure 3-2). Cereal grain accounted for 43 percent of the total tonnage between Illinois and Louisiana, and other agricultural products accounted for 26 percent. The river carried 93 percent of the cereal grain between Illinois and Louisiana, compared to 6 percent by rail, and it carried 82 percent of "other agricultural products"[2] between those two states, compared to 15 percent by rail and 3 percent by truck.

Effect of Low River Levels

The ability to move freight on the Mississippi River is affected by extreme water levels, whether too much due to flooding or too little due to drought. Currently, low water levels in the Lower Mississippi River due to scant rainfall have severely hampered fall 2022 barge shipments, especially on the vital stretch between Cairo, IL, and Memphis, TN (Figure 3-2). Groundings and the need for dredging have closed sections of the river and halted barge movements for intermittent periods. U.S. Coast Guard District 8 (New Orleans) reported a backup of more than 2,000 barges on the Lower Mississippi in early October. Low water also restricts the loads each barge can carry, and the narrower channel restricts the number of barges in a single tow.

Rain from Hurricane Roselyn eased the problem slightly in late October, but long-term weather forecasts do not anticipate enough rain to restore full river operations for at least several months.

[1] These include Minnesota, Wisconsin, Iowa, Illinois, and Missouri along the Mississippi north of its confluence with the Ohio River; Kansas and Nebraska along the navigable portion of the Missouri River; and Indiana, Ohio, Kentucky, West Virginia, and Pennsylvania along the Ohio River.

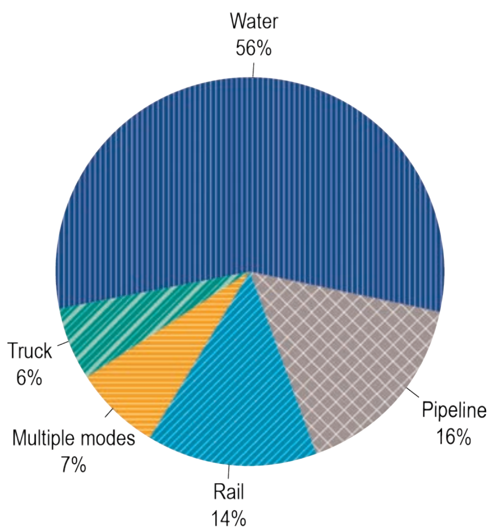
[2] The category of "other agricultural products" excludes cereal grains, live animals and seafood, milled grain, and foodstuffs.

Box 3-A Freight Analysis Framework

The Freight Analysis Framework (FAF), produced through a partnership between the Bureau of Transportation Statistics and the Federal Highway Administration, integrates data from a variety of sources to create a comprehensive picture of freight movement among states and major metropolitan areas by major commodity groups and by all modes of transportation. Primarily based on data from the Commodity Flow Survey (CFS), FAF incorporates data from international trade, agriculture, extraction, utility, construction, service, and other sectors.

FAF version 5 (FAF5) provides estimates for tonnage, value, and ton-miles by regions of origin and destination, commodity type, and mode. Data are available for the base year (currently 2017), the recent years (2018–2020), and forecast year estimates through 2050. Data may be accessed through the FAF Data Tabulation Tool.

Figure 3-1 Percent Tonnage by Mode Between States on the Upper Mississippi River System and Louisiana



NOTE: Percentages do not sum to 100 due to rounding.

SOURCE: FHWA/BTS Freight Analysis Framework version 5.4 at www.bts.gov/faf available as of December 2022.

Rail shipment is the normal alternative to barges, but the rail system can have difficulty absorbing such a massive short-term shift. Moreover, concerns over a possible rail strike in 2022 made shippers hesitant to rely on a rail option.

Critical Timing of Seasonal Products

Many major barge commodities, such as coal, chemicals, and petroleum, move at similar volumes year-round. Grain and other farm products, however, are seasonal. In 2022, downbound (southbound) grain shipments from the Upper Mississippi through Lock 27, the southernmost lock on the river, followed the 2021 pattern through October (Figure 3-3), but many of those shipments have stalled or been on the Lower River.

Unfortunately, disruptions to freight flow caused by low water have coincided with the peak shipping season for U.S. corn and soybeans, the Nation's largest export crops. The October downbound grain and agricultural product shipments on the Lower Mississippi below Lock and Dam 27 were predominately soybeans and corn, leaving those major export commodities most vulnerable to the Lower River disruption (Figure 3-4).

The implications of stalled shipments are apparent in barge shipping rates. By early September, barge rates were already at record highs. As Figure 3-5 shows, downbound grain rates on the Mississippi in October 2022 rose to more than double the 2021 peak and remained high in early November.

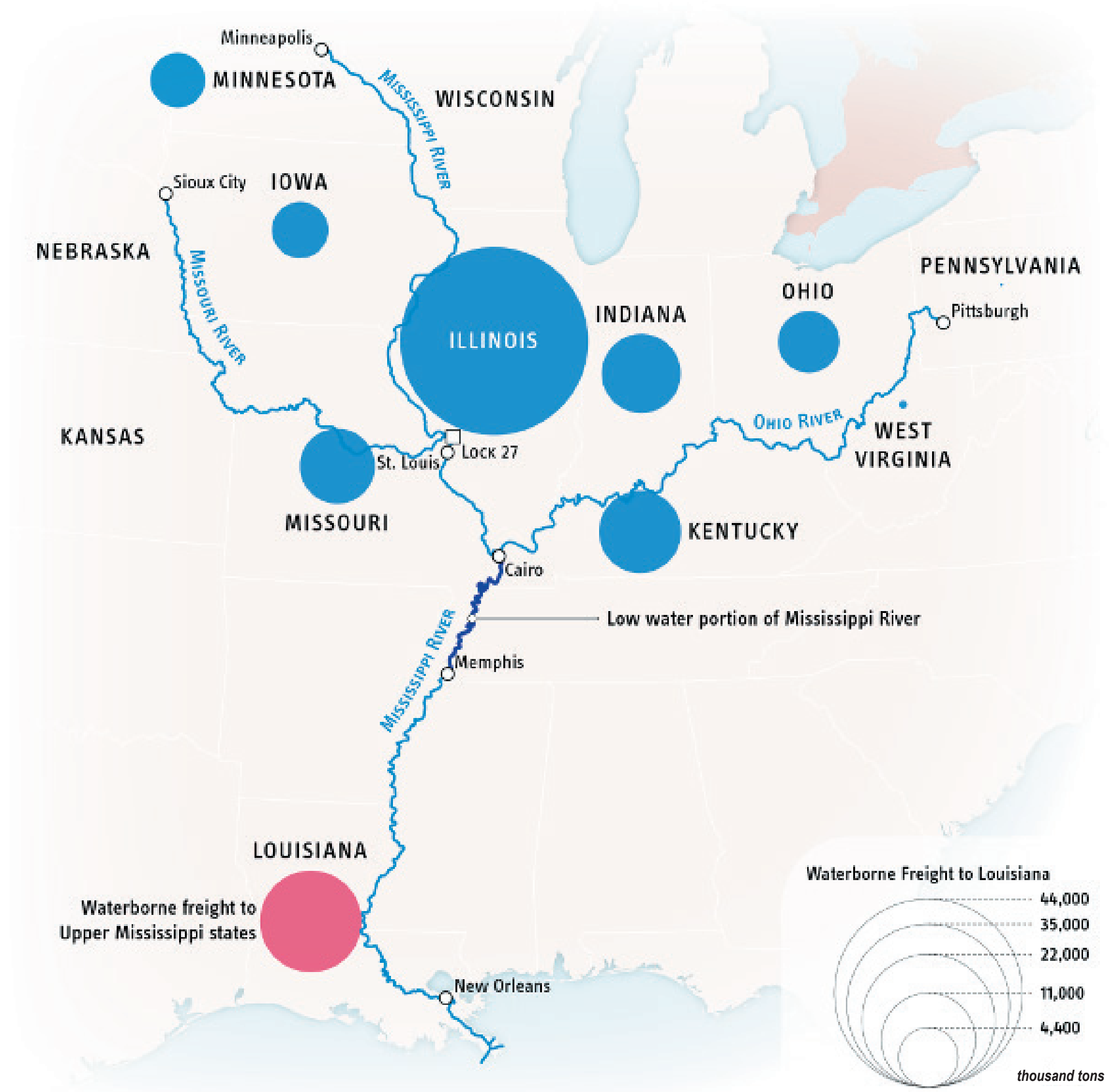
World Events and Freight Shipments

World demand and prices for grain have been rising due to Russia's invasion of Ukraine, drought in other producing areas, and increased consumption in China and elsewhere. Yet, despite the demand, U.S. grain and soybean exports are down due in part to the higher U.S. dollar and in part to the delivery delays caused by the compounded impact of low water and disruption to the supply chain. While domestic grain prices remain low, bid prices for U.S. export corn peaked in mid-October as the river delays were at their worst.

The Soy Transportation Coalition estimates that barge transportation accounts for about 6 percent of the delivered cost for soybeans shipped from Davenport, IA, to Shanghai, China. As Figure 3-5 indicates, October barge rates were as much as 400 percent above average, which would raise the delivered price of soybeans by about 24 percent, placing U.S. producers at a cost disadvantage compared to those in Brazil and other competitors.

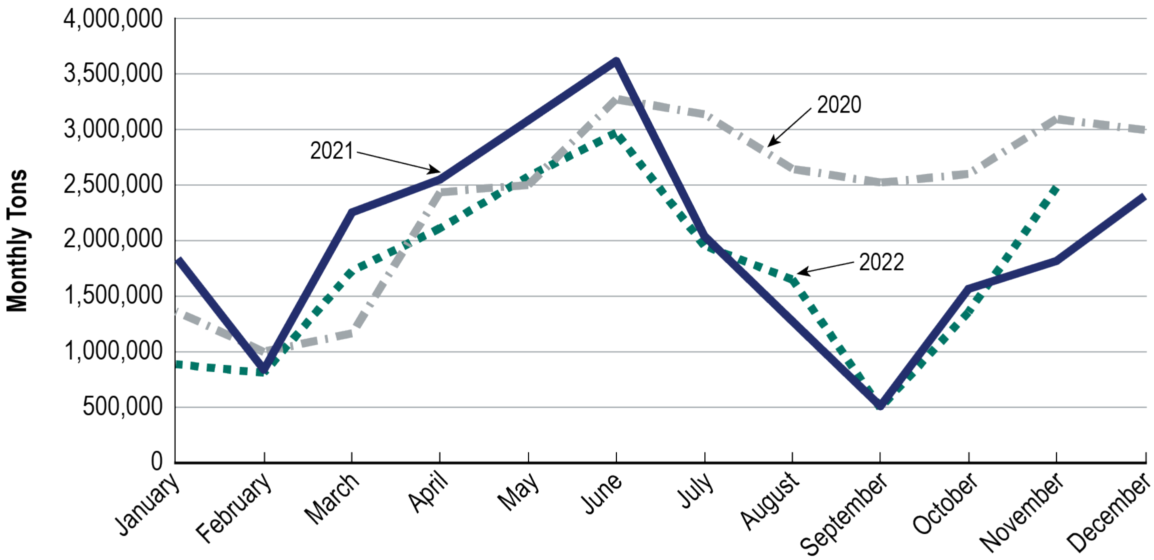
Grain is not the only commodity affected. The Waterways Council noted that the low water has also delayed coal shipments that are "very much

Figure 3-2 Waterborne Tonnage between States on the Upper Mississippi River System and Louisiana



SOURCES: FHWA/BTS Freight Analysis Framework version 5.4 at www.bts.gov/faf available as of December 2022.

Figure 3-3 Downbound Barge Grain Shipments



SOURCE: U.S. Department of Agriculture. Barge Dashboard at https://agtransport.usda.gov/stories/s/Barge-Dashboard/965a-yzgy/ available as of December 2022.

needed in Europe" due to the Russian invasion of Ukraine.

Besides delaying loaded downbound barge tows moving from producing areas to destination ports, such as Memphis, South Louisiana, and New Orleans, the low water also delays upbound tows moving fertilizer and cement for spring planting and construction, which also cuts the supply of empty barges for subsequent downbound trips.

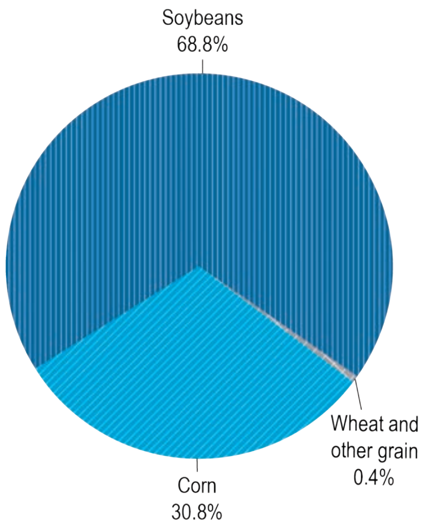
Factors That Affect Freight Transportation Demand

Domestic production and international trade are major drivers of freight transport demand. Production and trade growth affect the utilization of the Nation's highway, marine, and air freight transport systems and their ability to accommodate freight transport demand. U.S. gross domestic product (GDP) drives domestic and international freight transport demand through its influence on the scale of consumer demand and on the sectoral structure of the economy. U.S. economic sectors generate outputs given expected GDP growth, consumer demand, and markets for exports. Consumer demand has three elements: size, variety, and geographic concentration of consumers. The size and the variety of commodities consumers demand and the value of consumer purchases are major drivers of the number of freight shipments. The geographic concentration of consumers is an important driver of trip lengths, load factors, and mode choice.

U.S. Production of Goods and Services

U.S. manufacturing, mining, construction, agriculture, and wholesale and retail trade sectors are especially dependent on freight transport and logistics systems. In 2021, the economic activity on the goods and services produced by these sectors, referred to as gross output, had a value of $12.8 trillion (Table 3-1) [USDOC BEA 2022a]. The total gross output of these sectors shows a decline from 2019 to 2020, when the economy was most impacted by COVID-19, but construction, agriculture, and

Figure 3-4 October 2022 Downbound Grain and Agricultural Product Shares

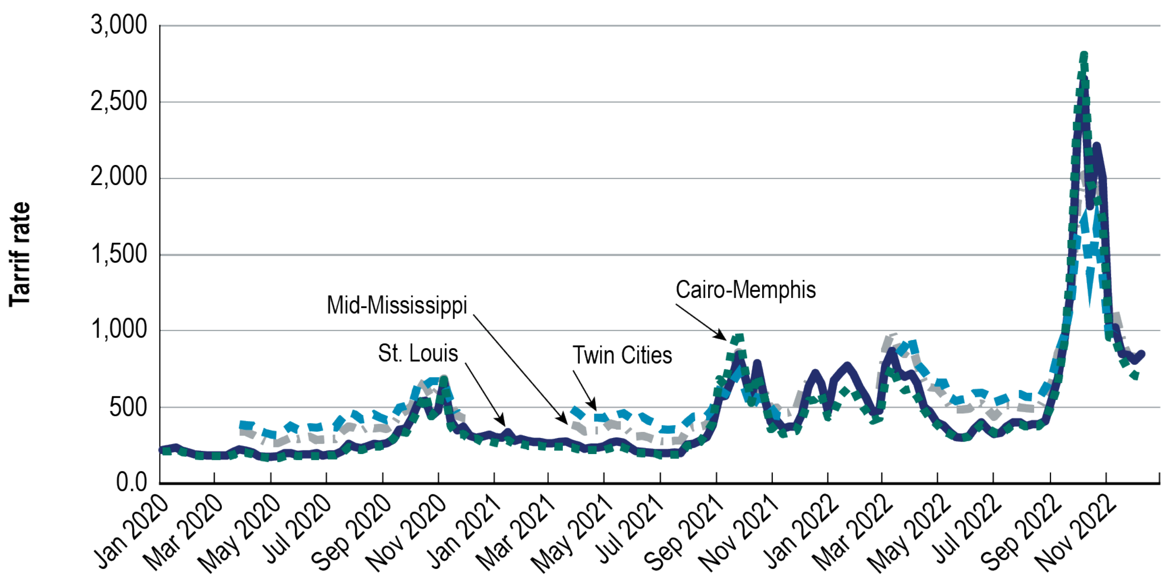


SOURCE: U.S. Department of Agriculture. Barge Dashboard https://agtransport.usda.gov/stories/s/Barge-Dashboard/965a-yzgy/ available as of December 2022.

retail trade increased their output from 2019 to 2020. Moreover, in 2021, the construction and retail trade sectors experienced their highest outputs during the 2016–2021 period. Transportation and Warehousing, which provides the freight services these sectors depend on, contributed an output of about $623.7 billion in 2021, its highest output during the 2016–2021 period.

Table 3-1 also shows that the output for freight services increases or decreases in accordance with the ebbs and flows of the output of these sectors. For each year demonstrating output growth for these sectors, Transportation and Warehousing output also grew. Transportation and Warehousing output's decline from 2019 to 2020 was in accord with the output decrease of the freight system-dependent sectors for the same year. As these sectors increase outputs, then there will be more truck, rail, maritime, and

Figure 3-5 Grain Barge Shipping Rates



SOURCE: U.S. Department of Agriculture. Barge Dashboard at https://agtransport.usda.gov/stories/s/Barge-Dashboard/965a-yzgy/ available as of December 2022.

Table 3-1 Gross Output of Freight System-Dependent Industry Sectors: 2016–2021 (Billions of 2012 Chained Dollars)

Industry sector	2016	2017	2018	2019	2020	2021
Total of sectors highly dependent on transportation and warehousing	**12,384.0**	**12,562.2**	**12,920.0**	**12,927.6**	**12,361.1**	**12,788.5**
Sectors highly dependent on transportation and warehousing						
Agriculture, forestry, fishing, and hunting	524.7	535.3	532.9	519.8	543.3	528.4
Mining	570.8	633.5	721.7	757.2	647.0	632.0
Utilities	490.0	481.6	505.0	500.7	487.4	498.3
Construction	1,355.9	1,378.2	1,387.6	1,401.6	1,426.9	1,440.5
Manufacturing	6,010.3	5,984.0	6,112.8	6,093.1	5,658.3	5,773.2
Wholesale trade	1,776.4	1,841.1	1,885.6	1,864.0	1,787.4	1,988.5
Retail trade	1,655.9	1,708.5	1,774.4	1,791.2	1,810.8	1,927.6
Transportation and warehousing	546.7	572.6	591.0	595.3	573.7	623.7

NOTES: Chain dollars adjusts for inflation over time allowing for equitable comparisons among dollar amounts. Transportation and Warehousing includes warehousing and stroage, water, truck, and pipeline transportation only; rail and air transportation are excluded due to a mix of freight and passenger output. Transit and ground transportation and other transportation and support activities are also excluded due to their focus on passenger transportation.

SOURCE: Bureau of Economic Analysis, Gross Output by Industry (billions of 2012 chain dollars), available at https://apps.bea.gov/iTable/iTable.cfm?reqid=150&step=2&isuri=1&categories=ugdpxind as of October 2022.

air transport services needed to deliver their products.

International Trade

As discussed later, the movement of international trade is accommodated through a system of trade gateways consisting of ports, airports, and land-border crossings. In 2021, imports and exports valued at $4.6 trillion moved through these gateways, representing about 25 percent of U.S. GDP [USDOC BEA 2022b]. The value for 2021 marks the highest annual U.S. trade value during the 2012–2021 period and experienced a relatively sharp rise from $3.8 trillion in 2020 (Figure 3-6).

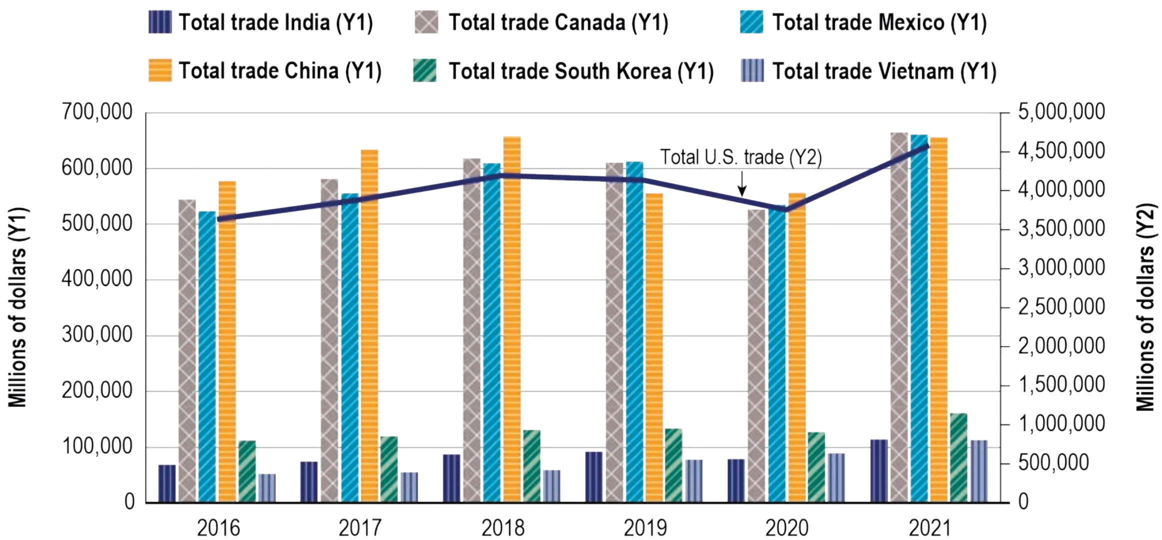
Canada for the first time emerged as the United States' largest trading partner in 2021 (Figure 3-6). U.S.-Canada trade was valued at nearly $666 billion in 2021. U.S. trades with Mexico and China were valued at $661 billion and $656 billion, respectively. Mexico's trade grew substantially during the 2016–2021 period, with both Mexico and Canada exceeding China in trade value in 2019 due to trade friction in 2018. Though China was the United States' leading trade partner in 2020 with the onrush of pandemic-related consumer purchases, Canada and Mexico reestablished their historic U.S. trade dominance in 2021, assuming the top 2 trading partner positions, with China moving to third in the top 10 trade partner list.

Both Mexico and Canada are likely to benefit from companies seeking to nearshore their production to reduce supply chain risk as well as to take advantage of the U.S.-Mexico-Canada trade agreement. As discussed later, Mexico has been the recipient of substantial foreign direct investment, which will have important implications for land border freight and U.S. port throughput volumes.

Total Freight Movement

In 2020, the U.S. freight transportation system moved more than 19 billion tons of freight worth

Figure 3-6 Trade Growth with Selected Top-Ten Trading Partners: 2016–2021 (Millions of Dollars).



SOURCE: Bureau of Census, U.S. Department of Commerce, "Top Trading Partners – December 2021", available at https://www.census.gov/foreign-trade/statistics/highlights/top/top2112yr.html, as of September 2022.

about $18.0 trillion (Table 3-2) through capital assets valued at about $7 trillion [USDOT BTS and FHWA 2022] consisting of ports, highways, rail systems, airports, and pipelines. Trucking by far was the most relied on freight transport mode; trucks transported 12.5 billion tons of freight valued at more than $13.1 trillion, about 65 percent and 73 percent of total freight weight and value, respectively. Trucking's freight volume was about 8.5 times higher than that of railed freight volume, the third-ranked freight mode. In 2020, pipelines transported 19.2 percent of total freight tons, moving 3.7 billion tons valued at close to $1 trillion. Except for two categories of modes, all the other modes experienced drops in freight weight from 2017 to 2020. Freight moved by air and air & truck increased in weight from 2017 to 2020. Only freight moved via pipeline showed an increase in both weight and value from 2017 to 2020.

Distance of Freight Movement and Modes of Transportation Used

A high percentage of freight in terms of both value and weight is moved over relatively short distances. In 2020, for example, freight moved by all modes below 100 miles represented about 30 percent of the total freight value and 35 percent of total weight (Figure 3-7), or $5.4 trillion and 6.8 billion tons. The proportion of the total value and weight increases to 56 and 74 percent, respectively, for shipment distances up to 249 miles, raising value and weight to $10.2 trillion and 14.2 billion tons.

Modal shares of freight vary considerably by distance. Trucks carry the largest shares by value,tons, and ton-miles of all goods shipped in the United States. As Figure 3-7 shows, trucking was the leading transport mode for all distances in 2020 by value, even for distances greater

Table 3-2 Freight Mode Weight and Value: 2017 and 2020

	Weight							
	2017				2020			
Millions of tons	**Total**	**Domestic**	**Exports[1]**	**Imports[1]**	**Total**	**Domestic**	**Exports[1]**	**Imports[1]**
TOTAL	**19,578**	**17,478**	**1,115**	**985**	**19,211**	**17,015**	**1,228**	**969**
Truck	12,805	11,848	513	443	12,520	11,558	492	471
Rail	1,610	1,202	243	165	1,459	1,034	258	167
Water	915	662	160	93	784	601	130	52
Air, air and truck	6	2	2	2	8	2	3	3
Multiple modes and mail	688	536	89	63	645	512	75	58
Pipeline	3,451	3,133	100	218	3,716	3,232	267	217
Other and unknown	102	94	8	1	79	75	3	1

	Value							
	2017				2020			
Billions of 2017 dollars	**Total**	**Domestic**	**Exports[1]**	**Imports[1]**	**Total**	**Domestic**	**Exports[1]**	**Imports[1]**
TOTAL	**18,839**	**15,082**	**1,555**	**2,203**	**18,024**	**14,463**	**1,413**	**2,148**
Truck	13,690	11,297	960	1,433	13,148	10,829	853	1,466
Rail	553	227	126	201	537	213	127	197
Water	293	184	55	53	242	166	43	34
Air, air and truck	654	159	246	249	599	140	226	232
Multiple modes and mail	2,658	2,362	108	188	2,489	2,262	70	157
Pipeline	946	851	29	66	998	851	86	61
Other and unknown	45	2	31	12	12	2	8	3

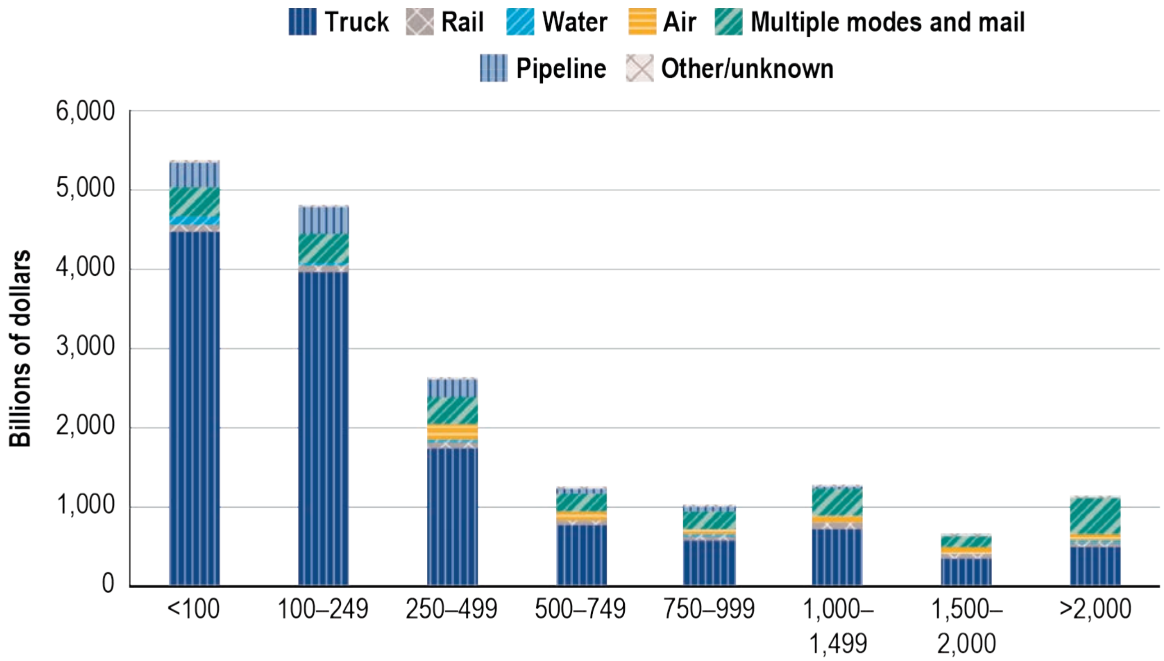
[1] Data do not include imports and exports that pass through the United States from a foreign origin to a foreign destination by any mode.

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

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.4, September 2022.

Figure 3-7 Domestic Shipment Value and Weight by Mode and Distance Bands: 2020

A. Total Value by Distance Band: 2020



B. Mode Share of Value by Distance Band: 2020

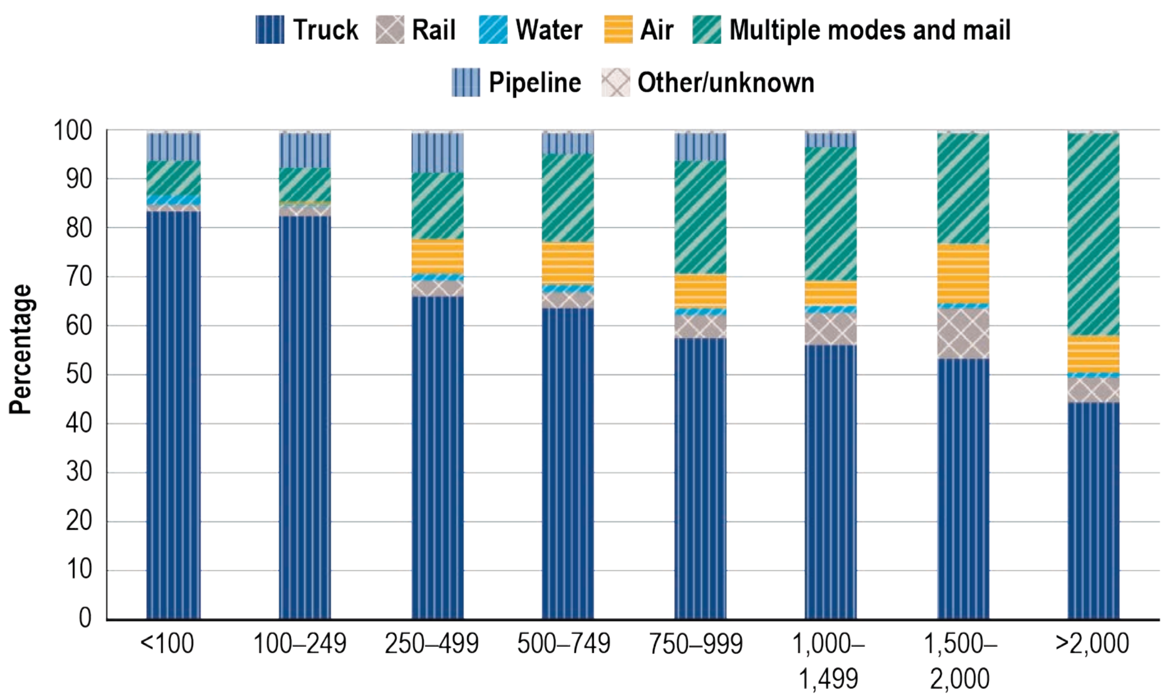
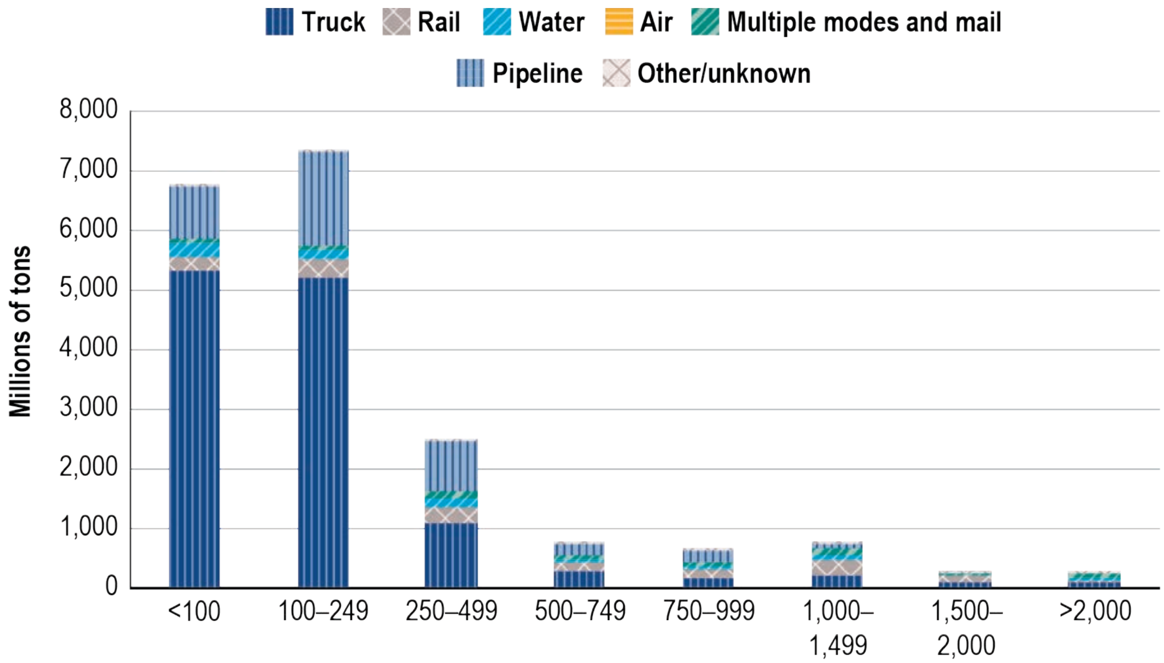


FIGURE 3-7 Continued

C. Total Tonnage by Distance Band: 2020



D. Mode Share of Tonnage by Distance Band: 2020

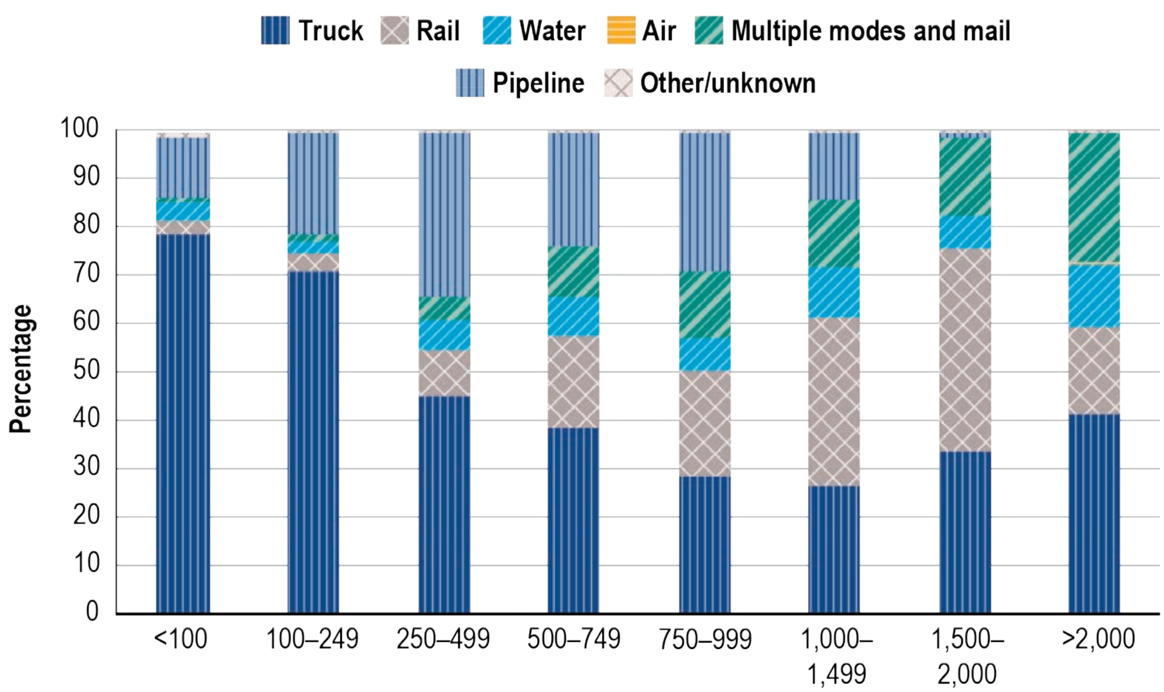
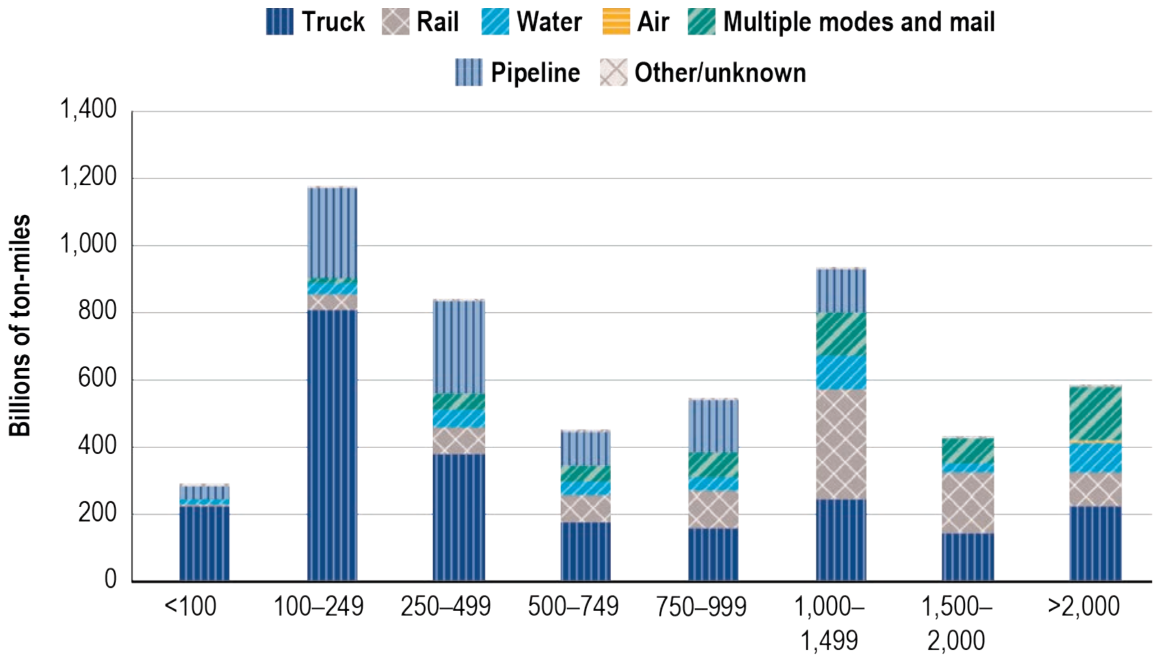
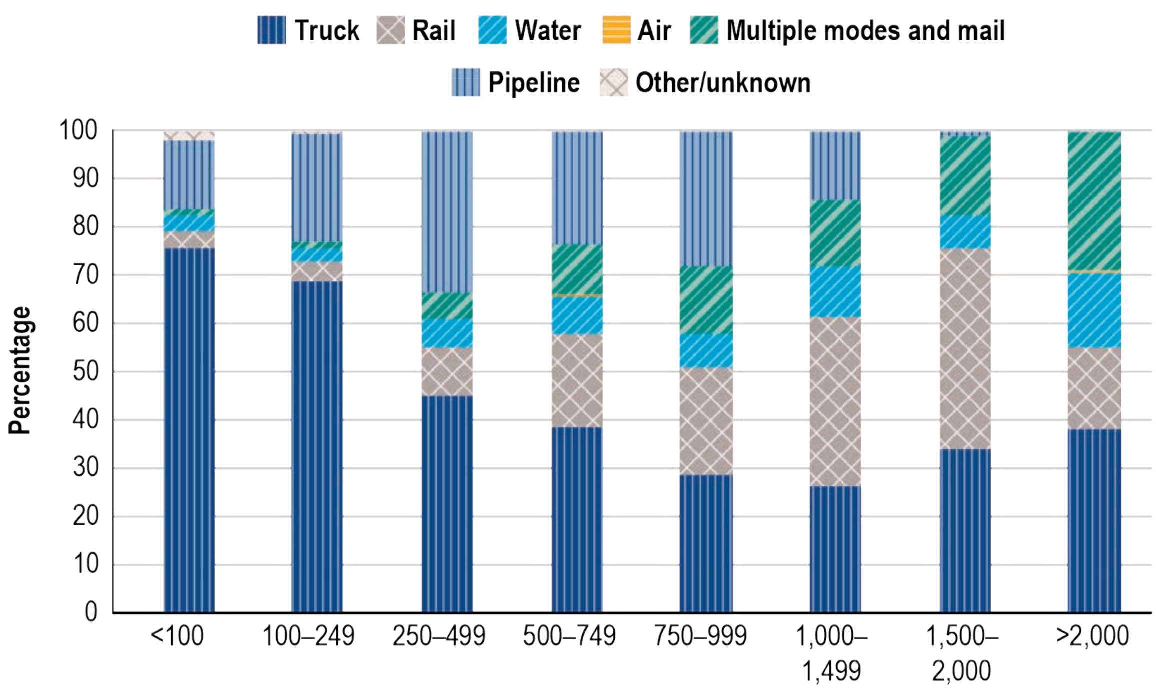


FIGURE 3-7 Continued

E. Total Ton-Miles by Distance Band: 2020



F. Mode Share of Ton-Miles by Distance Band: 2020



Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.5, October 2022.

than 2,000 miles. In terms of tons, trucking was the preferred mode to destinations from below 100 miles and up to 749 miles. Rail leads in tonnage and ton-miles for goods shipped from 1,000 to 2,000 miles with heavy commodities. Air and multiple modes accounted for more than half of the value of high-value shipments moving over 2,000 miles.

Top 10 Commodities

Table 3-3 and Figure 3-8 present the top 10 domestic commodities by weight and mode, and by value and mode, respectively, in 2020. With nearly 13 million tons, the top 10 commodities together represent 66.7 percent of all domestic commodities by weight (Table 3-3). Most of the commodities may be characterized as bulk freight (note the absence of manufactured goods) and all of the commodities are transported by multiple modes, including in some cases nominal amounts by air. Bulk commodities shipped by air are likely relatively higher value specialty products that are transported in breakbulk form (e.g., sacks and barrels on pallets in air freight). The greatest single commodity by weight is coal and petroleum products-n.e.c. ("not elsewhere classified"), where pipelines convey nearly 2.3 billion tons (79 percent) of the total of about 2.9 billion tons for that commodity. Gravel, cereal grains, and non-metallic mineral products, the second-, third-, and fourth-ranked commodities by weight, are largely moved by truck.

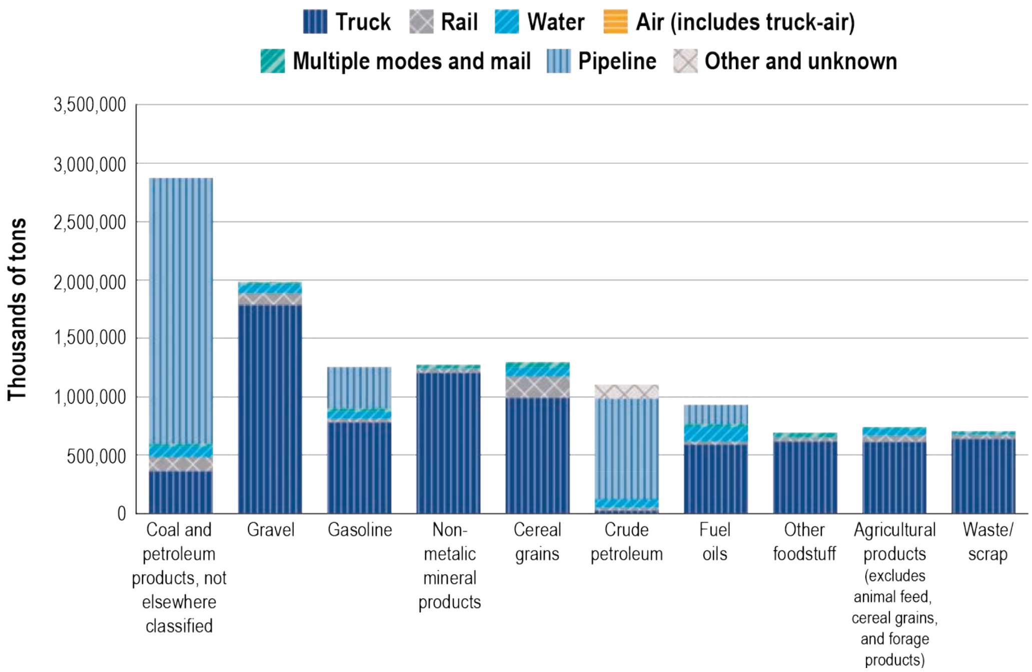
The top 10 commodities by value represent about 70 percent of the total value of all commodities. The top 10 by value list is in stark contrast with the top 10 by weight list, as manufactured goods predominate the top 10 commodities by value (Table 3-3). Trucks carry $7.7 billion of freight, or 71 percent of the total top 10 freight value of about $10.8 billion. The "Multiple modes and mail" category carries 15.7 percent of the total value of the top 10 commodities (Figure 3-9).

Table 3-3 Top 10 Commodities by Weight and Value: 2020

Commodities by Weight	Thousands of tons	Commodities by Value	Billions of 2020 dollars
Coal and petroleum products, not elsewhere classified	2,878,389	Electronics	1,723,397
Gravel	1,988,558	Mixed freight	1,533,025
Gasoline	1,258,338	Motorized vehicles	1,377,615
Non-metallic mineral products	1,276,869	Pharmaceuticals	1,218,496
Cereal grains	1,299,820	Machinery	1,105,044
Crude petroleum	1,106,424	Miscellaneous manufactured products	868,119
Fuel oils	935,526	Plastics/rubber	825,823
Other foodstuffs	693,902	Other foodstuffs	718,350
Agricultural products (excludes animal feed, cereal grains, and forage products)	741,036	Coal and petroleum products, not elsewhere classified	692,807
Waste/scrap	708,158	Gasoline	669,841
Top 10 Total	**12,887,021**	**Top 10 Total**	**10,732,517**
Total of all Commodities	**19,331,315**	**Total of all Commodities**	**18,062,704**
Top 10 Share of Total	**66.7%**	**Top 10 Share of Total**	**59.4%**

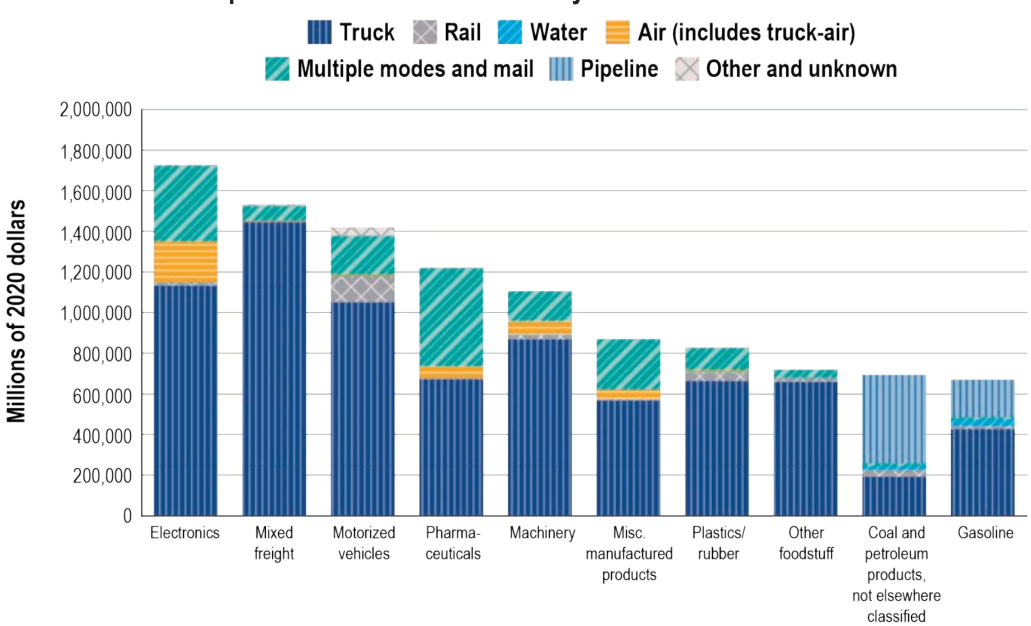
SOURCE: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics, and USDOT, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 5.4, October 2022.

Figure 3-8 Tonnage of Top 10 Domestic Commodities by Mode: 2020



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.4, October 2022.

Figure 3-9 Value of Top 10 Domestic Commodities by Mode: 2020



NOTE: "Other foodstuffs" and "Other agricultural products" do not include foodstuff and agricultural categories too small to make this top-ten list.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.4, October 2022.

International Freight

International freight, valued at $3,561 billion in 2020 (Table 3-2), holds a relatively small share of total U.S. freight value of $18 trillion in the same year, but the small share is a misleading indicator of its importance. Because international freight is handled in the Nation's maritime ports, land borders, and airports, there is a high concentration of logistics activities in these areas. This is especially true for the maritime ports of Los Angeles and Long Beach, both of which are physically located in the same metropolitan area.

Table 3-4 shows total U.S.-International freight by geography and mode. Vessels transported $1,045,619 million (58.3 percent) between the United States and Asia, whereas air transported $671,964 million (37.5 percent). More comparable dollar amounts were transported by vessel and air (42.7 vs. 50.5 percent) between the United States and Europe.

Table 3-5 presents the United States' top 25 gateways out of 328 international points of entry in the United States [U.S. Customs and Border Protection 2022]. The number one- and number two-ranked gateways relative to the value of imported and exported freight are airports, while the Laredo-Texas land border holds the number three position. Maritime gateways overall accounted for 40 percent of all gateways freight value, compared to 38 and 22 percent for airports and land border posts, respectively.

Figure 3-10 shows the value of the Nation's top 25 gateways in 2020, 19 of them handling more imports than exports. As the number one gateway, John F. Kennedy International Airport, NY, handled freight exports and imports valued at $215.5 billion, about $1 billion more than Chicago, IL. Laredo, TX, as the number one land border gateway, handled freight valued at $201.4 billion, while the number one maritime gateway, the Port of Los Angeles, handled export and import freight valued at $196.9 billion. The Port of Los Angeles was also the number one out of the top 25 import gateways, handling imports valued at $169.1 billion, about $7.5 billion ahead of the Chicago gateway. Laredo was United States' number one export gateway, with an export value of about $80 billion, followed closely by John F. Kennedy International Airport at about $79 billion.

U.S. North American Freight

Canada and Mexico, as U.S. border countries and the number one and two U.S. trade partners in 2021 (Figure 3-6), respectively, rely heavily on trucking, pipeline, and rail modes (Figure 3-11). In 2021, U.S.-Canada freight flow totaled $664.2 billion, an increase of 26.4 percent from $525.5 billion in 2020. On the southern border, U.S.-Mexico freight flow totaled $661.2 billion in 2021, an increase of 22.9 percent from $538.1 billion in 2020.

Because of the heavy reliance on pipeline to move crude oil, natural gas, and refined petroleum products, pipelines dominated U.S.-Canada trade, carrying 37 percent of freight weight in 2021—15 percent greater than each of the 22 percent shares carried by truck and rail (Figure 3-11). U.S.-Mexican trade tells a different story for 2021, with trucking dominating trade at 34 percent, followed by the 30 percent share of trade carried aboard vessels. Rail's market share of about one-fifth of total trade is similar for both countries. The air mode carries a relatively negligible share of the weight of both trades.

Laredo, TX, and Detroit, MI, were the third and eighth largest U.S. gateways in terms of freight value in 2020 (Figure 3-10), with trucks representing 22 and 36 percent of total freight trade in Canada and Mexico, respectively. In 2020, Texas's border crossings alone had about 4.4 million inbound trucks and nearly 9.2 thousand inbound trains. In contrast, Michigan had about half as many inbound

Table 3-4 Value of U.S.-International Freight Flows by Geography and Transportation Mode: 2021 (Millions of Dollars)

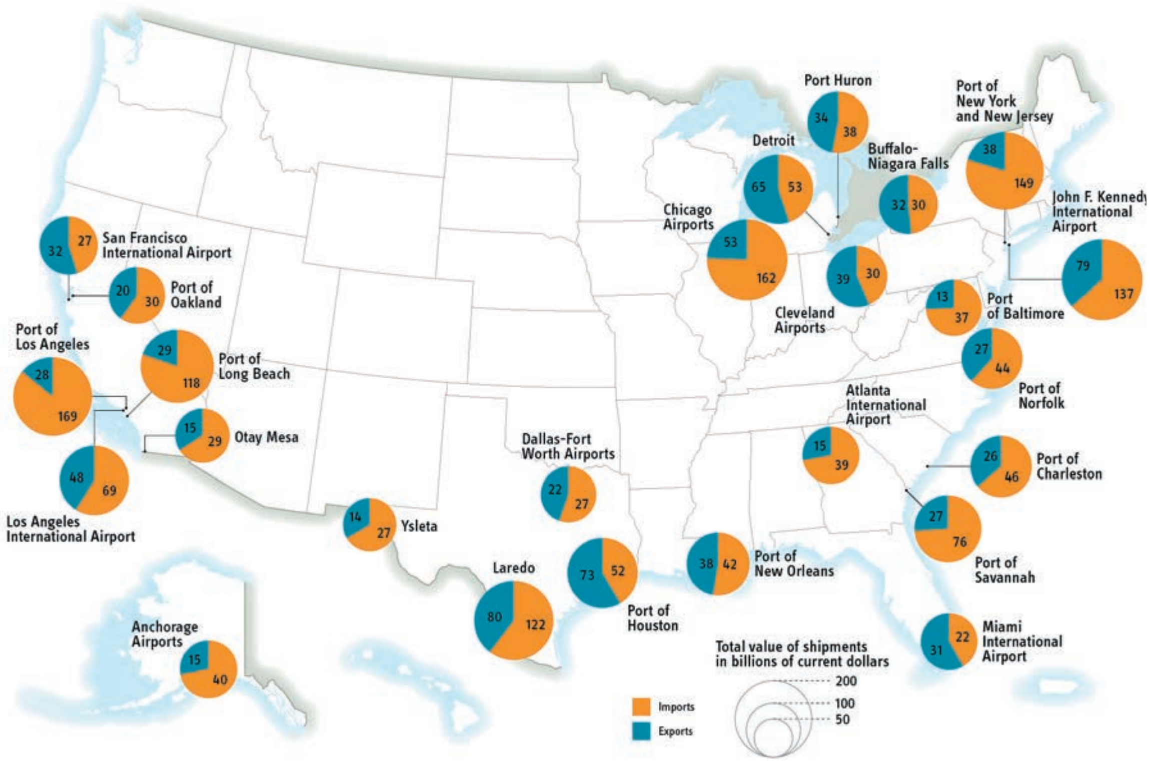
	Mode						
Geography	**Truck**	**Rail**	**Pipeline**	**Air**	**Vessel**	**Other**	**TOTAL**
Canada	367,039	102,241	86,192	34,941	30,584	44,549	665,546
Mexico	460,850	84,217	12,026	17,921	66,887	19,239	661,140
Asia	NA	NA	NA	671,964	1,045,619	76,694	1,794,277
Europe	NA	NA	NA	532,754	450,396	72,124	1,055,274
Other	NA	NA	NA	98,591	292,312	18,216	409,119

KEY: NA = not applicable.

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

SOURCE: Truck, Rail, and Pipeline: U.S. Department of Transportation, Bureau of Transportation Statistics, TransBorder Freight Data, available at www.bts.gov/transborder; **Air, Vessel, and Other:** U.S. Department of Commerce, Census Bureau, *USA Trade Online*, https://usatrade.census.gov/ as of August 2022.

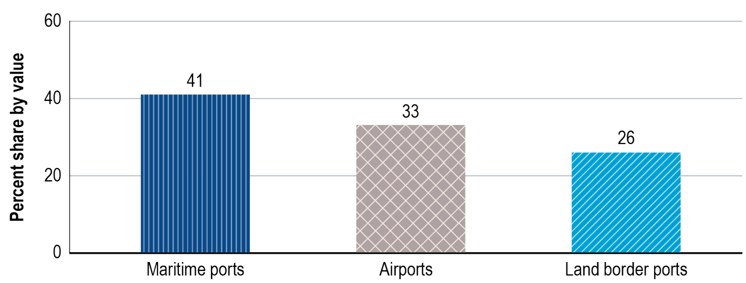
Figure 3-10 Top 25 U.S. International Freight Gateways by Freight Value: 2020



SOURCES: Air: U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, USA Trade Online, available at https://ustrade.census.gov as of January 7, 2022. **Land:** U.S. Department of Transportation, Bureau of Transportation Statistics, North American Transborder Freight Data, available at https://www.bts.gov/transborder as of March 7, 2022. **Water:** U.S. Army Corps of Engineers, Navigation Data Center, personal communication, special tabulation, November 12, 2020, and November 2, 2021.

Table 3-5 International Freight Gateways and Their 2020 Rankings by Value (Billions of Dollars)

Maritime Ports	Gateway Rank	Airports	Gateway Rank	Land Border Ports	Gateway Rank
Los Angeles, CA	4	John F. Kennedy International Airport, NY	1	Laredo - Texas	3
New York, NY	5	Chicago, IL (Port)	2	Detroit - Michigan	8
Long Beach, CA	6	Los Angeles International Airport, CA (Port)	9	Port Huron - Michigan	13
Houston, TX	7	New Orleans, LA (Port)	11	Buffalo-Niagara Falls - New York	16
Savannah, GA	10	Cleveland, OH (Port)	15	Otay Mesa - California	24
Charleston, SC	12	San Francisco International Airport, CA (Port)	17	Ysleta Port of Entry	25
Norfolk, VA	14	Anchorage, AK (Port)	18	Hidalgo - Texas	29
Oakland, CA	21	Atlanta, GA (Port)	19	El Paso - Texas	30
Baltimore, MD	22	Miami International Airport, FL (Port)	20	Eagle Pass - Texas	32
Tacoma, WA	26	Dallas-Fort Worth, TX (Port)	23	Santa Teresa - New Mexico	33
Corpus Christi, TX	28	Newark, NJ (Port)	27	Pembina - North Dakota	35
New Orleans, LA	31	Seattle-Tacoma International Airport, WA (Port)	48	New Orleans Customs District n.e.c.	37
Seattle, WA	34			Nogales - Arizona	38
Miami, FL	36			Champlain-Rouses Point - New York	40
Jacksonville, FL	39			Blaine - Washington	41
Brunswick, GA	42			Chicago Customs District n.e.c.	45
Port Everglades, FL	43			Brownsville - Texas	49
Philadelphia, PA	44			Calexico-East - California	50
Mobile, AL	46				
Gramercy, LA	47				
TOTAL value (billions of dollars)	**$1,263.2**		**$1,017.2**		**$807.1**
Share of the Top-50 TOTAL	**41%**		**33%**		**26%**

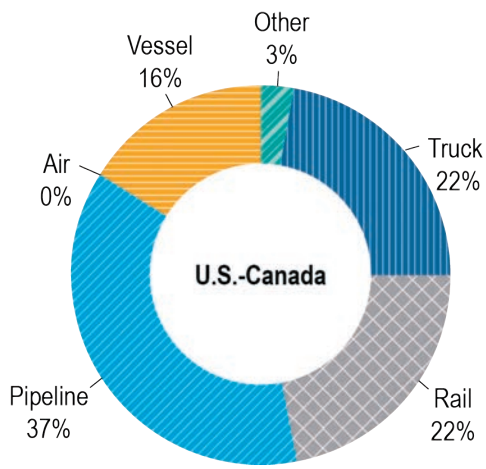


NOTES: All data: Trade levels reflect the mode of transportation as a shipment enters or exits at a border port. Flows through individual ports are based on reported data collected from U.S. trade documents. Trade does not include low-value shipments. (In general, these are imports valued at less than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

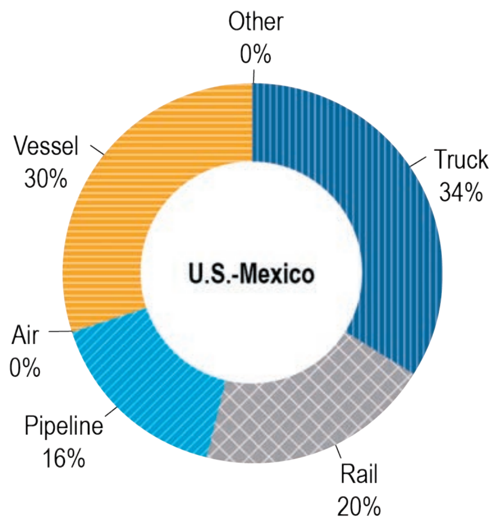
SOURCE: Airports: U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, USA Trade Online, available at https://usatrade.census.gov as of Jan. 7, 2022. **Land Border Posts:** U.S. Department of Transportation, Bureau of Transportation Statistics, North American Transborder Freight Data, available at https://www.bts.gov/transborder as of Mar. 7, 2022. **Maritime:** U.S. Army Corps of Engineers, Navigation Data Center, personal communication, special tabulation, Nov. 12, 2020, and Nov. 2, 2021.

Figure 3-11 Modal Shares of U.S. Trade with Canada and Mexico: 2021

A. Modal Shares in U.S.-Canada Trade in Tons, 2021; Tons = 573.7 Million



B. Modal Shares in U.S.-Mexico Trade in Tons, 2021; Tons = 400.3 Million



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, TransBorder Freight Data, available at www.bts.gov/transborder as of May 2022.

trucks as Mexico did (about 2.1 million) and a little more than half as many inbound trains with 4.9 thousand [USDOT BTS 2022a].

Inbound trucks and trains crossing the Texas border in 2020 moved about 37 billion and 14 billion tons, respectively. Eight states—Texas, California, Georgia, Illinois, Kentucky, Michigan, New Jersey, and Ohio—accounted for 79 percent of all freight moved. Forty-one percent of the freight volume crossing the Texas-Mexico border remained for distribution in Texas, while 38 percent was distributed to the other seven states [FAF, USDOT BTS and FHWA 2022]. In 2020, about 22.7 million and 15.9 million tons were moved on inbound trucks and trains, respectively, across the Michigan border. In addition to Michigan, this freight was destined to eight other states: Ohio, Indiana, Texas, Wisconsin, California, Kentucky, Georgia, and Tennessee [FAF, USDOT BTS and FHWA 2022]. Illinois is the largest inbound freight recipient among these nine states, with trucking the leading mode choice.

Shifts in Containerized Freight

A review of Middle Eastern and Asian countries[3] containerized imports and exports indicates a supply chain shift from the U.S. West Coast ports to the U.S. East Coast ports during the period 2011–2021. Improvements to the Panama and Suez Canals, along with advances in the capability of U.S. East Coast ports to accommodate larger vessels, increased the options liner carriers[4] have for freight delivery. With these improvements, U.S. East Coast ports have benefited from greater connectivity to liner shipping networks.

[3] The U.S. Census Bureau includes the following countries as part of Asia: Asia Near East includes Bahrain, Gaza Strip, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, West Bank Administered by Israel, and Yemen; Asia-South includes Afghanistan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka; Asia-Other includes Bhutan, Brunei, Burma, Cambodia, China, Hong Kong, Indonesia, Japan, Korea-North, Korea-South, Laos, Macau, Malaysia, Maldives, Mongolia, Philippines, Singapore, Syria, Taiwan, Thailand, Timor-Leste, and Vietnam.

[4] A liner carrier is a service that operates on a schedule with a fixed port rotation and published dates at the advertised ports

Figure 3-12 shows that U.S. West Coast ports have historically served as the gateway for imported containerized Asian cargoes, despite the larger U.S. East Coast populations. However, the U.S. East Coast has shown continuous growth of Asian import trades over the past 10 years, approaching a near-even split in 2021, with U.S. East Coast port import throughput of 62 million metric tons versus the West Coast ports' 64.3 million tons. When U.S.-China trade frictions materialized in 2018, the U.S. West Coast ports showed a precipitous decline (8.6 percent) in Asian imports, with growth stalled in U.S. East Coast ports in 2018 and a decline in 2019–2020 of 1.1 percent.

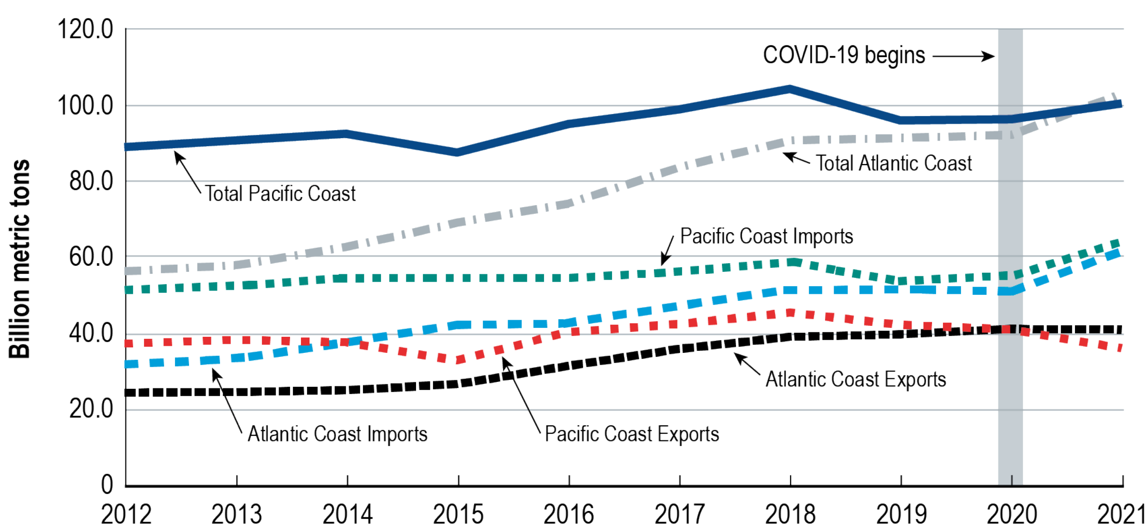
Figure 3-12 also reflects the pandemic-related surge of Asian imports from 2020–2021, with the U.S. East Coast ports showing 21.4 percent growth versus the West Coast ports' growth of 16.2 percent. U.S. East Coast average annual growth rates, referred to as CAGR,[5] over the period 2011–2021 are higher at 7.4 percent than the West Coast's average annual growth rate of 3.5 percent.

U.S.-Asia export performance on the U.S. West Coast also shows a significant loss of Asian export market share to the U.S. East Coast ports, as Figure 3-12 shows. Overall, the average annual growth rate in U.S. East Coast exports with Asia for the years 2011–2021 was 5.1 percent, compared with a 0.6 percent decline for the West Coast ports. Interestingly, the West Coast port containerized volumes have declined continuously since 2018 when U.S.-China trade friction began. While both U.S. East Coast and West Coast ports experienced declines since COVID-19 in 2020, the U.S. West Coast ports experienced an 11.7 percent drop in Asian exports, while the U.S. East Coast ports had a negligible decline of 0.2 percent.

With the U.S. East Coast port growth in U.S. containerized export volumes and near-equilibrium market share between U.S. West Coast and East Coast ports for imports, it is

[5] CAGR is the Compound Annual Growth Rate, which is the average annual growth rate over a period longer than one year; here, we determine the CAGR for the period 2011–2021

Figure 3-12 U.S. East Coast and West Coast Asian Containerized Freight Volumes: 2012–2021



SOURCES: U.S. Department of Commerce, Census Bureau, Economic Indicators Division, available at http://usatrade.census.gov as of September 2022.

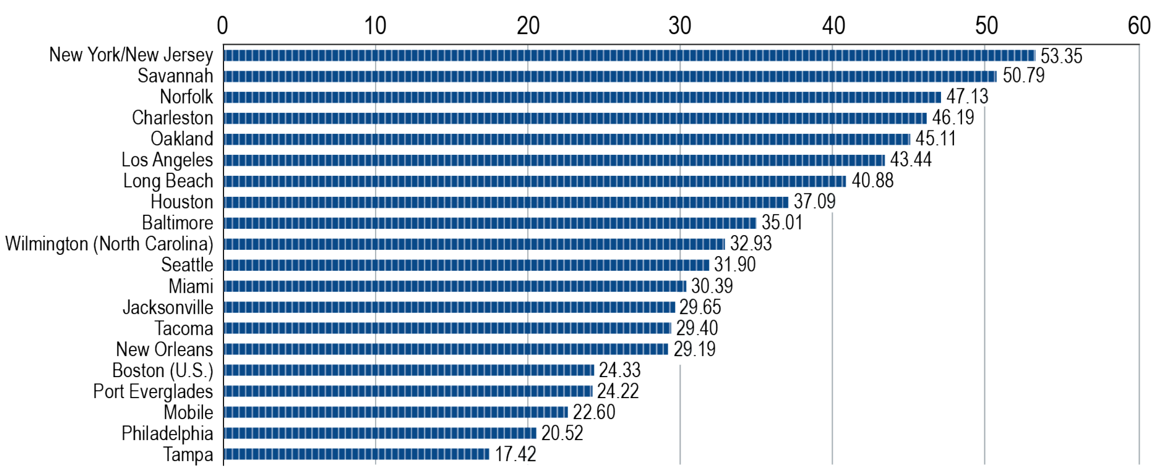
not surprising that U.S. East Coast ports have overtaken the U.S. West Coast ports as the containerized cargo gateway for Asian trades. Combining both containerized imports and exports, the U.S. East Coast ports for the first time surpassed West Coast port container freight weight in 2021 (Figure 3-12), handling nearly three million tons more than West Coast ports. The 2011–2021 CAGR of the total Asian containerized freight volume for U.S. East Coast ports was 6.4 percent versus 1.2 percent for West Coast ports.

The United Nations Conference on Trade and Development created the Liner Shipping Connectivity Index (LSCI) in 2004 as a measure of how well countries and ports are connected to the global shipping network.[6] Figure 3-13 presents the top 20 LSCIs for U.S. ports. The U.S. East Coast Port's success in capturing greater Asian market share is enabled in part by the ports' ability to connect with global shipping networks; ports with a high degree of network connectivity allows them to offer a wider range of shipping options than ports with lower connectivity.

The U.S. East Coast port of New York/New Jersey, Savannah, Norfolk, and Charleston are ranked as the top four most connected ports, with five other U.S. East Coast ports among the top 20. Oakland, Los Angeles, and Long Beach rank fifth, sixth, and seventh, respectively, with only one other U.S. West Coast port finding itself in the top 20. This largely explains the supply chain shifts from the U.S. West Coast to the U.S. East Coast as U.S. East Coast ports expanded their capacity and capabilities. Importantly, U.S. Gulf Coast ports also invested in port improvements; the ports of Tampa, New Orleans, and Houston also appear in the U.S. top 20 most-connected ports.

[6] UNCTAD's connectivity indexes are published quarterly available at https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=170026, and https://unctad.org/system/files/official-document/rmt2017_en.pdf as of 18 October 2022.

Figure 3-13 U.S. Top 20 Container Port Liner Shipping Connectivity Index: 2021



SOURCES: United Nations Conference on Trade and Development, Liner Shipping Connectivity Index, 2021, available at https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=92 as of October 2022.

Shortening Supply Chains: Nearshoring, Reshoring, and Foreign Direct Investment[7]

Nearshoring, reshoring, and foreign direct investment (FDI) have important implications for trade flows and hence the facilities used to accommodate these flows. A U.S. plant nearshoring to a country on the Nation's borders, for example, means a likely shift of its supply chain from U.S. coastal ports to land border crossings, which are largely shipped by truck. Production and labor costs, tax policy and incentives, and the state of trade relationships, among other factors, can affect factory location decisions, where countries source their imports, and how they route their exports.

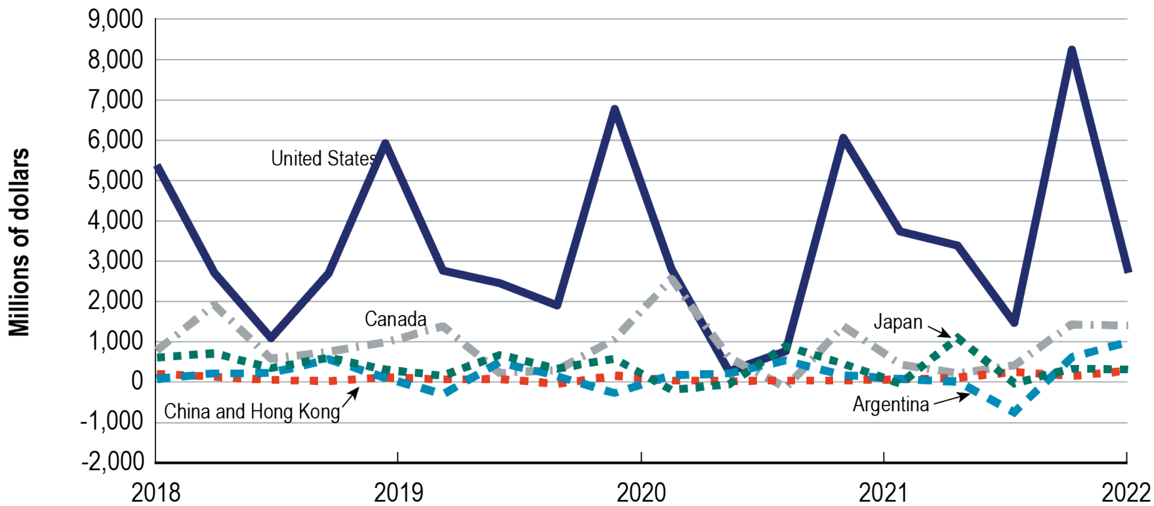
U.S.-China trade friction in 2018 caused some U.S. and Chinese manufacturers in China to relocate production capacity to other countries around them [Rapoza 2020 and WSJ 2019]. The recent supply chain constraints can also encourage U.S. companies to bring production closer to home, where shorter supply chains can be more readily managed for risk. Some companies, under the rubric of the United States-Mexico-Canada trade agreement (USMCA), have relocated production capacity to Mexico, where hard (e.g., rail and road accesses) and soft (e.g., trade and regulatory frameworks) have been long-established.

There are also indications that U.S. companies are reshoring some production capacity and that foreign direct investments (FDI) are being made in new plant operations, though the former is not necessarily a recent phenomenon. For example, the National Institute of Standards and Technology estimates that one million jobs were reshored to the United State during the period 2010–2020 [NIST 2022], with recent data indicating the addition of more than 600,000 jobs since 2020 [Reshoring Initiative 2022]. Largely encouraged by the new U.S. CHIPS and Science Act, U.S. semiconductor manufacturers Intel, GlobalFoundries, and Micron have announced plans to reshore fabrication plants in the United States [Moser 2022]. For FDI in 2021, foreign companies invested more than $333 billion in acquiring, establishing, or expanding U.S. businesses, an increase from $141 billion from COVID year 2020, with $121 billion of the 2021 amount invested in manufacturing [USDOC BEA 2021]. The recent decision by a major textile goods supplier to relocate some of its production capacity to California from Jordan exemplifies the FDI trend in the United States [Sousa 2022].

FDI in a country at the Nation's borders can also induce a shift in supply chains. Mexico, for example, has received $11.5 billion from its top 5 FDI countries in the first quarter of 2022 alone, as shown in Figure 3-14, which also presents the quarterly FDI flows to Mexico for the top 5 countries during the period 2018 through the first two quarters of 2022. FDI flows from the United States are far and above the investments made by the other four countries—exceeding their combined investments. An upward trend in U.S. FDI can be observed around the timeframe of the USMCA's signing and implementation in 2020. A sharp decline is also observed in the third quarter of 2020 with the advent of COVID-19, with another surge observed in 2022 as U.S. manufacturers sought to shorten their supply chains; the U.S. investments reported for the first two quarters in 2022 have already surpassed the U.S. companies' entire 2020 investments. Note that the other four countries, though showing a far lower scale of FDI, will also benefit from proximity to U.S. markets under USMCA's rubric. This will largely impact truck flows in U.S.-Mexican cross-border trades given its predominance over other modes.

[7] Foreign direct investment occurs when a foreign company invests in another country for purposes of acquiring, establishing, or expanding business activity.

Figure 3-14 **Foreign Direct Investment in Mexico by Top-5 Countries, 2016 Through Second Quarter of 2022**



SOURCES: Gobierno de México, "Información Estadística de la Inversión Extranjera Directa", Información estadística general de flujos de IED hacia México desde 1999, available at https://www.datos.gob.mx/busca/dataset/informacion-estadistica-de-la-inversion-extranjera-directa as of 26 September 2022.

Changing Freight Distribution Practices and the Impact of e-Commerce

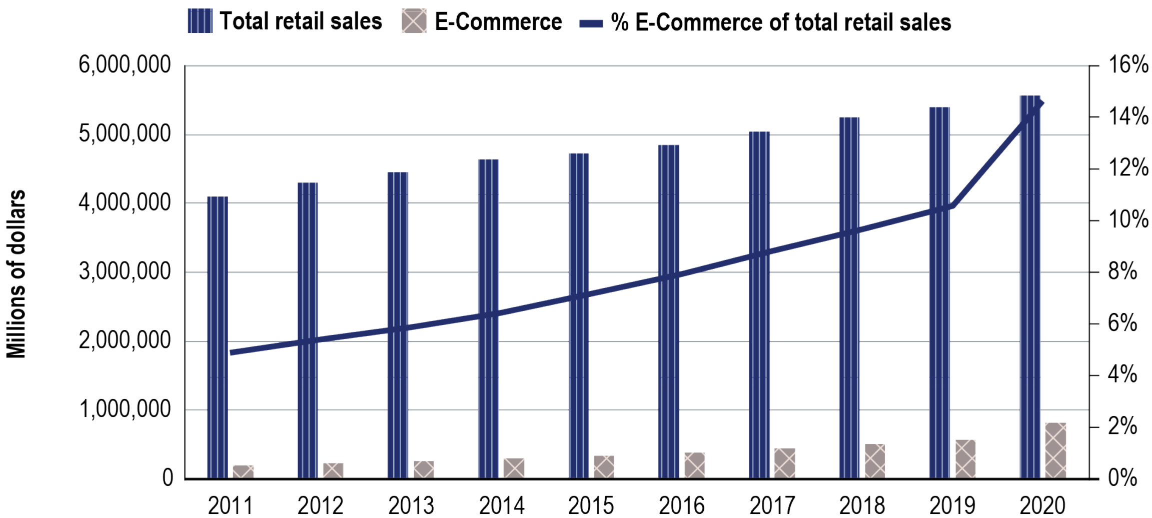
In recent years, large nationwide retailers created distribution centers in coastal port areas; after clearance from U.S. Customs, marine containers would move from ports to these centers or at cross-docking facilities[8] in distribution centers, sorted in accord with the store to where the products were assigned, and then loaded onto trailers for final delivery. While these retailers still rely on distribution centers near ports, the increased use of e-commerce platforms means that retail goods inventory is now forward-positioned in intermediate locations in suburbs and in closer proximity to urban centers, and even within cities, to meet customer demands for quick-order delivery of goods.

Figure 3-15 illustrates how e-commerce retail sales have steeply risen in recent years, especially during the COVID-19 year 2020, when e-commerce accounted for 14.6 percent of all retail sales, up nearly three times its 4.9 percent share in 2011. In contrast, total retail sales in 2020 are only 3 percent higher than that in 2019. The year 2016 saw for the first time shoppers spending more than 50 percent of their purchases online [UPS 2016]. With retailers focused now on customer online and ship-to-store experiences, e-commerce sales can be expected to continue to rise.

Increasing e-commerce sales as a proportion of retail sales will have the effect of decreasing shipment distances, creating greater challenges for mitigating traffic, especially in the approaches to urban areas. This can change trucking operations as an increasing number of trucks will be deployed for shorter hauls and last-mile deliveries.

[8] Cross-docking facilities enable the direct transfer of goods from inbound trucks to outbound trucks for delivery to multiple locations without interim storage and hence eliminate storage fees and storage time.

Figure 3-15 Growth of Retail and E-Commerce Share of Total Retail Sales, 2011–2020



SOURCES: U.S. Census Bureau, Annual Retail Trade Survey: 2020, Estimated Annual U.S. Retail Trade Sales - Total and E-Commerce: 1998-2020, available at https://www.census.gov/data/tables/2020/econ/arts/annual-report.html as of September 2022.

Supply Chain Disruption and Freight Transportation Performance

The Nation's freight transportation network consists of many nodes and links, each of which may become a bottleneck and affect the overall freight transportation performance. The COVID-19 pandemic has heightened the awareness of such supply chain bottlenecks. Marine containers provide a good example as they are moved through various links (when the container moves, such as ships, roads, rail, and barges) and nodes (where the container is processed or stored, such as marine terminals, customs, border posts, free zones, and distribution centers). Links and nodes also exist in the port areas as container ships move between the port's entrance buoy to a berth and containers are loaded and discharged, stored, and moved through gate processing. Supply chain disruptions experienced over the past several years put significant stresses on many of these nodes and links throughout the network, which are captured by some of the BTS freight performance measures.

Container Port Performance

In the port area, there is a range of indicators that can be generated to gauge the performance of marine terminal operations. The ability to collect data related to the time a vessel spends in a port is enabled using the Automatic Identification System (AIS), which identifies the vessel and tracks its speed, direction, and location. The AIS can identify the port or terminal the vessel is calling. BTS uses AIS data for the time the vessel spends at the berth, referred to as container vessel dwell time.

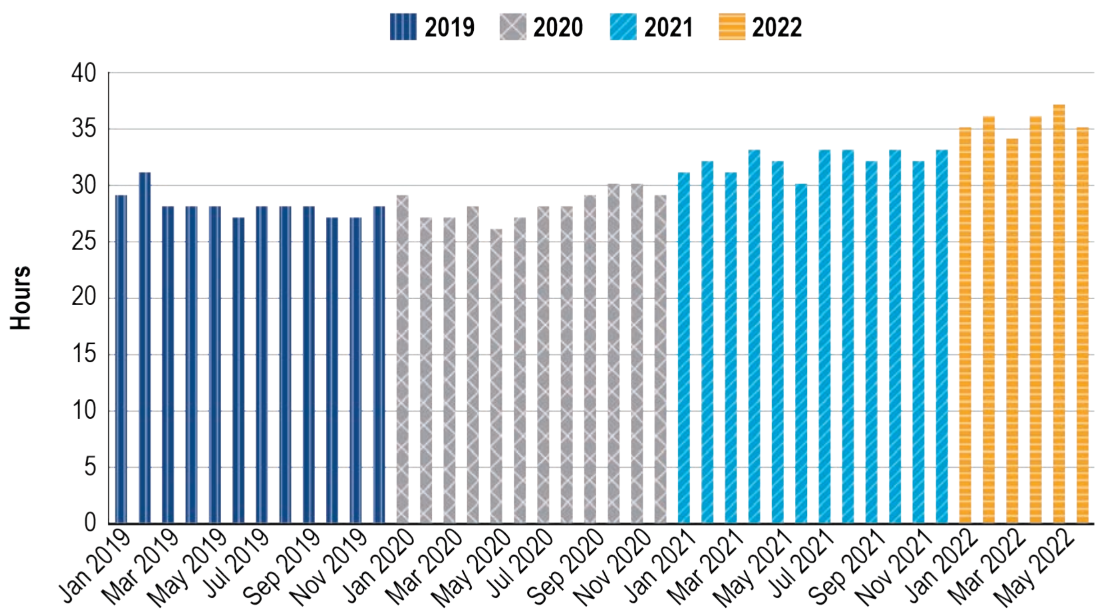
Figure 3-16 shows the average vessel dwell time for the top 25 U.S. container ports. In 2019, 2020, and 2021, the average dwell time was 28.1 hours, 28.2 hours, and 32.1, respectively. The average dwell time continued to increase in the first half of 2022 reaching 35.5 hours, altogether showing a gradual increase due to COVID-related demand [USDOT BTS 2022b]. The impact of COVID-related demand notwithstanding, dwell time can be affected by the vessel's size and the call size. For container ships, size is indicated by the capacity of the vessel, usually in twenty-foot equivalent units (TEU). Call size refers to the container volume that is loaded onto or discharged from the vessel, also reported in TEU.

Figure 3-17 illustrates the impact larger vessels have had at the United States' largest container port complex in San Pedro Bay, which includes the ports of Los Angeles and Long Beach.

The figure shows a general decline in the number of ship calls from 2005 to 2015, from 2,817 ship calls in 2005 to 2,070 ship calls in 2015. However, container volume per call, reflected in TEUs, increased from an average of 5,039 TEUs per call in 2005 to 7,420 TEUs per call in 2015 as vessel calls decreased and ship size increased. Given shipping alliance efforts to maximize capacity utilization, and the likelihood of even larger vessels increasing their share of total port calls since 2015, it is probable that the average volume per call has since increased in Los Angeles and Long Beach.

The World Bank ranks container ports on an annual basis according to their performance as measured by vessel waiting time (at anchor) and vessel berth time [WBG 2022]. The World Bank collects vessel AIS data and a carrier's operational time stamps for 370 container ports worldwide. A performance index that incorporates call size and ship size (TEU capacity) is calculated as they have a bearing on berth time, as the above noted vessel call trends of the San Pedro Bay ports suggest. An index is calculated for each port and reported by both total score and scores by ship size category. The index represents the time the (1) vessel waits at anchor, (2) the vessel's buoy-to-berth transit time, and (3) vessel's total berth time. Port performance overall is thus measured by the vessel's total time in port, from arrival to

Figure 3-16 Average Container Vessel Dwell Time for Top 25 U.S. Container Ports: 2019–June 2022



NOTES: Vessel calls of less than 4 hours or more than 120 hours were excluded as representing calls either too short for significant cargo handling or too long for normal operations.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, calculated using AIS data from the U.S. Coast Guard's Nationwide Automatic Identification System (NAIS) archive, processed by the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, through the AIS Analysis Package (AISAP) software application, as of December 2021.

the entrance buoy to berth departure, and thus considers more broadly port performance than indicated by container vessel (berth) dwell time alone.

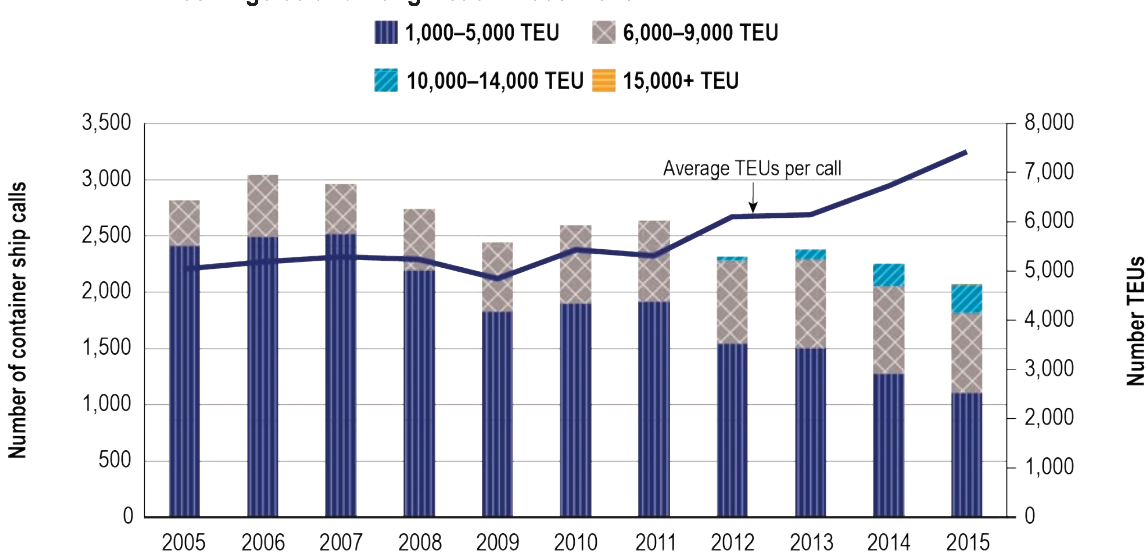
Figure 3-18 identifies the U.S. top 25 container ports based on TEU, with the ports of Los Angeles, Long Beach, and New York numbering among the top 3. Only the port of New Orleans, on the lower end of the top 25, handles more exports than imports. Honolulu handles the highest number of domestic containers. Table 3-6 presents the World Bank's global rankings of these ports for each port's overall rank by vessel size category.

Virginia, ranked 23rd of 370 ports, has the highest ranking of the U.S. top 25 ports while also ranking 19th for the 8,501–13,500-TEU vessel size category. Virginia's rank, however, is far lower for vessels of less than 1,500-TEU capacity, at 168. Miami ranks 29th overall and 19th for the 1,501–5,000-vessel size category, but 133rd for the 5,001–8,500 vessel size category. The rankings overall indicate that not all vessel size categories are receiving the same level of service, demonstrating the constant challenges that port operators face in balancing berth and equipment allocation with often multiple vessel calls of different capacity vessels.

Truck and Rail Performance

The earlier-noted shift of Asian container trades to U.S. East Coast ports encouraged a shift from intermodal rail transport to truck transport because distances from the East Coast are shorter to Mid-west markets. Consequently, the average dwell time at major terminals increased for all major terminals for the eastern railroads while that for the western railroads did not increase as much or even decreased, reflecting the relative changes in the congestion level at the rail terminals in different locations. For

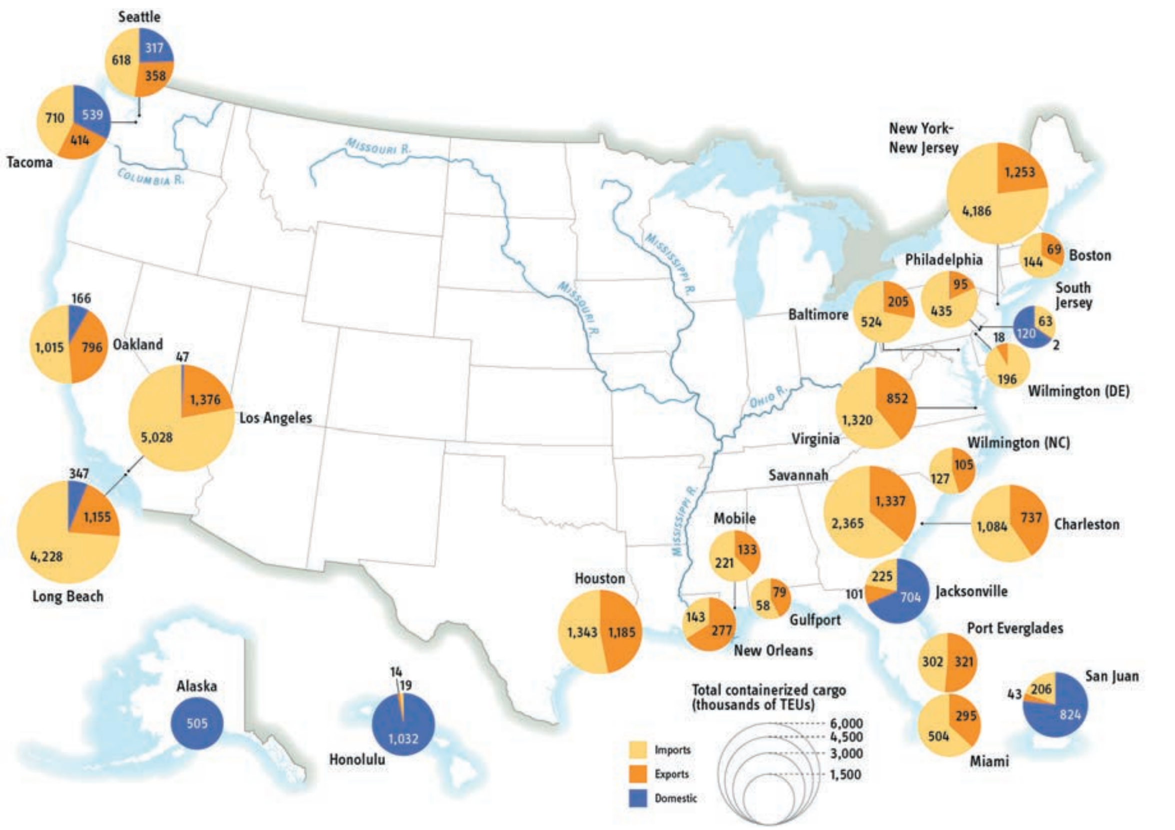
Figure 3-17 Vessel Size and Call Trends and Average Container Throughput per Call, Ports of Los Angeles and Long Beach: 2005–2015



KEY: TEU = twenty-foot equivalent unit.

SOURCE: Vessel call data and size category from San Pedro Bay Ports Clean Air Action Plan, Bay Wide Ocean-Going Vessel International Maritime Organization Tier Forecast 2015-2050, July 2017, p. 3; TEU volume data from the Port of Los Angeles, Annual Container Statistics, available at https://www.portoflosangeles.org/business/statistics/container-statistics and Port of Long Beach, TEUs Archive: 1995 to Present by Year, available at https://polb.com/business/port-statistics#yearly-teus; data at both ports available as of October 20221.

Figure 3-18 U.S. Top 25 Container Ports Based on Twenty-Foot Equivalent Units (TEUs)



SOURCE: U.S. Army Corps of Engineers, Navigation Data Center, personal communication, special tabulation, Nov. 12, 2020, and Nov. 2, 2021.

Table 3-6 World Bank Container Port Performance Index Rankings of Top-Ten U.S. Container Ports: 2021

Port	Overall Rank	Rank by vessel size ranges				
		<1,500 TEU	1,501–5,000 TEU	5,001–8,500 TEU	8,501–13,500 TEU	>13,500 TEU
Los Angeles	370	0	346	224	181	103
Long Beach	369	258	348	227	175	102
NY/NJ	251	160	226	138	121	75
Savannah	367	268	336	214	179	100
Houston	119	119	173	113	101	0
Virginia	23	168	60	44	19	40
Oakland	359	206	229	186	167	96
Charleston	130	79	102	102	75	80
Tacoma	345	0	276	196	173	0
Seattle	322	0	268	190	170	0

KEY: TEU = twenty-foot equivalent unit.

SOURCE: World Bank, Container Port Performance Index 2021, available at https://openknowledge.worldbank.org/handle/10986/37542 as of October 2022.

example, according to the BTS Supply Chain Indicators (www.bts.gov/freight-indicators), the western railroad's (BSNF's) average dwell time was 26.62 hours in 2020, 25.30 hours in 2021, and 27.10 hours in 2022. While the corresponding indicator for the eastern railroad (CSX) was 18.20, 21.60, and 23.60, respectively, showing a steady increase every year. CSX experienced some dramatic increases at terminals like Louisville, KY (52.3 percent from 2021 to 2022) and Toledo, OH (32.5 percent from 2021 to 2022). The average dwell time by another eastern railroad, NS, at Macon, GA, increased from 28.50 hours in 2021 to 37.90 hours in 2022. No western railroads experienced such dramatic increases in the same period [BTS Supply Chain Indicators 2022].

It is interesting to note that this increase does not seem to have as much to do with railroads as with terminals. For example, the average dwell time by the Central railroad CP went from 17.7 hours in 2021 to 26.6 hours in 2022 at Albany, NY. The same railroad experienced similar large increases at Glenwood, MD and Harvey, IL. No terminals on the West Coast experienced such increases, regardless of railroads [BTS Supply Chain Indicators 2022].

A consistent pattern is seen in average truck speed in the vicinity of ports. For example, the average truck speed around the port of Los Angeles-Long Beach generally increased from 2019 through 2022, particularly in the second half of each year, while that around the port of New York-New Jersey is generally lower in 2022 than in 2020 and 2021. Take as an example Octobers of 2020, 2021, and 2022 for which the latest data is available, the average truck speed around the port of Los Angeles-Long Beach was 19.7 mph, 20.2 mph, and 20.6 mph, respectively, while that around the port of New York-New Jersey was 19.0 mph, 18.9 mph, and 18.8 mph, respectively. One increased annually and the other the opposite [BTS Supply Chain Indicators 2022].

Additional Data Needs

Previous editions of the Transportation Statistics Annual Report highlighted long-standing needs for more timely and granular data on freight flows; more complete data on the domestic transportation of U.S. foreign trade, costs of shipping freight, and last-mile movements of freight; and better data on the performance of the freight transportation system. As noted in the last chapter of this report, BTS is undertaking several activities to address these long-standing needs for improved freight statistics. Among the actions are initiatives for improved measurement of the volume, availability, and performance of containerized freight, the detailed needs for which are described in this section.

In response, the Ocean Shipping Reform Act (OSRA) of 2022 (P.L. 117-146) was signed into law on June 15, 2022. Section 16 of the OSRA included mandates for BTS to produce statistics on the total street dwell times (the amount of time an empty or loaded container or a bare or loaded chassis spent between exiting the gate and returning to the terminal) for intermodal shipping containers and chassis. In addition, BTS is required to measure the average out-of-service percentage for chassis. The data that BTS is obtaining will include chassis and container operators, location, fleet availability, and usage.

The Freight Logistics Optimization Works (FLOW) initiative is a joint effort between the USDOT and the freight industry. The initiative will allow industry partners to make better-informed decisions to move goods efficiently through data sharing. BTS is the independent steward of this data-sharing initiative across a privately operated enterprise that spans from shipping lines, ports, terminal operators, truckers, railroads, warehouses, and beneficial cargo owners.

BTS has identified several important freight data gaps through a recent effort in developing the Section 25003 report. For example, the report recognizes that small-area freight origin and destination data and tools are needed for local decision-making. Likewise, support is required to measure freight trip ends (last-mile) and trips from warehouses to retail and office establishments (middle-mile).

A long-existing challenge to freight analysis in general and freight economic analysis in particular is the lack of the freight cost data. None of the Commodity Flow Survey (CFS), Freight Analysis Framework (FAF), and other minor freight data sources provide systematic and system-wide cost information on a per ton, per mile, per ton-mile basis. Information on cost details by commodity, by mode, by route, by region, etc. will greatly benefit all freight analysis

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CHAPTER 4
Transportation Economics

Introduction

Transportation plays a vital role in the American economy by making economic activity possible. The provision and consumption of transportation are major economic activities in themselves, both of which contribute directly and indirectly to the economy. This chapter discusses these direct and indirect contributions:

- Contribution of transportation to gross domestic product;
- Use of transportation by non-transportation industries (e.g., manufacturing) to produce goods and services;
- Demand for transportation services as an economic indicator;
- Persons employed by the transportation industry and in transportation occupations and their wages;

Highlights

- Transportation accounted for 8.4 percent of the U.S. gross domestic product in 2021, up from 7.7 percent in 2020 but down from 9.1 percent in 2019.
- In 2021, the wholesale and retail trade sector continued to require more transportation services than any other sector to produce one dollar of gross output.
- The volume of freight transportation services, provided monthly as measured by the freight Transportation Services Index, has grown since the 2020 economic recession, but as of September 2022 remains below the pre-pandemic August 2019 high.
- Transportation and transportation-related industries employed 14.9 million people (10.2 percent of the U.S. labor force) in 2021—up 3.9 percent from 2020 and surpassing the 2019 level of 14.8 million workers.
- Employment in both the transportation and warehousing sector and transportation-related industries sector increased in 2021, but employment in the transportation and warehousing sector grew at a faster rate (8.0 and 1.2 percent, respectively).
- The racial/ethnic composition of the transportation and warehousing sector is more diverse than the U.S. labor force.
- The unemployment rate in the transportation and warehousing sector has fallen since the May/July 2020 all-time high, but in 23 out of the 27 months since July 2020, it exceeded the pre-pandemic 2019 level for the same month.
- Fuel prices increased in 2021 but remained below the peak reached in 2012.

Continued »

Highlights Continued

- Transportation's contribution to inflation reached a high of 58.6 percent in June 2021 due to high fuel prices and supply chain issues.
- Businesses purchasing transportation services faced rising costs in 2021 as seen through higher truck spot rates, inland waterway transport rates, and ocean freight rates.
- Layoffs and discharges remain stable after the February to April 2020 economic recession, and COVID-19 caused a 401.2 percent increase in layoffs and discharges from January 2020 to March 2020—the highest level reached in the past decade.
- The period spanning 2020 to 2021 had the largest year-over-year increase in inflation-adjusted terms for motor gasoline (all types) and the second largest increase for jet fuel and on-highway diesel since 1990.
- In 2021, the costs for rail, truck, and water transportation services reached their all-time high, suggesting an increase in the costs businesses face for providing these transportation services.

- Public (government) and private expenditures on transportation facilities, infrastructure, and systems, which enable the movement of both people and goods domestically and internationally; and
- The costs faced by producers and users (businesses and household consumers) of transportation.

The full scope of transportation's role in the economy and historical data are available in the Bureau of Transportation Statistics' (BTS's) *Transportation Economic Trends*.[1]

Transportation's Contribution to GDP

Contribution of Transportation Goods and Services to GDP

Gross domestic product (GDP) is an economic measure of the value of the final goods and services produced in the United States in a year (without double counting the intermediate goods and services used to produce them).[2] Figure 4-1 divides GDP into six categories (transportation, healthcare, housing, food, education, and all other goods and services). In 2021, transportation accounted for 8.4 percent of GDP, up from 7.7 percent in 2020 but down from 9.1 percent in 2019. While transportation accounts for the second smallest share, transportation plays a vital role in the economy by making economic activity possible (e.g., by transporting the raw materials needed to manufacture goods and transport products).

Contribution of Transportation Services to GDP

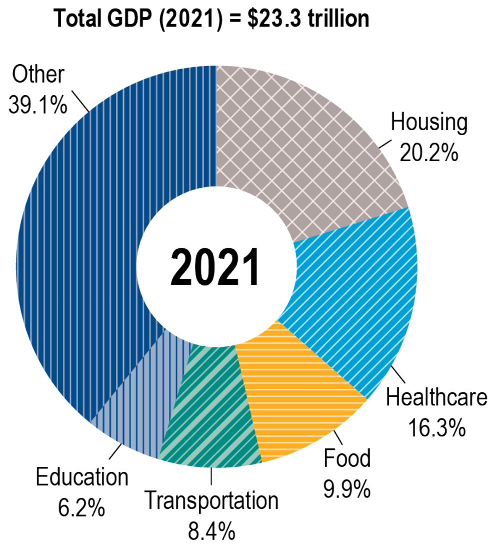
The previous section shows the contribution of both transportation goods and services to GDP, while this section measures the contribution of transportation services to GDP using the Transportation Satellite Accounts (TSAs).[3] BTS developed the TSAs to estimate the contribution

[1] https://www.bts.gov/tet.

[2] This measure is termed the production or output approach. Equivalent GDP measures are termed (1) the income approach, measured as the sum of the aggregate compensation paid to employees, business profits and taxes less subsidies and (2) the expenditure method measured as the sum of private consumption and investment, government spending, and net exports.

[3] For further information on how to measure transportation's contribution to GDP, see The Contribution of Transportation to the Economy in BTS' *Transportation Economic Trends*, available at https://www.bts.gov/tet as of September 2022.

Figure 4-1 Shares of U.S. GDP: 2021



SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts Tables, tables 1.1.4, 2.4.4, 3.11.4, 3.15.4, 4.2.4, 5.4.4, 5.5.4 and 5.7.4B (price deflators); 1.1.5, 2.4.5, 3.11.5, 3.15.5, 4.2.5, 5.4.5, 5.5.5 and 5.7.5B (current dollars); 1.1.6, 2.4.6, 3.11.6, 3.15.6, 4.2.6, 5.4.6, 5.5.6 and 5.7.6B (chained dollars), available at apps.bea.gov/iTable/index_nipa.cfm as of November 2022..

of in-house transportation services to the economy and the contribution of transportation carried out by households using household vehicles.[4] In addition, the TSAs provide the contribution of for-hire transportation—as estimated by the Bureau of Economic Analysis.

In 2021, transportation services' (for-hire, in-house, and household) total contribution to GDP was $1,330.6 billion (5.6 percent). This contribution to the economy, as measured by the TSAs, is less than the final demand attributed to transportation (Figure 4-1) because it counts only the contribution of transportation services and not transportation goods (e.g., the contribution from motor vehicle manufacturing). For-hire transportation contributed $689.2 billion (2.9 percent) to an enhanced U.S. GDP of $23.7 trillion.[5] In-house transportation services (air, rail, truck, and water) provided by non-transportation industries for their own use contributed an additional $229.9 billion (1.0 percent) to enhanced GDP. Household transportation, measured by the depreciation cost associated with households owning motor vehicles, contributed $411.5 billion (1.7 percent)—the largest transportation mode contributing to GDP.

Use of Transportation Services by Industries

Transportation indirectly contributes to the economy by enabling the production of goods and services by non-transportation industries. The amount of transportation services required to produce each dollar of output indicates how much a sector depends on transportation services. In 2021, the wholesale and retail trade sector required the most transportation services, at 9.3 cents (4.7 cents of in-house transportation operations and 4.6 cents of for-hire transportation services), to produce one dollar of output (Figure 4-2).

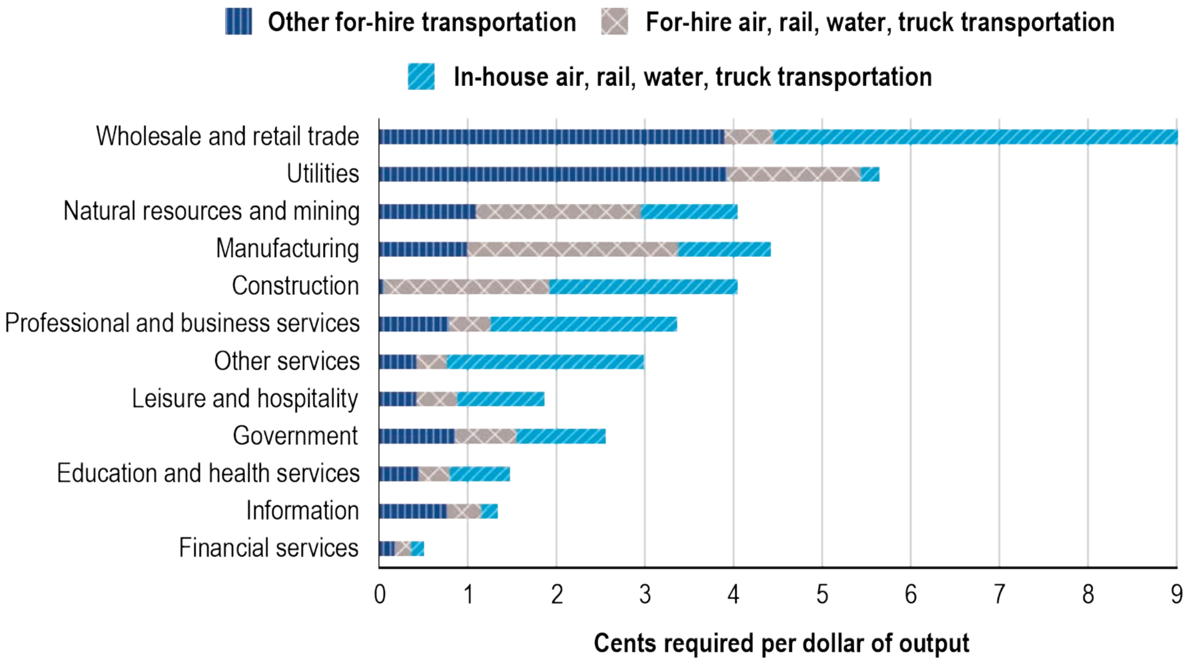
Transportation as an Economic Indicator

Transportation activities have a strong relationship to the economy. For example, increases in production create additional demand for freight transportation services. The

[4] For-hire transportation services consist of air, rail, truck, passenger and ground transportation, pipeline, and other support services that transportation firms provide to industries and the public on a fee basis. In-house transportation services consist of air, rail, truck, and water transportation services produced by non-transportation industries for their own use (e.g., grocery stores owning and operating their own trucks to move goods from distribution centers to retail locations). BTS calculates the contribution of household transportation as the depreciation associated with households owning a motor vehicle. For more information about the Transportation Satellite Accounts (TSAs), see U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Economic Trends*, chapter 2, available at https://data.bts.gov/stories/s/smrm-36nv/ as of September 2022.

[5] Enhanced GDP is the sum of the GDP published in the National Accounts plus the contribution of household transportation as measured by BTS in the Transportation Satellite Accounts.

Figure 4-2 Transportation Services Required to Produce One Dollar of Output by Sector: 2021



NOTE: Other for-hire transportation includes: pipeline, transit and ground passenger transportation; sightseeing transportation and transportation support; courier and messenger services; and warehousing and storage.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at http://www.bts.gov/satellite-accounts as of November 2022.

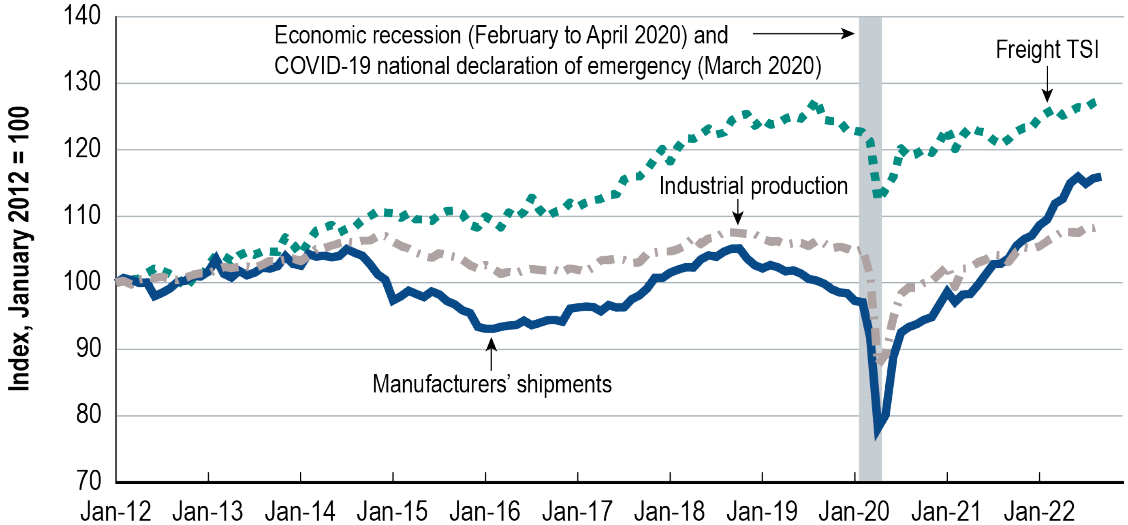
BTS freight Transportation Services Index (TSI) measures the volume of freight transportation services provided monthly by the for-hire transportation sector in the United States. The freight TSI began to rise in May 2020, mirrored by increases in industrial production and manufacturers' shipments (Figure 4-3) after an all-time high in August 2019. The decline from August 2019 preceded the February to April 2020 economic recession. While the freight TSI has grown since the 2020 economic recession, it has not surpassed the August 2019 high but nearly approached the same level in September 2022 (the latest data available).

BTS research shows that changes in the TSI occur before changes in the economy, making the TSI a potentially useful economic indicator.[6] This relationship is particularly strong for freight traffic as measured by the freight TSI.

Figure 4-4 illustrates the relationship between the freight TSI and the national economy from January 1979 through September 2022. The dashed line shows the freight TSI with long-term changes removed (detrended). The solid line shows the freight TSI after removing both long-term trends and month-to-month volatility (detrended and smoothed). The shaded areas represent *economic slowdowns* and the areas between represent *economic accelerations*, or periods of economic growth. The freight TSI usually peaks and turns downward before a growth slowdown begins and hits a trough and turns upward before a growth slowdown ends. The TSI indicated an economic slow-down in

[6] See U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Services Index and the Economy Revisited*, available at https://www.bts.gov/archive/publications/special_reports_and_issue_briefs/special_report/2014_12_10/entire as of December 2022

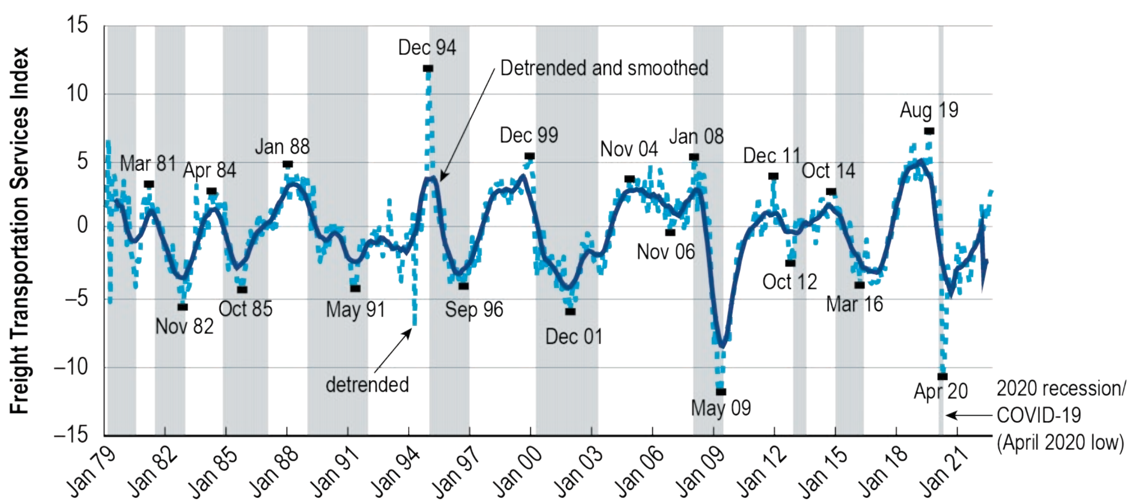
Figure 4-3 Industrial Production, Manufacturers' Shipments, and Freight Transportation Services Index (Seasonally Adjusted): January 2012–September 2022



NOTES: The Transportation Services Index is a weighted and chained index. All indexes re-indexed to January 2012 to facilitate visual comparison.

SOURCES: Industrial Production: Board of Governors of the Federal Reserve System, Industrial Production Index [INDPRO], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/INDPRO/ as of December 2022. **Manufacturers' Shipments:** U.S. Bureau of the Census, Value of Manufacturers' Shipments for All Manufacturing Industries [AMTMVS], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/AMTMVS/ as of December 2022. **Freight TSI:** U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Services Index, available at www.transtats.bts.gov/OSEA/TSI/ as of December 2022..

Figure 4-4 Freight Transportation Services Index and the Economic Growth Cycle



NOTES: Shaded areas indicate decelerations in the economy, and areas between are accelerations in the economy (growth cycles). Endpoint for deceleration begun in December 2014 has not been determined. Detrending and smoothing refer to statistical procedures that make it easier to observe changes in upturns and downturns of the data. Detrending removes the long-term growth trend and smoothing removes month-to-month volatility.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Services Index, available at https://data.bts.gov/stories/s/9czv-tjte as of December 2022.

August 2019. The slowdown deepened in early 2020 when the economy entered a recession, reaching a low in April 2020 and then entered a period of economic growth.

Transportation-Related Employment, Wages, Job Turnover, and Unemployment

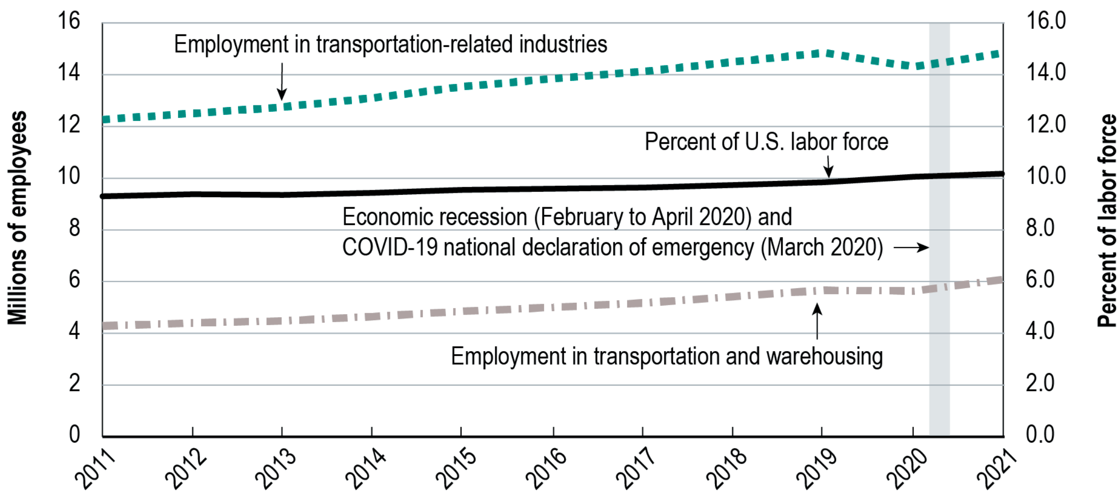
Transportation Employment and Selected Demographics of Workers

Industries in the transportation and warehousing sector and related industries outside the sector (e.g., automotive manufacturing) employed 14.9 million people (10.2 percent of the U.S. labor force) in 2021 in a variety of roles, from driving buses to manufacturing cars to building, operating, and maintaining ports and railroads [USDOT BTS 2022a]. The total number employed in transportation recovered from the decline in 2020 (caused by the February to April 2020 economic recession and COVID-19); growing 3.9 percent from 2020 to 2021 and surpassing the 2019 level of 14.8 million people.

The transportation and warehousing sector (North American Industry Classification System [NAICS] 48-49) directly employed 6.1 million workers in the United States in 2021—an increase of 8.0 percent from 2020. The 6.1 million amounted to 4.2 percent of the U.S. labor force (Figure 4-5), up from 3.8 percent in 2019 and 4.0 percent in 2020 [USDOT BTS 2022a]. Employment in transportation-related industries likewise increased from 2020 to 2021 (by 0.1 million). However, employment grew slower (1.2 percent increase) in transportation-related industries than in the transportation and warehousing sector, which experienced an 8.0 percent increase in employment from 2020 to 2021.

Persons who identify as white comprise the largest number of workers in the transportation and warehousing sector. However, persons who identify as white comprise a smaller share of the transportation and warehousing labor force

Figure 4-5 Transportation-Related Labor Force Employment in the United States: 2011–2021 (Millions)



NOTE: Shaded area indicates economic recession.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 3-23, available at www.bts.gov as of December 2022.

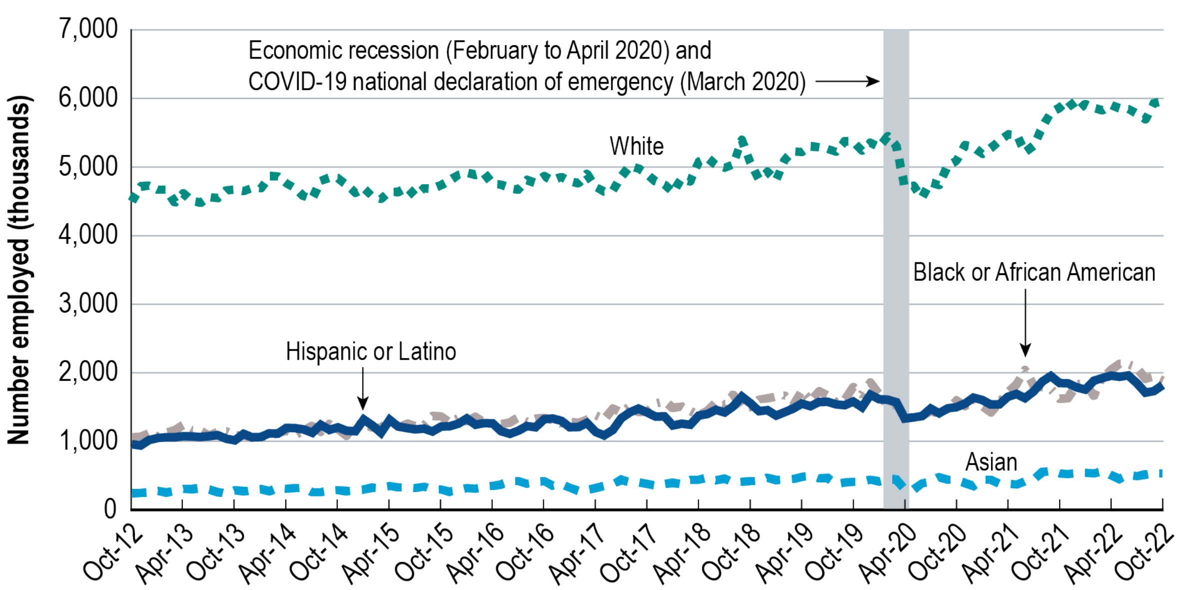
than the U.S. labor force by about 10 percentage points (Figure 4-6). This mainly is from persons who identify as Black or African American accounting for nearly 10 percentage points more of the transportation and warehousing labor force than the U.S. labor force. Persons of any race who identify as Hispanic or Latino account for a slightly larger share of the transportation and warehousing labor force than the U.S. labor force. The racial and ethnic differences between the transportation and warehousing and the U.S. labor force have remained relatively stable over the past decade (Figure 4-7).

Transportation Wages

Workers with transportation occupations earned a lower average hourly compensation ($34.32) than workers in all occupations ($40.90) in Q1 2022 [USDOL BLS 2022]. Figure 4-8 shows annual median wages for the largest, the lowest-paid, the highest-paid, and the fastest growing transportation occupations in the United States in 2021.

Annual wages vary widely, from a median annual wage of over $200,000 for airline pilots and over $129,000 for air traffic controllers to a median annual wage of $29,000 for ambulance drivers and attendants. The five lowest-wage transportation-related occupations collectively employed about 900,000 workers, while the five highest-wage occupations employed about 300,000 workers in 2021. Automation of transportation and technological changes affect which transportation occupations will gain or lose employment. From 2021 to 2031, the number of taxi drivers and chauffeurs, which includes drivers working for ride-hailing services, such as Uber and Lyft, is expected to grow the fastest at 28.5 percent—the 14th fastest

Figure 4-6 Employment in the Transportation and Warehousing Sector by Race and Hispanic/Latino Ethnicity: October 2012–October 2022 (Not Seasonally Adjusted)

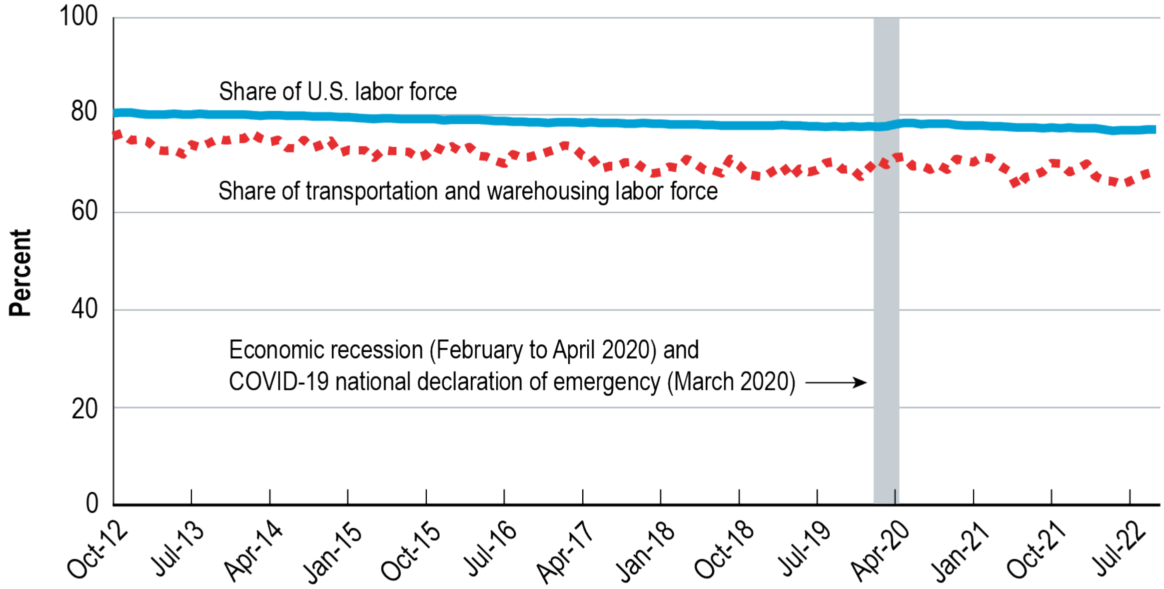


NOTES: Persons of Hispanic or Latino ethnicity may also identify any race. The sum of all persons employed in the transportation and warehousing sector is the sum of persons identifying as White, Black or African American, Asian, and other (not shown).

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey, series id LNU02000000, LNU02000003, LNU02000006, LNU02032183, LNU02000009, LNU02034569, LNU02038020, LNU02038051, LNU02038082, and LNU02038113, available at www.bls.gov/cps, as of December 2022.

Figure 4-7 Percent of Total Employed by Race and Hispanic/Latino Ethnicity: October 2012–October 2022 (Not Seasonally Adjusted)

A. White



B. Black or African American

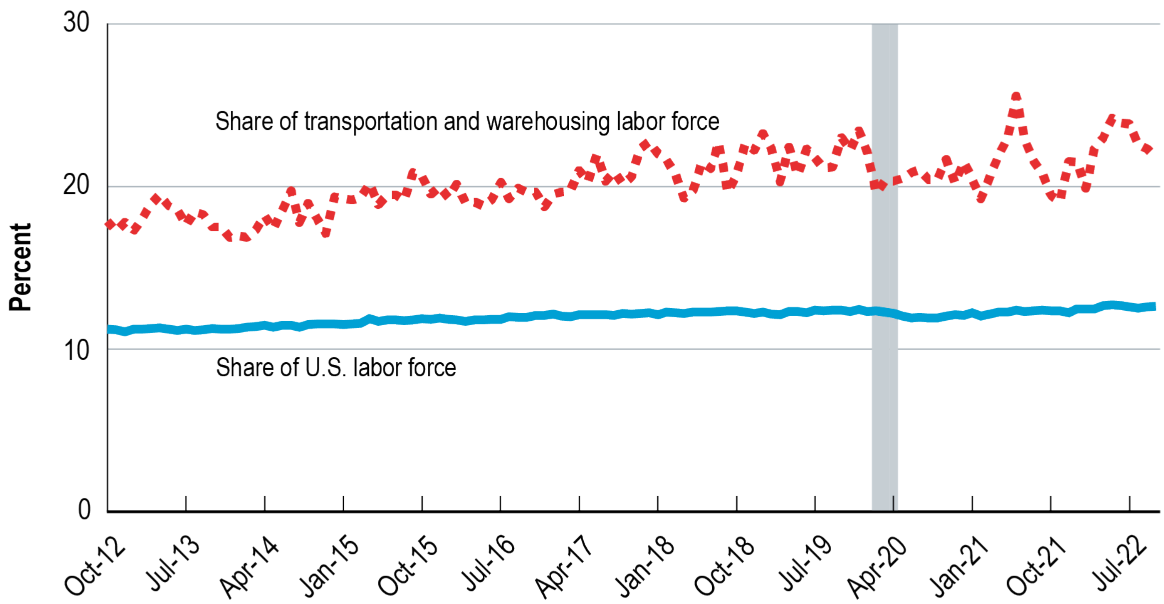
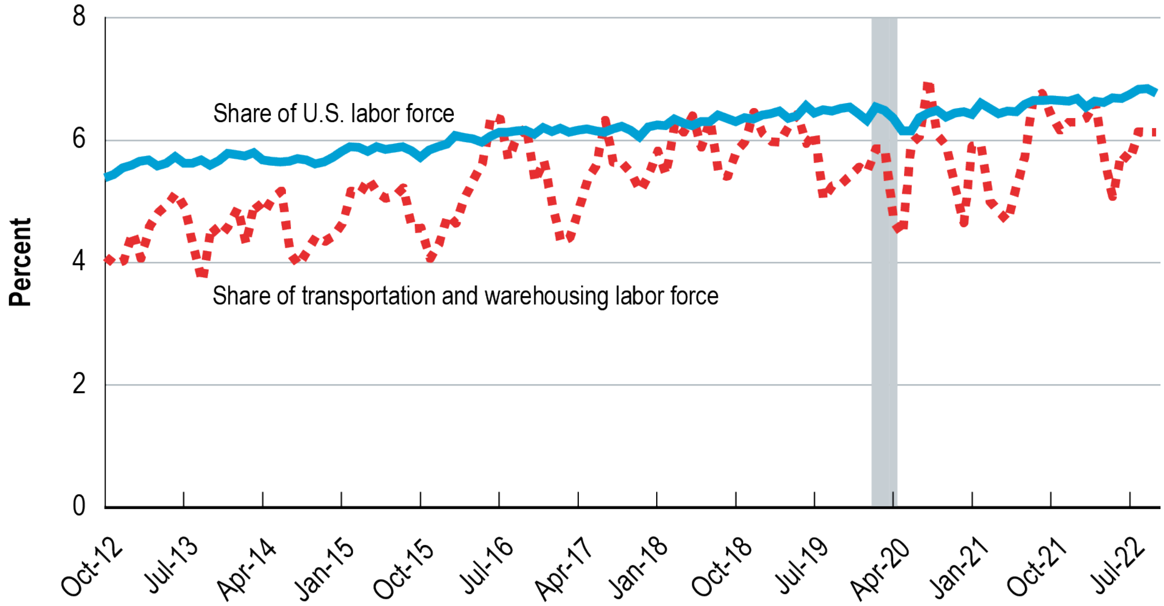
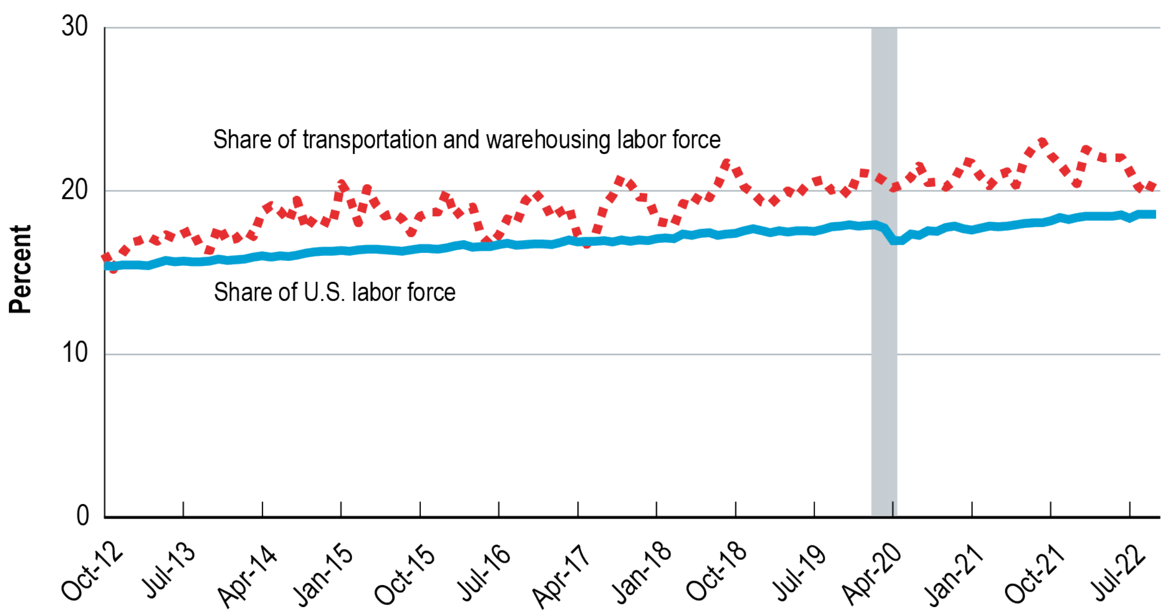


FIGURE 4-7 Continued

C. Asian



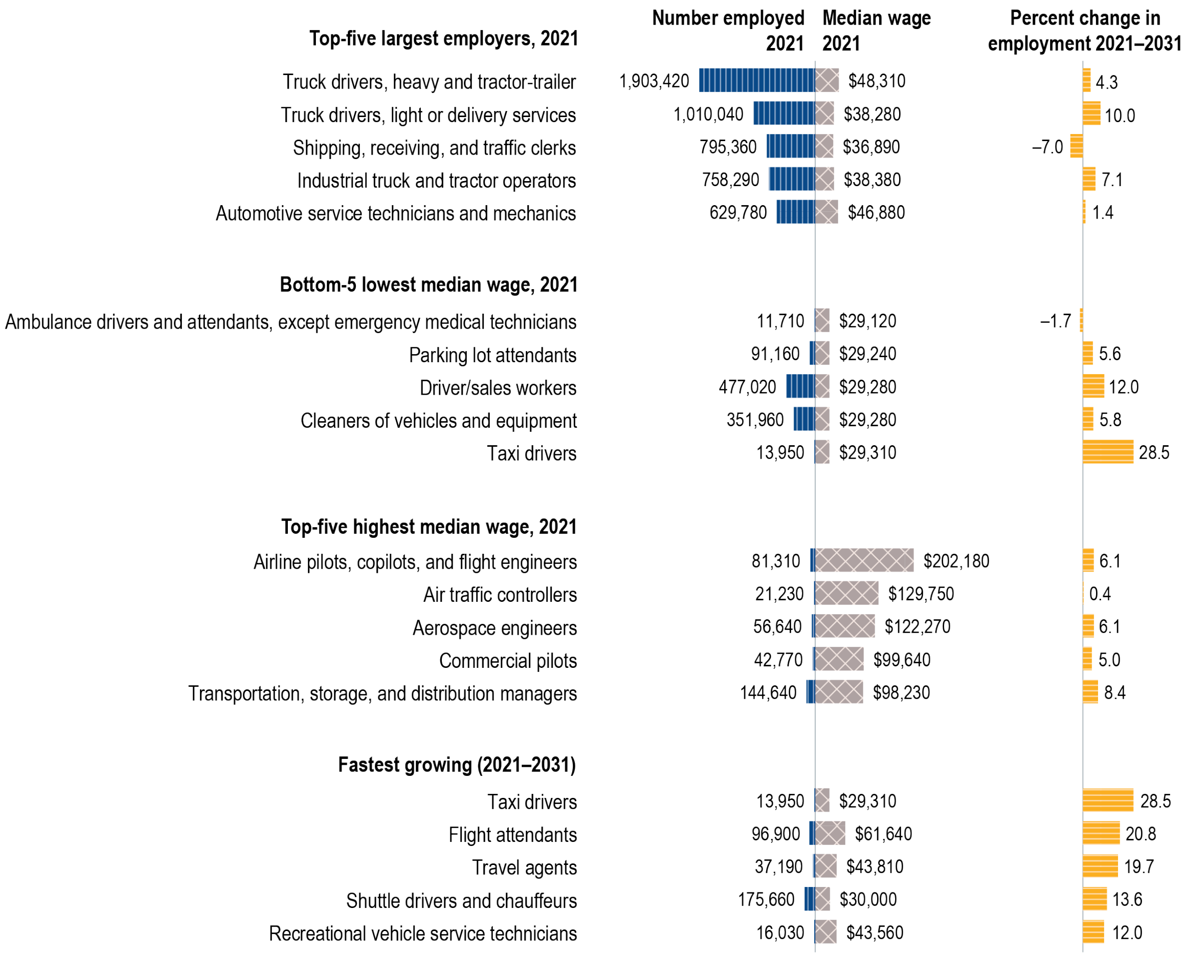
D. Hispanic or Latino



NOTES: Y-axis not the same for all graphs. Persons of Hispanic or Latino ethnicity may also identify any race. The sum of all persons employed in the transportation and warehousing sector is the sum of persons identifying as White, Black or African American, Asian, and other (not shown).

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey, series id LNU02000000, LNU02000003, LNU02000006, LNU02032183, LNU02000009, LNU02034569, LNU02038020, LNU02038051, LNU02038082, LNU02038113, available at www.bls.gov/cps, as of December 2022

Figure 4-8 Employment and Wages in Select Transportation Occupations: 2021



NOTES: Airline pilots typically fly on scheduled air carrier routes to transport passengers and cargo, while commercial pilots fly on non-scheduled air carrier routes. "Commercial pilots" includes charter pilots, air ambulance pilots, and air tour pilots. Ambulance drivers excludes emergency medical technicians.

SOURCES: Transportation occupations: U.S. Department of Transportation, National Transportation Statistics, table 3-24 Employment in Transportation and Transportation-Related Occupations, available at https://www.bts.gov/content/employment-transportation-and-transportation-related-occupations. **Employment and wages:** U.S. Department of Labor, Bureau of Labor Statistics, Occupational Employment and Wages, available at http://bls.gov/oes. **Projected growth rate:** U.S. Department of Labor, Bureau of Labor Statistics, Employment Projections, available at https://www.bls.gov/emp/tables.htm as of September 2022.

growing occupation out of the 1,079 occupations identified by the Bureau of Labor Statistics.[7]

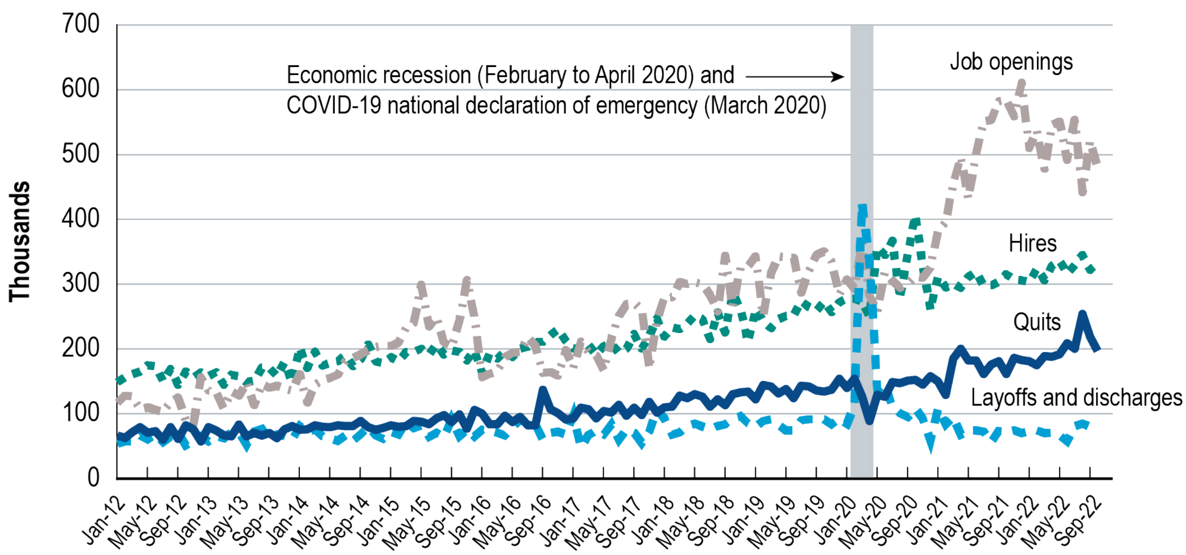
Job Openings and Labor Turnover

The number of job openings in the transportation, warehousing, and utilities sector reached an all-time high in December 2021 after growing 93.4 percent from September 2020 to September 2021—the largest 12-month gain over the past decade (Figure 4-9). The number of job openings fell 21.1 percent from the December 2021 high to October 2022 (the latest available data). While job openings declined, the number of hires rose—increasing 8.8 percent from December 2021 to October 2022. Hires offset quits during the December to October 2022 period. Layoffs and discharges remain stable after the February to April 2020 economic recession and COVID-19 caused a 401.2 percent increase in layoffs and discharges from January 2020 to March 2020—the highest level reached in the past decade.

Layoffs and discharges caused unemployment in the transportation and warehousing sector to reach an all-time high in May 2020 and matched again in July 2020 (Figure 4-10). The unemployment rate in the transportation and warehousing sector has fallen since the 2020 high, but in 23 out of the 27 months since July 2020, the unemployment rate in the transportation and warehousing sector exceeded the pre-pandemic 2019 level for the same month.

[7] See U.S. Department of Labor, Bureau of Labor Statistics, Employment Projections, Occupational Projections and Worker Characteristics, 2021-2031, available at https://www.bls.gov/emp/tables/occupational-projections-and-characteristics.htm as of September 2022.

Figure 4-9 Job Openings and Labor Turnover: Transportation, Warehousing, and Utilities Sector (Seasonally Adjusted): October 2012–October 2022



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey, series id LNU04000000 and LNU04034168, available at https://www.bls.gov/cps/data.htm as of December 2022.

Transportation Expenditures and Revenues

Public and Private Sector Expenditures and Revenue

Expenditures

The most recent data are for 2019, which show that federal, state, and local governments spent $384.2 billion on transportation. Most government spending on transportation takes place at the state and local levels, although state and local capital expenditures are often paid for in part with federal funds. In 2019, state and local governments spent $349.1 billion, including expenditures paid for with federal transfers, such as the Federal-Aid Highway Program and the Airport and Airway Trust Fund. The Federal Government spent $35.1 billion directly on transportation, excluding federal transfers to states [USDOT BTS 2022b].

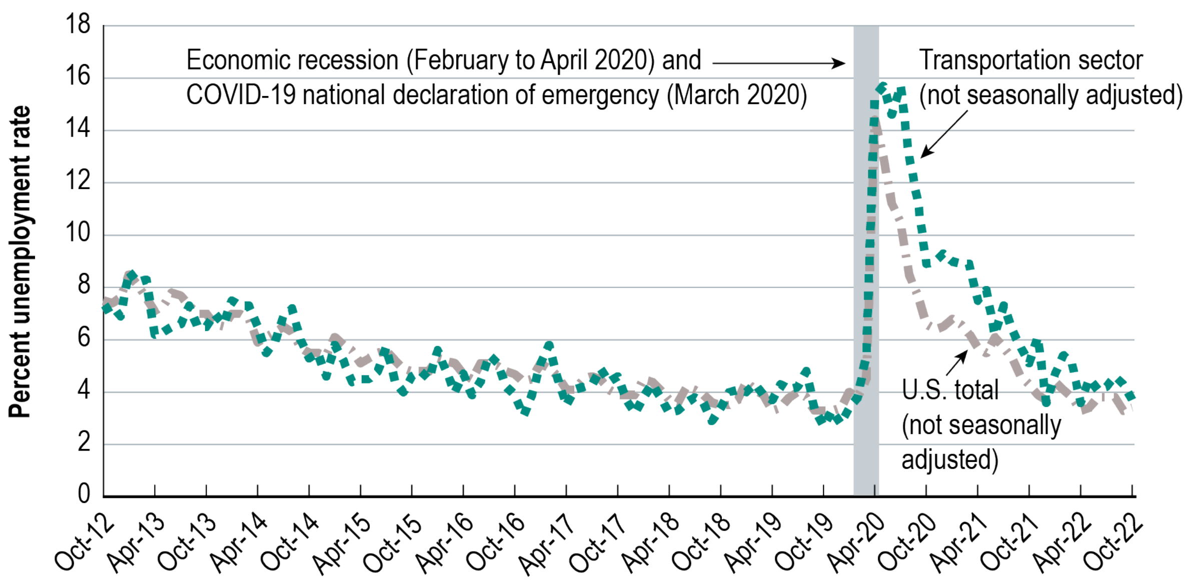
Most direct federal spending was for aviation ($19.3 billion, or 55.1 percent) followed by water ($9.3 billion, or 26.4 percent), highway ($3.6 billion, or 10.2 percent), railroads ($2.3 billion, or 6.4 percent), and the remainder on general support, transit, and pipeline costs ($0.7 billion, or 1.9 percent) (Figure 4-11).

State and local government spending (including expenditures paid for with federal grants) accounted for $349.1 billion of the $384.2 billion spent nationwide on transportation in 2019. Most of state and local spending was for highways ($236.0 billion, or 67.6 percent) followed by transit ($75.1 billion, or 21.5 percent), air ($31.0 billion, or 8.9 percent), water ($6.9 billion, or 2.0 percent), pipeline ($0.06 billion, or 0.02 percent), and general support ($0.02 billion, or 0.01 percent) (Figure 4-12).

Revenue

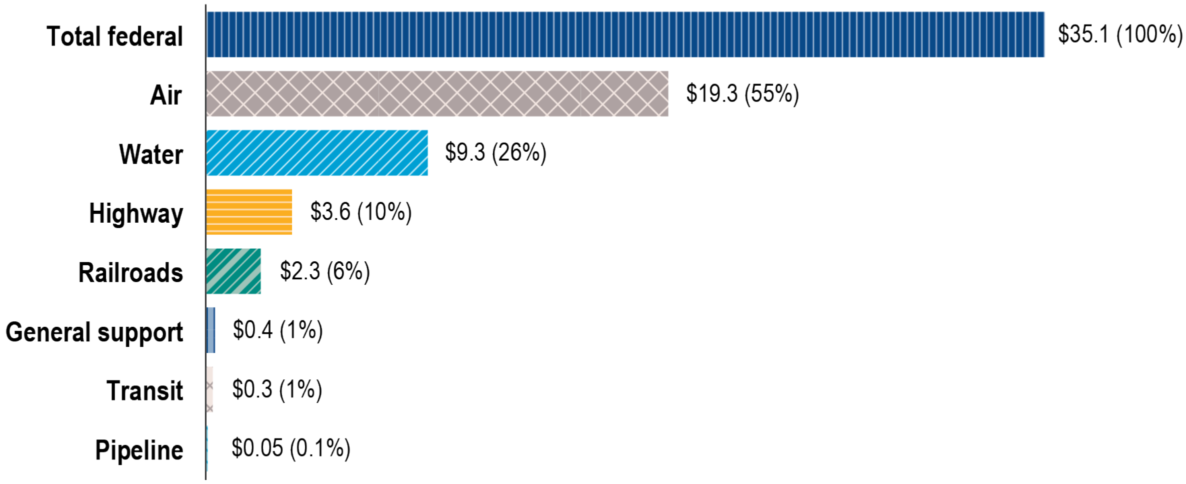
Government transportation revenue comes from user taxes and fees, such as gasoline

Figure 4-10 Job Openings and Labor Turnover: Transportation, Warehousing, and Utilities Sector (Seasonally Adjusted): January 2012–October 2022



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey, series id LNU04000000 and LNU04034168, available at https://www.bls.gov/cps/data.htm as of December 2022.

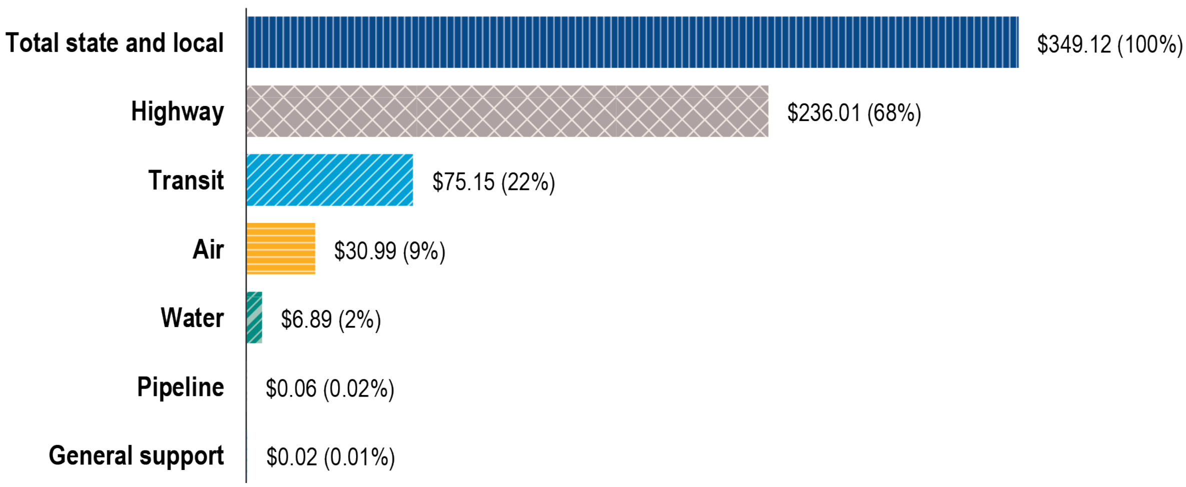
Figure 4-11 Federal Transportation Expenditures by Mode: 2019 (Billions of 2019 Dollars)



NOTE: 2019 data are latest available. Federal expenditure includes direct federal spending, excluding grants to state and local governments.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at https://data.bts.gov/Research-and-Statistics/Government-Transportation-Financial-Statistics-GTF/nu8j-7gmn as of September 2022.

Figure 4-12 State and Local Transportation Expenditures by Mode: 2019 (Billions of 2019 Dollars)



NOTE: 2019 data are latest available.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at https://data.bts.gov/Research-and-Statistics/Government-Transportation-Financial-Statistics-GTF/nu8j-7gmn as of September 2022.

taxes and tolls, air ticket taxes, and general revenues, as well as income from investing transportation funds and receipts from fines and penalties. In 2019, federal, state, and local government revenue collected and dedicated to transportation programs totaled $395.0 billion (in 2019 dollars) [USDOT BTS 2022b]. Over half of the revenue ($228.3 billion, or 57.8 percent) came from taxes and charges levied on transportation-related activities (own-source revenue). The remaining $166.7 billion (42.2 percent) came from non-transportation-related activities that support transportation programs, such as state or local sales or property taxes used to finance transportation projects (supporting revenue). Total (own-source and supporting) transportation revenues of $395.0 billion exceeded transportation expenditures of $384.2 billion by 10.8 billion in 2019. Contrastingly, total transportation revenues fell short of transportation expenditures in 2018 by $3.6 billion in 2018 [USDOT BTS 2022b]. This gap increased from 3.1 billion in 2017 to 10.8 billion in 2019. Of the $395.0 billion collected from and dedicated to transportation programs in 2019, the Federal Government collected $100.9 billion (25.6 percent). Of the $100.9 billion, the revenue sources were:

- $50.8 billion in highway revenues ($43.6 billion own-source and $7.3 billion supporting revenue),
- $22.2 billion in aviation revenues ($16.3 billion own-source and $5.8 billion supporting revenue),
- $13.3 billion in transit revenues (all supporting revenue),
- $11.8 billion in water transportation revenues ($2.2 billion own-source and $9.6 billion supporting revenue),
- $2.3 billion in rail transportation revenues (all supporting revenue),
- $0.45 billion in general support revenues (all supporting revenue), and
- $0.15 billion in pipeline revenues ($0.03 billion own-source and $0.12 billion supporting revenue).

State and local governments collected $294.0 billion (74.4 percent) of the $395.0 billion of total transportation revenue in 2019. Of this revenue, the state and local governments collected:

- $209.6 billion in highway revenue sources, such as fuel taxes, motor vehicle taxes, and tolls ($114.6 billion own-source and $95.0 billion supporting revenue);
- $28.7 billion in aviation-related revenue, such as landing fees and terminal area rental ($25.5 billion own-source and $3.2 billion supporting revenue);
- $49.3 billion in transit revenue—almost entirely from fares ($19.5 own-source and $29.8 supporting revenue); and
- $6.5 billion in water revenue (all own-source).

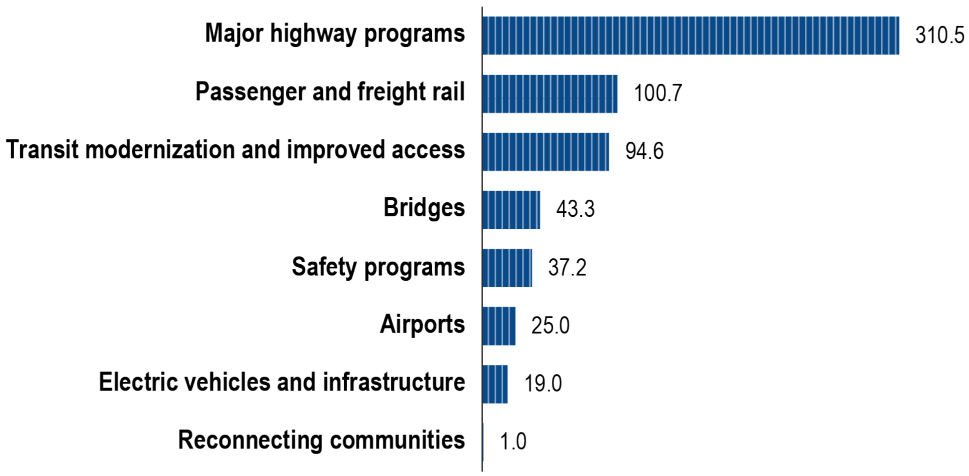
The Infrastructure Investment and Jobs Act (IIJA) (Public Law 117-58), known as the Bipartisan Infrastructure Law (BIL), was signed by President Biden on November 15, 2021. The BIL provides $1.2 trillion in funding, which includes $673.8 billion for transportation (Figure 4-13). The BIL provides funds for transportation infrastructure including roads, bridges, transit, airports, ports, and rail. The BIL also invests in other infrastructure, such as energy, water, and broadband access.

Transportation Investment

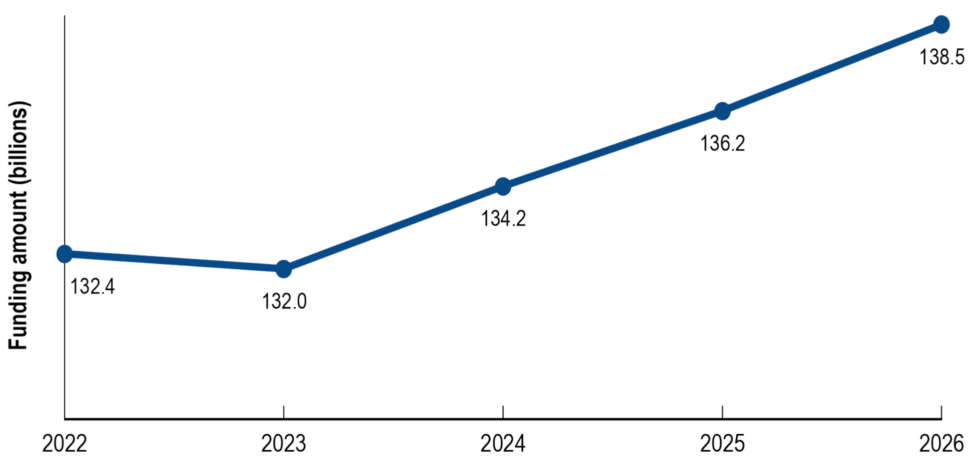
Transportation assets (infrastructure and equipment taking more than 1 year to consume) represent a small but important share of total public and private investment in the United States. In 2021, public and private investment in transportation infrastructure and equipment totaled $383.9 billion, or 7.8 percent—a significant drop from 14.2 percent in 2018—of the $4,939.6 billion of total national investment in all infrastructure, equipment, and intellectual property products (Table 4-1). Public and private investment in new transportation infrastructure accounted for $159.3 billion (3.2 percent), and private transportation equipment accounted for $224.5 billion (4.5 percent). Adjusted for inflation, total investment in new transportation infrastructure and equipment increased 4.9 percent from 2020 to 2021 but remained 16.5 percent below the 2019 level. Investment in transportation accounted for a smaller share of total investment in 2021 (7.8 percent) than in both 2019 and 2020 (10.3 and 8.1 percent of total investment respectively) [USDOT BTS 2022c].

Figure 4-13 Overview of the Transportation Component of the Infrastructure Investment and Jobs Act (IIJA), known as the Bipartisan Infrastructure Law (BIL)

A. IIJA Spending on Transportation by Major Program (Billions)



B. IIJA Transportation Funding Amounts by Year (Billions)



SOURCE: Compiled by the U.S. Department of Transportation, Bureau of Transportation Statistics, available at https://data.bts.gov/stories/s/cvki-zubk as of December 2022.

Table 4-1 Total Investment and Transportation Investment: 2021 (Current Dollars)

Investment	$ Billions	Percent
TOTAL investment	**4,939.6**	**100.0**
Transportation	**383.9**	**7.8**
Transportation infrastructure	159.3	3.2
Transportation equipment	224.5	4.5
Other (non-transportation)	**4,555.7**	**92.2**
Structures	1,900.8	38.5
Equipment	1,155.8	23.4
Intellectual property products	1,499.1	30.3

NOTES: Totals may not sum due to rounding. Investment includes spending on new structures and equipment and exclude maintenance and repair of existing structures and equipment. Intellectual property products are research and development; software; and entertainment, literary, and artistic originals.

SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts, National Income and Product Account Tables, Private Fixed Investment in Structures by Type, table 5.4.5 (millions), Private Fixed Investment in Equipment by Type, table 5.5.5 (millions), and Gross Government Fixed Investment by Type, table 5.9.5 (millions), available at https://apps.bea.gov/iTable/index_nipa.cfm as of September 2022.

Cost of Transportation

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

Fuel Prices

Fuel prices are a cost to industries that produce transportation services as well as to consumers. These industries embed the costs in the price they charge businesses and households—for the transportation services they provide for a fee. The period spanning 2020 to 2021 had the largest year-over-year increase in inflation adjusted terms for motor gasoline (all types) and the second largest increase for jet fuel and on-highway diesel since 1990 (Figure 4-14). Despite the increase, jet fuel, on-highway diesel, and motor gasoline (all types) prices remain below the peak reached in 2012, by 37.0, 31.2, and 15.2 percent, respectively.

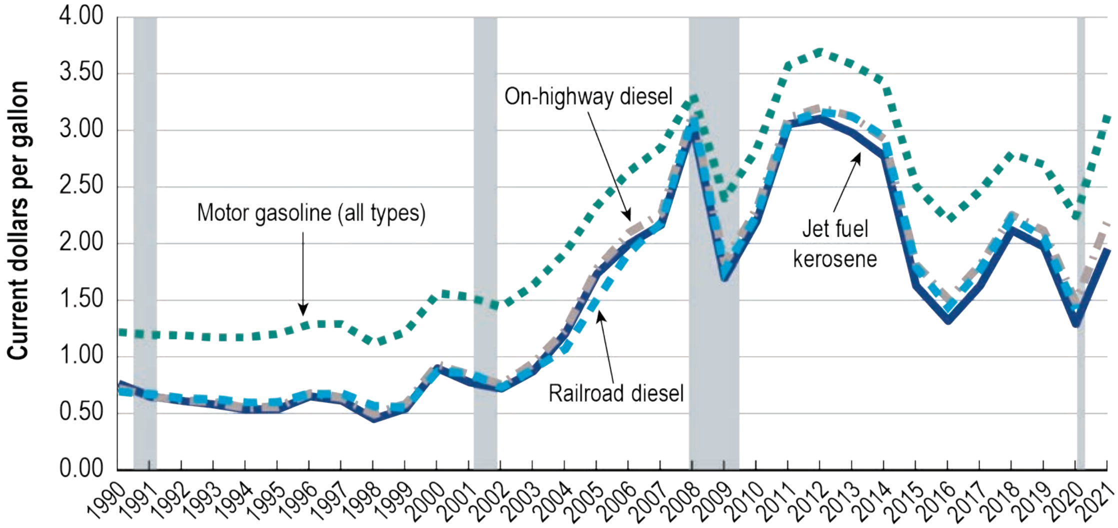
Prices Faced by Businesses Purchasing Transportation Services

Fuel, labor, and shipping rate, among other factors, affect the prices for-hire transportation providers charge for their services. The producers' price index (PPI) measures the average change over time in the amount producers receive for their output. The amount received by producers for selling their transportation services (e.g., airfares) are an indicator of the prices faced by households and businesses purchasing transportation services (e.g., airfare and shipping rates faced by households and businesses). In 2021, the costs for rail, truck, and water transportation services reached their all-time high level, suggesting an increase in the costs businesses face for providing these transportation services. Truck transportation service saw the largest price increase of 12.8 percent from 2020 to 2021, followed by water (7.5 percent) and rail transportation (4.9 percent). Air transportation saw the smallest increase of 0.9 percent after experiencing the largest decrease of 10.9 percent in 2020 (Figure 4-15). Like when faced by higher prices for labor, businesses may raise the prices they charge consumers for goods and services when they face higher prices for producing transportation services.

Transportation and Inflation

Inflation occurs when prices rise and purchasing power weakens over time. Inflation includes the prices faced by consumers for transportation, as measured by the Consumer Price Index (CPI)

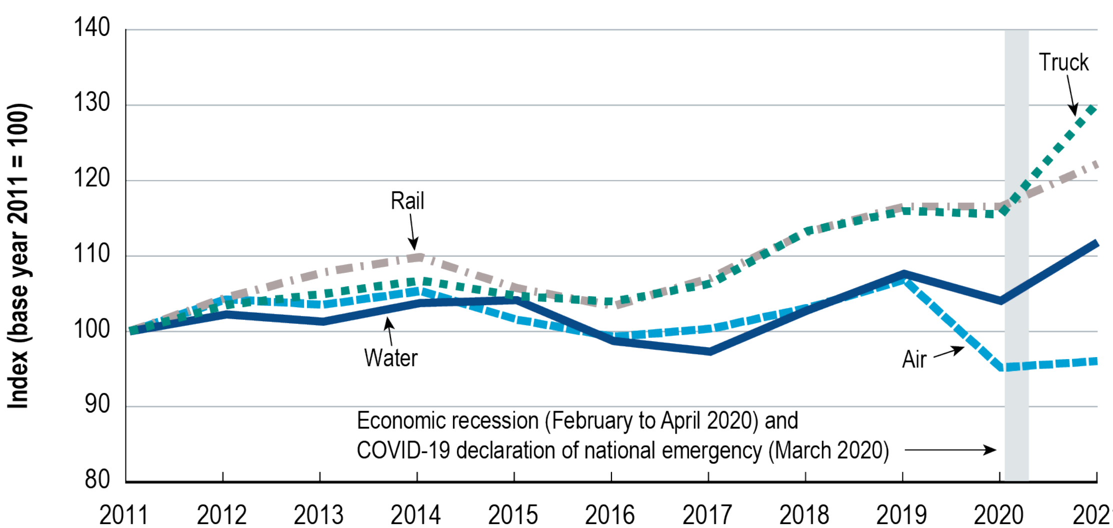
Figure 4-14 Sales Price of Transportation Fuel to End-Users (Current Dollars/Gallon): 1990–2021



NOTES: Motor gasoline and on-highway diesel fuel prices are retail prices and include taxes paid by the end-user. Gasoline price is the average retail price for regular and premium (leaded and unleaded) gasoline. On-highway diesel does not include biodiesel or other alternative fuels. Jet fuel prices are based on sales to end-users (sales made directly to the ultimate consumer, including bulk customers in agriculture, industry, and utility) but do not include tax. Railroad diesel fuel prices are the average price paid by freight railroads and include taxes paid. Shaded bars indicate economic recessions.

SOURCE: Bureau of Transportation Statistics, National Transportation Statistics, table 3-11: Sales Price of Transportation Fuel to End-Users (current cents / gallon), available at www.bts.gov as of September 2022.

Figure 4-15 Producer Price Indices for Producers of Selected Transportation and Warehousing Services: 2011–2021



NOTE: Producer Price Index data come from the U.S. Bureau of Labor Statistics.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index Industry Data, available at http://www.bls.gov/ppi as of September 2022.

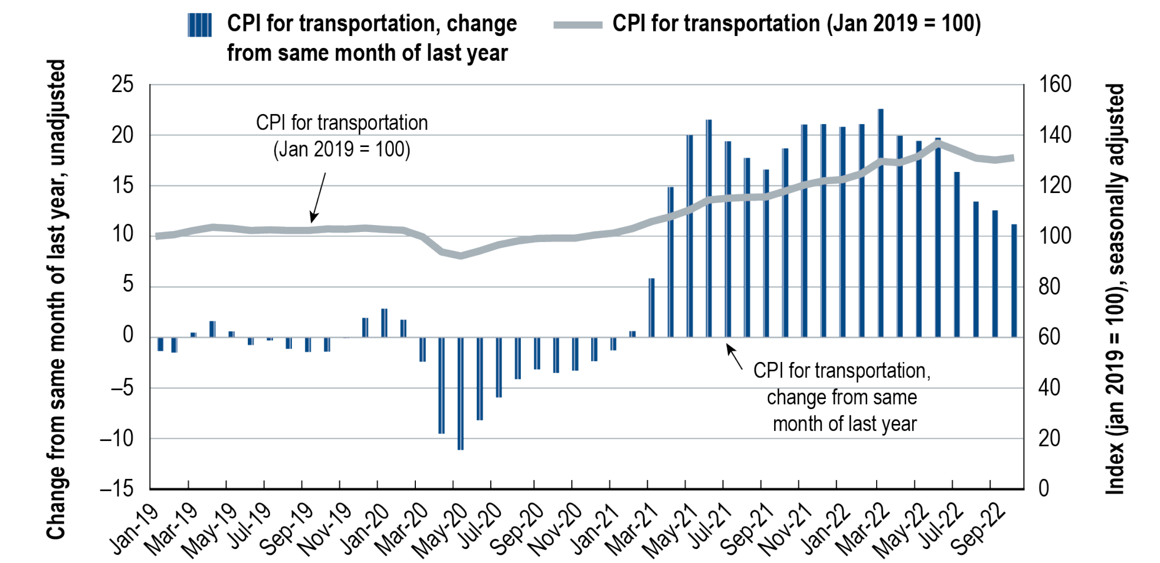
for items such as motor vehicles, gasoline, and airfares. It also includes the transportation costs, as measured in the Producer Price Index (PPI), that manufacturers, wholesalers, and retailers pass onto consumers in the prices they charge for their goods and services.

After steadily increasing since June 2020 to reach a new high in June 2022, the seasonally adjusted transportation CPI began to decline in June 2022 (Figure 4-16) —falling for three consecutive months before increasing slightly in October 2022.[8] The decline has brought transportation's contribution to year-over year price increases in all goods and services down, reaching its lowest share since February 2021 in September 2022 (Figure 4-17). Transportation's contribution had reached a high of 58.6 percent in June 2021 due to high fuel prices and supply chain issues that drove up the cost of used vehicles [BTS 2022c].

Transportation providers have faced increasing fuel and transportation equipment costs and as a result, producers have seen price increases for transportation services. Producers also have seen increases due to external factors, such as increased demand for imports and supply chain issues amplified by COVID-19. The price increases can be seen across multiple modes. Truck spot rates rose from mid-2020 (after falling during the February to April 2020 economic recession) through early 2022, corresponding with the increase in diesel fuel prices from 2020 to May 2022 (Figure 4-18) but also with increased demand for goods—seen through real

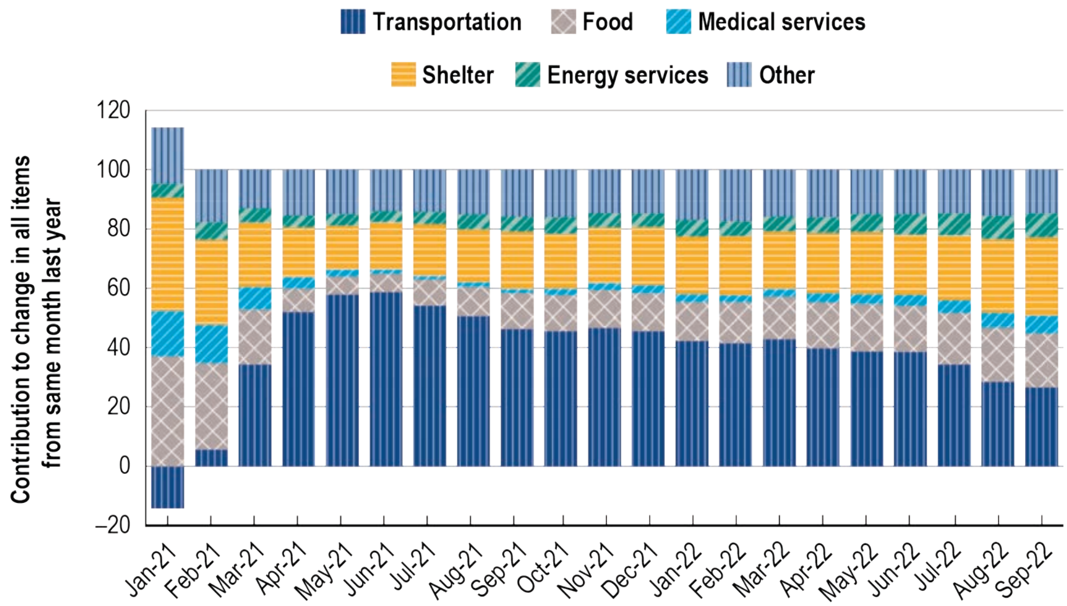
[8] The transportation CPI is the official measure of the price paid by consumers for transportation goods and services over time and hence a measure of inflation. Overall transportation includes private transportation (made up of new and used motor vehicles, motor fuel, motor vehicle parts and equipment, motor vehicle maintenance and repair, motor vehicle insurance, and motor vehicle fees) and public transportation (made up of airline fares, other intercity transportation, intracity transportation, and public transportation).

Figure 4-16 Consumer Price Index for Overall Transportation, Change from Same Month of the Previous Year (Unadjusted) and Seasonally Adjusted Value: January 2019–October 2022



SOURCE: Calculated by the U.S. Department of Transportation from the U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index, All Urban Consumers, U.S. City Average, seasonally adjusted (CUSR0000SAT) and unadjusted (CUUR0000SAT), available at www.bls.gov/cpi as of December 2022.

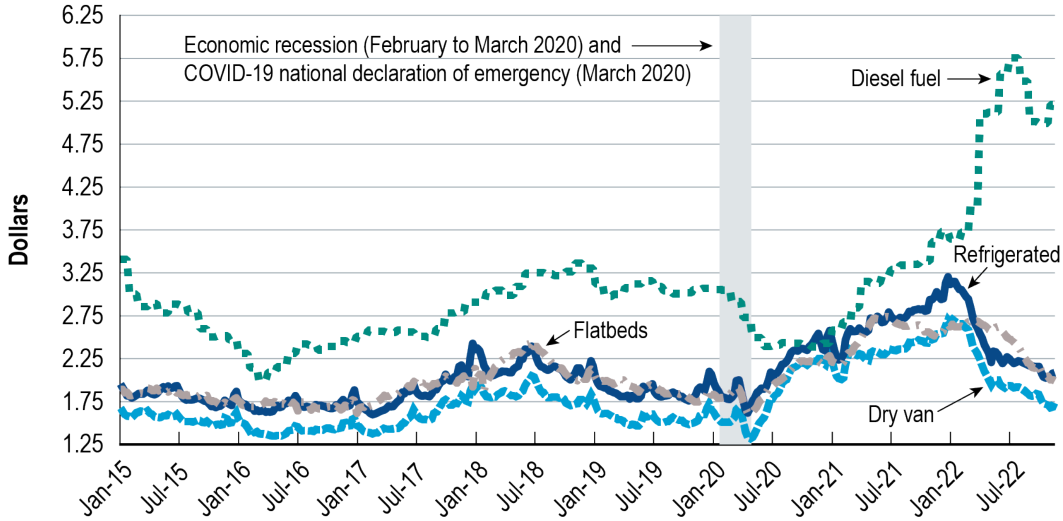
Figure 4-17 Contribution of Transportation to Inflation Compared to Food, Shelter, and Medical Services: January 2021–October 2022



NOTE: Energy services are services such as electricity and utility (gas) piped service.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, All Urban Consumers (Current Series), Unadjusted, US City Average, news release table 7, available at https://www.bls.gov/bls/news-release/cpi.htm.

Figure 4-18 Truck Spot Rates in Dollars Per Mile and Price of Diesel Fuel per Gallon: January 2015–November 2022



NOTE: This data is for spot market trucking loads, which is approximately one-tenth of the overall common carrier trucking market. The data provider (DAT) is the largest clearinghouse for shipments that are not part of a pre-existing hauling contract. Dry van includes freight transported in enclosed cargo holds.

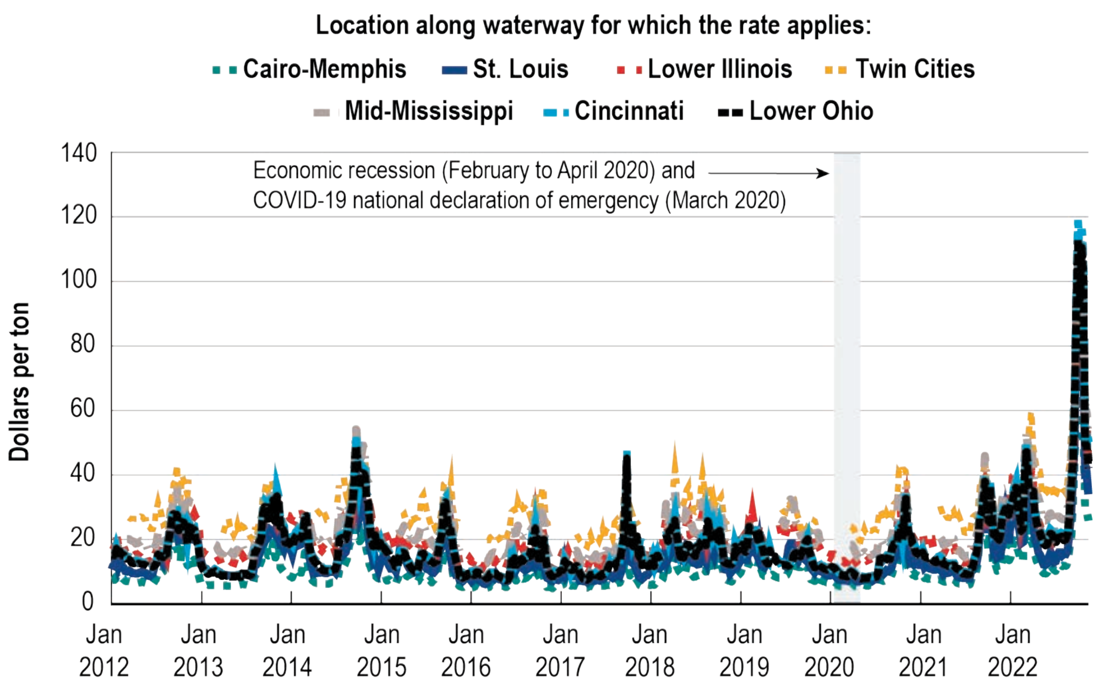
SOURCE: DAT Freight Analytics.

increases in imports and personal consumption expenditures.[9] Despite fuel price increases in 2021, downbound barge rates remained fairly stable in 2021, hovering around $20 per ton, before increasing in the fall of 2022 when the Mississippi River fell to record low levels (Figure 4-19). External factors likewise contributed to the rise in ocean freight rates. COVID-19 increased the demand for imported goods, which combined with port issues (e.g., congestion, labor disputes, and COVID-19 protocols) and the control of a few companies over prices, caused freight container shipping rates from Central China to the U.S. West Coast to rise 578 percent from February 2020 (the month prior to COVID-19 being declared a national emergency) to August 2021 [White House 2022]. Ocean freight rates from Central China to the United States have fallen, but as of October 2022, remain 211.0 percent above the pre-pandemic rate (Figure 4-20).

Producers, such as automotive manufacturers, purchase a variety of services to acquire raw materials, produce goods and services, and move their products to market. From January 2021 through July 2022, transportation and related services, such as freight forwarding,

[9] See U.S. Department of Transportation, Bureau of Transportation Statistics, Latest Supply Chain Indicators, Personal Consumption on Durable Goods and U.S. Goods Imports, available at https://www.bts.gov/freight-indicators#durable as of December 2022.

Figure 4-19 Downbound Grain Barge Rates (Dollars per Ton): January 2012



NOTES: Weekly barge rates for downbound freight originating from seven locations along the Mississippi River System, which includes the Mississippi River and its tributaries (e.g., Upper Mississippi River, Illinois River, Ohio River, etc.). The seven locations are: (1) "Twin Cities," a stretch along the Upper Mississippi; (2) "Mid-Mississippi," a stretch between eastern Iowa and western Illinois; (3) "Illinois River," along the lower portion of the Illinois River; (4) "St. Louis"; (5) "Cincinnati," along the middle third of the Ohio River; (6) "Lower Ohio," approximately the final third of the Ohio River; and (7) "Cairo-Memphis," from Cairo, IL, to Memphis, TN. Under the percent-of-tariff system, each city on the river has its own benchmark, with the northern most cities having the highest benchmarks. They are as follows: Twin Cities = 619; Mid-Mississippi = 532; St. Louis = 399; Illinois = 464; Cincinnati = 469; Lower Ohio = 446; and Cairo-Memphis = 314. Breaks in the lines indicate no rate record for that week at that location.

SOURCE: United States Department of Agricultures, Downbound Grain Barge Rates, available at https://agtransport.usda.gov/Barge/Downbound-Grain-Barge-Rates/deqi-uken as of December 2022.

contributed an increasing share to the year-over-year increase in the price for all services purchased by producers. Transportation and related services have accounted for a progressively smaller share of inflation since July 2022, reaching its lowest share since August 2021 in September 2022 (Figure 4-21).

Data Gaps

Needs for the Future

Changes induced by the COVID-19 pandemic, including price increases and supply chain issues, underscore the need for:

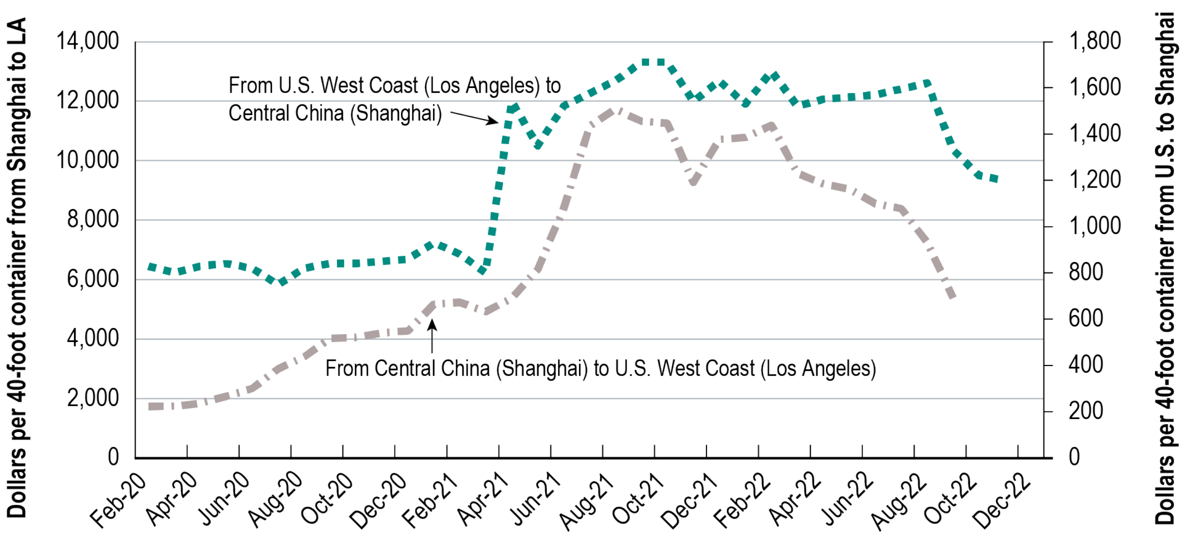
- Timely data on the volume of transportation services to better gauge the current supply and demand for freight transportation services and
- Granular employment data to measure unmet transportation labor needs.

In addition, decision makers would benefit from:

- Information related to the economic contribution of shared transportation services (e.g., ride-hailing and bikeshare),
- Timely data to measure public transportation expenditures and revenue across all levels of government, and
- Expanded financial statistics to measure innovative finance in transportation, such as public–private partnerships.

BTS has begun to improve and expand its transportation financial data series.

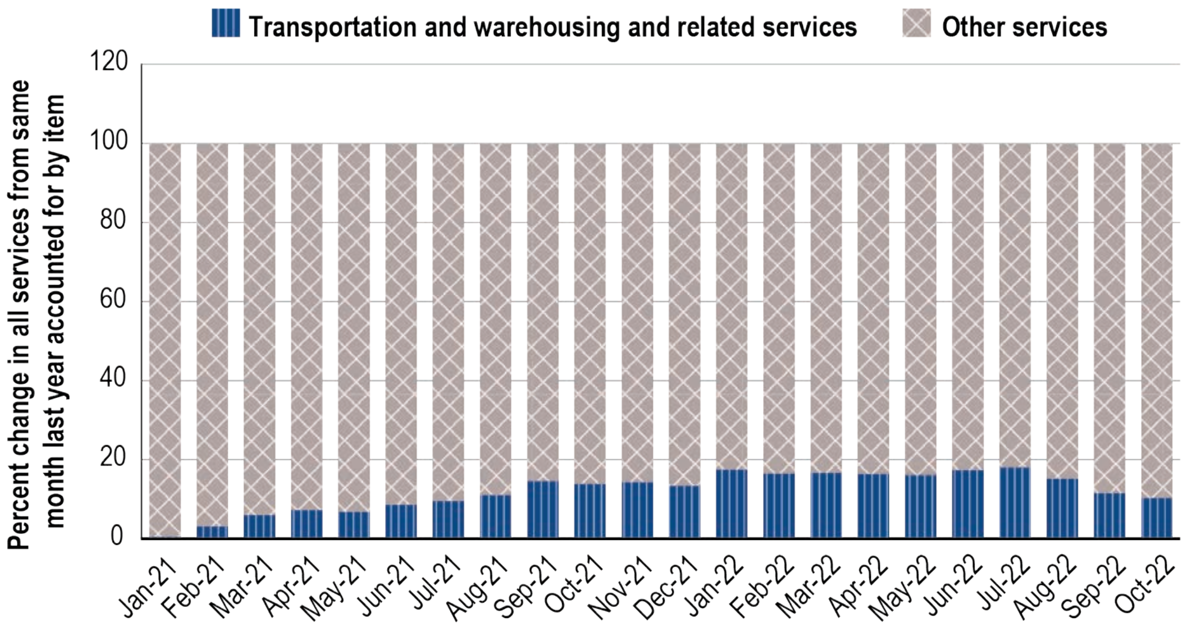
Figure 4-20 Freight Rates in Dollars per 40 foot container from Central China (Shanghai) to U.S. West Coast (Los Angeles): February 2020–September 2022



NOTE: Spot ocean freight rates for a single container transaction in the selected eastbound transpacific trade routes.

SOURCE: U.S. Department of Agriculture, Agricultural Market Service, Container Ocean Freight Rates from Drewry Supply Chain Advisors' Container Freight Rate Insight.

Figure 4-21 Contribution of Transportation and Related Services to Inflation Faced by Producers of Goods and Services: January 2021–October 2022



NOTES: Includes air transportation of freight, airline passenger services, rail transportation of freight and mail, rail transportation of passengers, truck transportation of freight, courier and messenger services (except air), U.S. postal service, arrangement of freight and cargo, marine cargo handling, operation of port waterfront terminals, airport operations (excluding aircraft maintenance and repair), towing, tugging, docking, and related services, freight forwarding, warehousing, storage, and related services purchased by industries to produce output.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics' calculations from U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index (Current Series), Unadjusted WPU301601, WPU301602, WPU3021, WPU3022, WPU3011, WPU3012, WPUFD42, WPU3131, WPU3132, WPU3211, WPU3111, WPU3112, WPU3113, and WPU3121, available at https://www.bls.gov/ppi/data.htm.

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CHAPTER 5
Transportation Safety

Introduction

While transportation is safer today than a generation or two ago, it continues to be risky—especially on the Nation's highways, which account for 95 percent of the fatalities and over 99 percent of the injuries from transportation incidents. Transportation incidents claimed 40,851 lives in 2020, of which all but 2,027 involved highway motor vehicles.

Fatalities involving highway motor vehicle crashes and collisions rose sharply in 2020, the first year of the COVID-19 pandemic, resulting in 38,824 fatalities—nearly 2,500 more than in

Highlights

- In 2020, the most recent year with complete data, more than 40,000 people died and 2.3 million were injured in transportation incidents.
- In the 3 years prior to the start of the pandemic in early 2020, highway fatalities, people injured, and crashes were trending downward, although still above the 60-year low reached in 2011.
- In 2020, fatalities for all modes of transportation rose 6.3 percent over 2019, people injured fell 16.3 percent, and crashes and accidents fell 22.3 percent.
- Highways remained the dominant cause of transportation fatalities (about 94 percent), people injured (99 percent), and crashes and accidents (about 99.6 percent) in 2020, the last year for which crash and injury data are complete.
- Highway fatalities in the first year of the pandemic increased in spite of the decline in vehicle miles traveled (VMT), resulting in a 2020 fatality rate of 1.34 deaths per 100 million VMT, compared to 1.11 in 2019. The 2020 rate was the highest rate since 2008.
- In 2020, rural areas continued to have a highway fatality rate notably higher per 100 million VMT than urban areas: 1.84 vs. 1.08.
- Contributing factors to the rise in the highway fatality rate during 2020 include increased speeding, alcohol use, and failure to wear safety belts.
    - Speeding coupled with drinking is common in highway crashes. Specifically, 37 percent of speeding drivers in fatal crashes in 2020 were found to be alcohol-impaired Blood Alcohol Content (BAC) of 0.08 or above compared to just 17 percent of non-speeding drivers in fatal crashes.
    - About 46 percent of the drivers in fatal speeding-related crashes in 2020 were not wearing seat belts at the time of the crash, versus 21 percent of drivers involved in non-speeding fatal crashes [USDOT NHTSA 2022a].

Continued »

Highlights Continued

- The estimated economic costs of alcohol-impaired highway crashes in 2010 was $44 billion, and $201.1 billion when quality of life considerations were included. This is nearly one-fourth of the $836 billion estimated total societal cost of motor vehicle accidents in 2010 [USDOT NHTSA 2018c].
- While highway fatalities went up, people injured went down in 2020. On average, 1 person was injured in every 2.5 crashes in 2019, but this ratio fell to 1 person injured for every 2.3 crashes in 2020.
- The projected 2021 traffic fatality rate per 100 million VMT is 1.33, lower than the 2020 rate of 1.34. The projected 2022 traffic fatality rate per 100 million VMT for the first half of the year is 1.27, lower than the projected rate of 1.30 for the first half of 2021.Highlights

2019. This was a surprise given the reduced level of highway travel in 2020 during the pandemic. Highway travel increased in 2021 and so did motor vehicle involved deaths—which neared 43,000, a level of fatalities last seen in 2005. NHTSA's early estimates for the first two quarters of 2022 suggest a minimal increase of 0.5 percent compared to the same quarters of 2021 [USDOT NHTSA 2022k].

As for the other transportation modes, rail and transit rail, air, water, and pipelines collectively had a slight increase in fatalities between 2019 and 2020—1,879 vs. 2,027—but rail, transit, and water fatalities all increased in the 2020–2021 period compared to 2019.

This chapter discusses recent transportation fatality and injury statistics, focusing especially on 2019, 2020, and 2021 (and partial 2022 data as available), thus illuminating changes in transportation safety from just before to during the first 2 years of the on-going COVID-19 pandemic. It also examines data on factors that contribute to crashes and accidents, progress made to improve safety, and the challenges that remain. Data on transportation fatalities, injuries, and accidents are incomplete for 2021, so a complete view of COVID-19 consequences for transportation safety is limited to the first 10 months of the pandemic.

Fatalities and People Injured by Mode

Transportation's toll in fatalities and people injured is notably high—the number two cause of unintentional fatalities when all modes are considered [USDHHS CDC WISQAR]. Figure 5-1 shows the transportation fatalities by mode in 2020, when nearly 41,000 people died, and Table 5-1 shows deaths in 2010 and from 2016–2021.[1] Over 2.3 million people were injured in transportation crashes and accidents in 2020, with more than 99 percent of injuries attributable to highway motor vehicles (Table 5-2).

Owing to a change in estimation procedures, injury estimates are only given for 2016 and onwards in Table 5-2, with no estimate provided for 2010. Appendix D discusses why fatality and other safety data differ among various sources.

Highway Motor Vehicles[2]

As shown in Figure 5-1, highway motor vehicles were involved in about 94 percent of

[1] As for the decade between 2011 and 2020, about 376,000 people died in transportation incidents, of which all but about 22,000 involved highway motor vehicles. While fatalities averaged about 37,600 fatalities per year over the 10 years, there was considerable year-by-year variation: deaths in 2011 were at their lowest point in 6 decades, then rose for 5 straight years through 2016, before falling in 2017–2019 and then rising steeply in 2020, the first pandemic year.

[2] Highway-Rail Grade crossing crashes are discussed in the subsection of the chapter called "Ignoring risks and warnings."

all transportation fatalities in 2020, and also, as shown in Table 5-2, over 99 percent of people were injured in U.S. transportation crashes and incidents. Both the number and rate of highway fatalities have decreased over the last half-century—with deaths falling from a yearly rate of more than 5 per 100 million VMT in the 1960s to 1.08 per 100 million VMT in 2014, a historic low point. The fatality rate subsequently fluctuated before jumping from 1.11 in 2019 to 1.34 in the pandemic year 2020, the largest annual rise on record [USDOT NHTSA 2022a].

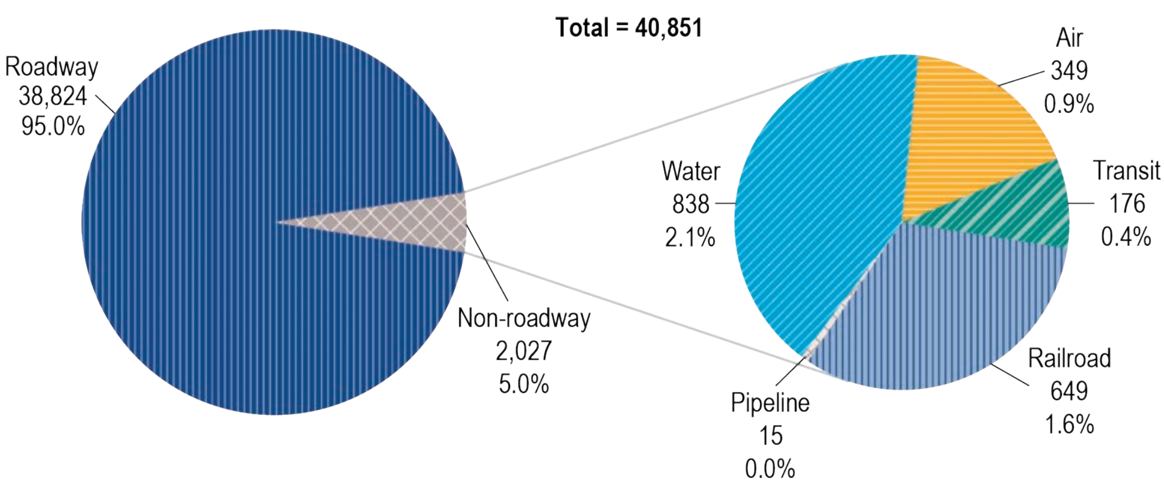
The 2010 to 2020 period saw a dramatic increase in highway fatalities, with increases projected to continue through 2021 and at least the first half of 2022 [USDOT NHTSA 2022k]. In 2011 fatalities had fallen to 32,479, the lowest number since 1949. Over the next 5 years, fatalities rose, reaching 37,806 in 2016, then declined each year in 2017, 2018, and 2019, but were still 12 percent more than in 2011. Then came the pandemic in 2020, with dramatic increases in fatalities followed by estimates of an even higher increase in 2021, with road fatalities projected to surpass 40,000, a level not seen in 15 years [USDOT NHTSA (a)]. Early estimates for the first half of 2022 project yet another increase of 0.05 percent in highway fatalities over what NHTSA had projected for the first half of 2021 [USDOT NHTSA 2022k].

As discussed in appendix D, the rise in highway fatalities in the pandemic year 2020 could be associated with risky behaviors by vehicle occupants, as evidenced by

- A 17 percent increase in deaths in speed-related crashes,
- A 14 percent increase in deaths from alcohol-impaired driving crashes, and
- A 21 percent increase in deaths from vehicle occupants being ejected (reflecting a failure to wear a seat belt).

Data are not yet available to determine if theses same factors may contribute to the projected high number of fatalities for 2021. It is also possible that additional factors are affecting

Figure 5-1 Transportation Fatalities by Mode: 2020



NOTES: Transit and Railroad counts include some roadway fatalities. Caution must be exercised in comparing fatalities across modes because significantly different definitions are used. In particular, Rail and Transit fatalities include incidents that do not involve vehicles, such as fatalities from falls in transit stations or railroad employee fatalities from a fire in a work shed.

SOURCE: U.S. Department of Transportation, National Roadway Safety Strategy (February 2022), available at www.transportation.gov as of September 2022..

highway safety not yet isolated from the data [USDOT NHTSA 2022a].[3]

Fatalities of nonoccupants—pedestrians, bicyclists, and other cyclists[4], and other nonoccupants—increased by 2,310, from 5,110 in 2010 to 7,420 in 2019 and then rose another 3.9 percent in 2020 [USDOT NHTSA 2022a]. Nonoccupants accounted for just under 20 percent of U.S. motor vehicle related deaths

[3] A change instituted with the release of 2020 data rounds people injured, injury crash, and property-damage-only crash estimates to the nearest whole number. Prior year reports presented these estimates rounded to the nearest thousand.

[4] Bicyclists and other cyclists including riders of two-wheel, non-motorized vehicles, tricycles, and unicycles powered solely by pedals.

Table 5-1 Transportation Fatalities by Mode: 2010 and 2016–2021

Mode	2010	2016	2017	2018	2019	2020	2021	Change from 2019 to 2020
TOTAL fatalities	**35,040**	**39,748**	**39,364**	**38,755**	**38,425**	**40,851**	**U**	▲
Air	477	408	347	395	452	349	U	▼
Highway	32,999	37,806	37,473	36,835	36,355	38,824	(P) 42,915	▲
Railroad[1]	631	631	677	662	727	649	762	▼
Transit rail[2]	197	150	151	174	173	176	176	▲
Water	821	737	709	682	707	838	696	▲
Pipeline	22	16	7	7	11	15	13	▲
Other counts, redundant with above								
U.S. Air carrier[3]	2	0	0	1	4	0	U	▼
On-demand air taxi and commuter carrier	17	27	16	16	34	26	U	▼
General aviation	458	386	331	379	414	332	U	▼
Railroad, trespasser deaths not at highway-rail crossing	441	468	505	499	536	518	614	▼
Railroad, killed at public crossing with motor vehicle	136	130	140	132	128	94	128	▼
Rail, passenger operations	215	254	307	255	266	197	234	▼
Rail, freight operations	520	507	510	539	590	546	656	▼
Transit, non-rail	102	109	98	86	95	113	146	▲
Recreational boating	672	701	658	633	613	767	658	▲
Commercial waterborne	149	36	51	49	94	71	38	▼

[1]Includes Amtrak. Fatalities include those resulting from train accidents, highway-rail crossing incidents, and other incidents.

[2]Includes transit employee, contract worker, passenger, revenue facility occupant, and other fatalities for all modes reported in the National Transit Database.

[3]Air carriers operating under 14 CFR 121, scheduled and nonscheduled service.

NOTES: Highway-2021 is a statistical projection of 2021 fatalities. For more information, see the complete notes from the source. **Pipeline** fatalities includes those resulting from asphyxiation, fire, and explosions, which include causes such as excavation, natural or outside forces, and other causes of damage or failure. ***Other counts, redundant with above*** help eliminate double counting in the Total fatalities. See NTS table 2-1 in source below for adjustments to avoid double counting, complete source notes and an expanded time-series.

SOURCES: Various sources as cited by U.S. Department of Transportation, Bureau of Transportation, National Transportation Statistics, table 2-1, available at www.bts.gov as of August 2022. **Highway-2021:** U.S. Department of Transportation, National Highway Traffic Safety Administration, *Early Estimates of Motor Vehicle Traffic Fatalities And Fatality Rate by Sub-Categories in 2021*, DOT HS 813 298, Available at https://crashstats.nhtsa.dot.gov as of September 2022..

in 2020 [USDOT NHTSA 2022a]. However, pedestrian deaths remain below the high point of 8,096 in 1979 [as cited in USDOT BTS NTS table 2-1].

Some other countries of comparable economic status to the United States have shown greater reductions in highway fatalities on a per-capita basis, both in recent decades and during the pandemic. The 27 countries of the European Union (EU)—excluding the United Kingdom, which left the EU in early 2020—reduced their road fatalities by 36 percent between 2010 and 2020.

Analysts often examine two categories of people when looking at safety data: those inside the vehicle and those outside the vehicle (including motorcycle riders and passengers). Between 1996 and 2020, the share of fatalities of people inside vehicles (occupants) fell while the share of fatalities outside vehicles rose—from an 80:20 percent ratio in 1996 to a 66:34 percent ratio in 2020. In 2020, all categories of fatalities, whether inside or outside vehicles, increased from 2019, except for occupants of vans and large trucks [USDOT NHTSA 2022a].

In 2020, 5,579 motorcyclists died, the highest number since NHTSA began collecting statistics in 1975. This was an 11 percent increase, and 535 more deaths than in prepandemic 2019. Factors that may contribute to the increase include increased ridership, the increasing age of riders, reduced helmet usage, speeding, and alcohol impairment [USDOT NHTSA 2022a].

Table 5-2 Transportation Injuries by Mode: 2016–2020

Mode	2016	2017	2018	2019	2020	Change from 2019 to 2020
TOTAL	**3,080,975**	**2,762,866**	**2,727,427**	**2,757,277**	**2,304,701**	▼
Air	240	229	271	260	202	▼
Highway[a]	3,061,885	2,745,268	2,710,059	2,740,141	2,282,015	▼
Railroad	8,027	8,890	8,326	7,997	5,503	▼
Transit rail	7,264	6,307	6,368	6,648	4,094	▼
Water	3,357	3,084	3,004	3,002	3,536	▲
Pipeline	87	32	78	36	42	▲
Other counts, redundant with above						
U.S. Air carrier[b]	0	0	1	4	0	▼
On-demand air taxi and commuter carrier	27	16	16	34	26	▼
General aviation	386	331	379	414	332	▼
Railroad, injured at public crossing with motor vehicle	468	505	499	536	518	▼
Transit, non-rail	109	98	86	95	113	▼
Recreational boating	701	658	633	613	767	▲
Commercial Wterborne	36	51	49	94	71	▼

[a]2016–2020 estimates are not comparable to earlier year estimates due to methodology change.

[b]Air carriers operating under 14 CFR 121, scheduled and nonscheduled service.

NOTE: Please see the National Transportation Statistics table 2-2 in source below for complete source notes and an expanded time-series.

SOURCES: Various sources as cited U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics (NTS), table 2-2. Available at www.bts.gov as of August 2022; Highway-2020: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Overview of Motor Vehicle Crashes in 2020*, DOT HS 813 266, Available at https://crashstats.nhtsa.dot.gov as of September 2022.

In the 10 years between 2011 and 2020, motorcyclist fatalities for the 55-and-older age group rose from 23 to 27 percent. The average age of motorcycle riders who died in crashes increased from 40 in 2008 to 43 in 2020. The number of motorcyclist fatalities per 100 million VMT was about 28 times greater than that for passenger car occupants [USDOT NHTSA 2022c].

Large-truck occupant fatalities increased each year between 2015–2019, as fatalities climbed to 893 in 2019—up from 530 in 2010—but declined in 2020 to 831. Every year, several times as many people outside large trucks (e.g., occupants of other vehicles and nonoccupants) die in large truck crashes as the truck occupants. The occupants of other vehicle fatalities in large truck crashes had fallen to under 3,000 in 2009, but subsequently increased in most years, and has exceeded 3,500 in every year since 2017. There were 4,134 deaths for people outside of large trucks in 2020 crashes involving large trucks, 5 fewer than in 2019 [USDOT NHTSA 2022i].

Some fatalities and people injured from motor vehicle incidents take place off of public roadways (e.g., pedestrians struck in driveways, people injured in parking lot collisions, bicyclists hit on private roads, and children and other people unintentionally run over in driveways)

Box 5-A COVID-19 and Highway Safety: 2020 vs. 2019

38,824 people died on U.S. roads in 2020.

Fatalities compared to 2019's *36,355:*

- ▲ 6.8% overall
- ▲ 21% rate per 100 million VMT
- ▲ 14% in alcohol-impaired-driving crashes
- ▲ 17% in speeding-related crashes
- ▲ 11% motorcyclists
- ▲ 3.9% pedestrians
- ▲ 14% unrestrained passenger vehicle occupants
- ▲ 21% ejected passenger vehicle occupants
- ▲ 9.4% in single-vehicle crashes
- ▲ 8.5% in urban areas
- ▲ 12% during nighttime
- ▲ 9.5% during weekend

Estimated 2,282,015 people injured on U.S. roads in 2020.

Injured compared to 2019's *2,740,141:*

- ▼ 17% overall
- ▼ 6.0% rate per 100 million VMT
- ▼ 17% drivers and passengers
- ▼ 1.5% motorcyclists
- ▼ 28% pedestrians
- ▼ 21% pedalcyclists
- ▼ 7.8% people in large-truck crashes
- ▲ 4.1% large-truck occupants in single-vehicle crashes
- ▼ 10% other people in large-truck crashes
- ▼ 40% nonoccupants in large-truck crashes

Estimated 5,215,071 non-fatal crashes on U.S. roads in 2020.

Non-fatal crashes compared to 2019's 6,756,084:

- ▼ 22% overall
- ▼ 17% injury crashes
- ▼ 25% property-damage-only (PDO) crashes
- ▼ 6.8% injury crash rate per 100 million VMT
- ▼ 15% PDO crash rate per 100 million VMT

Travel patterns compared to 2019:

- ▼ 11% overall VMT

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration. *Overview of Motor Vehicle Crashes in 2020*. March 2022. DOT HS 813 70. Available at www.nhtsa.gov/ as of September 2022.

and are not usually included in roadway statistics. The National Highway Traffic Safety Administration (NHTSA) has been surveilling these incidents since 2007 and released its latest annual estimates for the 2016 through 2020 period in September 2022 [USDOT NHTSA 2022m]. NHTSA found that 12,247 people died in these non-traffic incidents over these 5 years, an average of 2,449 people per year. On average, about 87,000 people from non-traffic incidents were estimated to be injured each year as well. The number of fatalities went up each of these year too, with 3,157 fatalities in 2020. The number of people injured in non-traffic incidents declined each year, with the low point, 66,426, occurring in 2020. These fatalities and people injured are normally not added to NHTSA's annual totals for highway fatalities and people injured; the combined annual total in 2020 would be 8.1 percent more if the motor vehicle involved non-traffic fatalities are added in.

The figure shows the contrasts between 2019 and 2020 for deaths from fatal motor vehicle crashes, people injured in crashes, and the estimated outcomes from non-fatal crashes.

In 2019, the calendar year before the pandemic, motor vehicles accounted for 36,355 fatalities and 2.7 million people injured. There were declines in fatalities in March, April, and May 2020 due to a sharp drop in driving, but motor vehicle fatalities increased dramatically in the remaining months so that deaths for the full 2020 year rose by 2,469. Projections for 2021 anticipate a further 10.5 percent rise in fatalities over 2020, when VMT very nearly returned to pre-pandemic levels.

The COVID-19 pandemic was officially declared a national emergency on March 13, 2020. As shown, after the decline in deaths and VMT in March, April, and May, highway vehicle fatalities moved sharply higher in the remaining months of 2020 compared to the same months in 2019, even though the VMT remained below 2019 levels (Figure 5-2). While the number of fatal crashes increased, injury crashes declined, as did property-damage-only crashes—an outcome more in line with expectations, given reduced VMT.

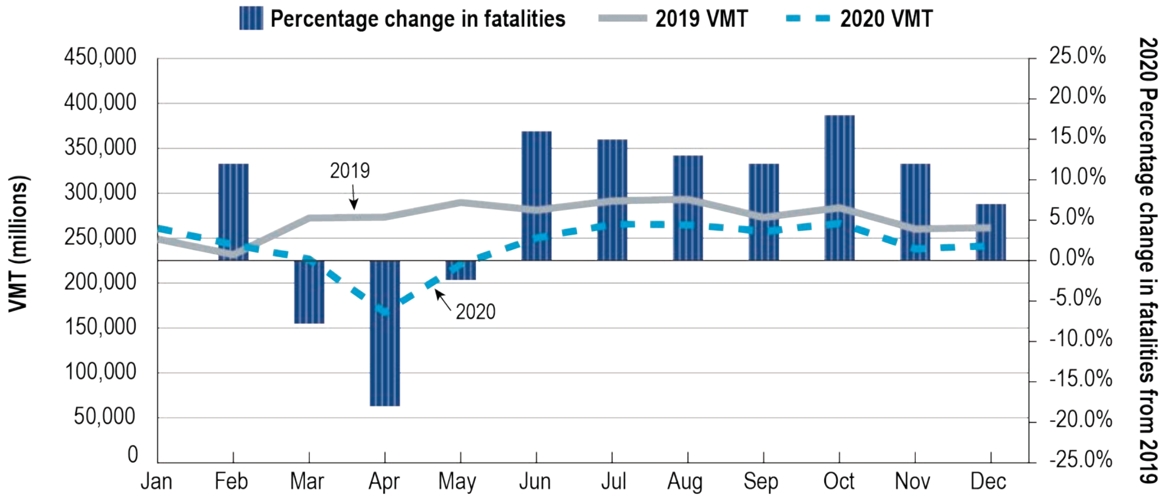
For the year 2020, highway fatalities increased by 6.8 percent despite an 11 percent decrease in VMT. VMT rebounded in 2021 to nearly the level in 2019, and fatality projections for 2021 post a further increase of 10.5 percent in fatalities compared to 2020.

Interestingly, the number of people injured in highway crashes declined by 17 percent in 2020, and the number of non-fatal crashes decreased by 22 percent. Fender benders and similar property-damage-only crashes declined by 25 percent. These reductions appear to be in line with the reduction in VMT, which declined by 11 percent overall. The ratio of fatalities to injuries between 2019 and 2020 changed from 0.0132 to 0.0170, a 28 percent increase, while the ratio of fatalities to total crashes changed from 0.0054 to 0.0074, a 37 percent increase. The ratio of people injured to total crashes also increased, but not as steeply—from 0.4056 in 2019 to 0.4346 in 2020, an increase of about 7 percent.

Differences in Highway Fatalities by Sex and Age

The number of highway fatalities varies significantly by sex and age. Although males comprise about half of the U.S. population (estimated at 49 percent according to the U.S. Census) and 48 percent of VMT, they accounted for 72 percent of highway fatalities in 2020. About 2.6 males died in highway crashes to every 1 female that year—28,033 males vs. 10,690 females [USDOT NHTSA 2022a]. The number of males killed in 2020 was up 8.6 percent from 2019, versus 1.9 percent for females.

Figure 5-2 VMT and Percentage Change in Fatalities by Month: 2019 and 2020



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration. Over-view of Motor Vehicle Crashes in 2020. March 2022. DOT HS 813 70. Available at www.nhtsa.gov/ as of September 2022.

Males, on average, drive about 6 more miles per day than females—about 22.2 versus 16.1 miles [USDOT FHWA 2018]. Also, males account for large majorities of the three categories of road users for whom fatality numbers have risen most in recent years, accounting for about

- 71 percent of pedestrian fatalities,
- 87 percent of bicycle fatalities, and
- 92 percent of motorcycle fatalities in 2020 [IIHS no date].

Males are the drivers in 72 percent of fatal crashes and have a higher risk than females of being the driver in fatal crashes as measured by100 million miles of vehicle travel. They are also more likely than females to be speeding (30 vs. 20 percent) and to be alcohol impaired (33 vs. 23 percent) when they are in fatal crashes [IIHS no date].

In every age group in 2020, male drivers have higher rates of involvement in fatal crashes than females. Involvement rates for the 16 to 20 year age group are the highest, with the rate for teenage males over twice that of their female cohort. Thereafter, involvement rates decline for both sexes in all age groups until age 75 and above, when they again rise [NHTSA 2022a].

Despite the continued high involvement rate for teenage drivers in fatal crashes, that rate is appreciably lower than in earlier decades. Many factors contributed to this decline, including greater adoption of graduated licensing systems, restrictions on nighttime driving, and prohibiting teenage drivers from having teenage passengers in their car [IIHS no date].

Rural/Urban Highway Fatalities

Urban area highway fatalities first exceeded those in rural areas in 2016, a trend that has continued in subsequent years, so that in 2020 there were about 5,000 more urban than rural deaths (Figure 5-3). Rural fatalities decreased by 6 percent between 2011 and 2020, while urban fatalities increased by 49 percent [USDOT NHTSA 2022d].

In comparison to 2019, traffic fatalities in urban areas increased by 9 percent in the pandemic year 2020, compared to 2 percent in rural areas. Urban area fatalities involving an alcohol-impaired driver increased 17 percent versus 9 percent in rural areas. Some 30 percent of the deaths in fatal crashes in urban areas involved speeding, slightly more than the 28 percent in rural area crashes. Before the pandemic in 2019, 26 percent of the deaths in urban fatal crashes involved speeding, compared with 27 percent in rural areas.

The overall number of rural traffic fatalities had been declining for many years, before the slight rise during 2019. By contrast, urban traffic fatalities had been on the rise for several years before the pandemic, and before the dramatic jump in 2020 [USDOT NHTSA 2022d]. Rural areas accounted for about 55 percent of fatal crashes involving large trucks in 2020. This represents a decline from 63 percent in 2015 [USDOT NHTSA 2022(i) and FMCSA 2021a].

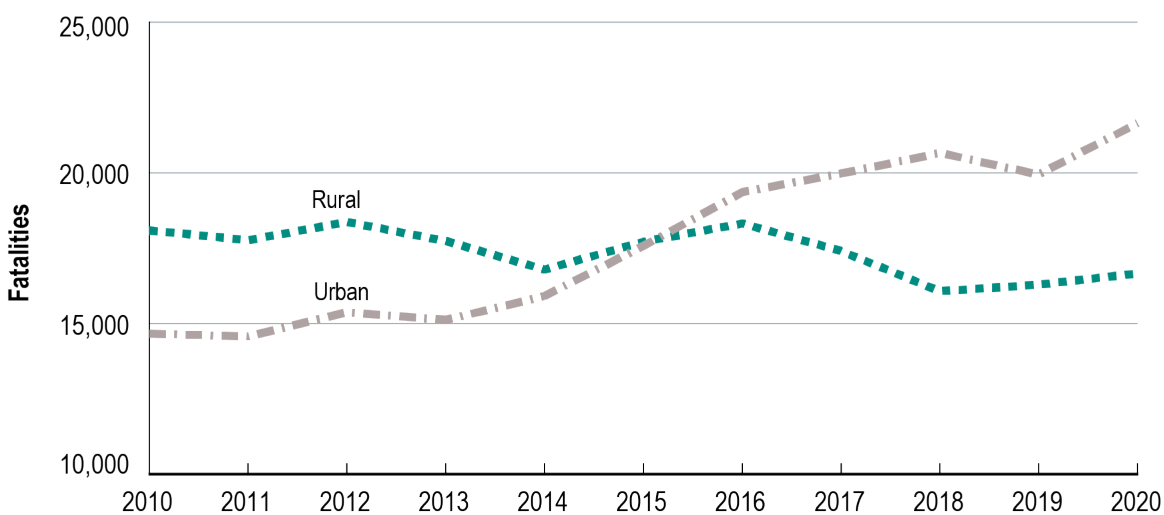
Yet, despite these differentials, in 2020 rural areas continue to have a fatality rate that is much higher per 100 million VMT than urban areas: 1.84 in rural areas compared to 1.08 in urban areas (Figure 5-4). Accounting for only 31 percent of total VMT in 2020, rural areas were the location for 43 percent of 2020 traffic fatalities.

NHTSA's analysis of fatal crashes indicates a notably slower emergency medical response time in rural areas than in urban areas. In 2020, rural fatal crashes, about 37 percent of victims did not arrive at a hospital for 1 to 2 hours from the time of the crash. This compares with 9 percent in 2020 urban fatal crashes [USDOT NHTSA (a)]. Differences in hospital arrival times could reflect such factors as emergency notification time, distances between crash scenes and medical facilities, and ambulance availability.

People Injured in Motor Vehicle Incidents

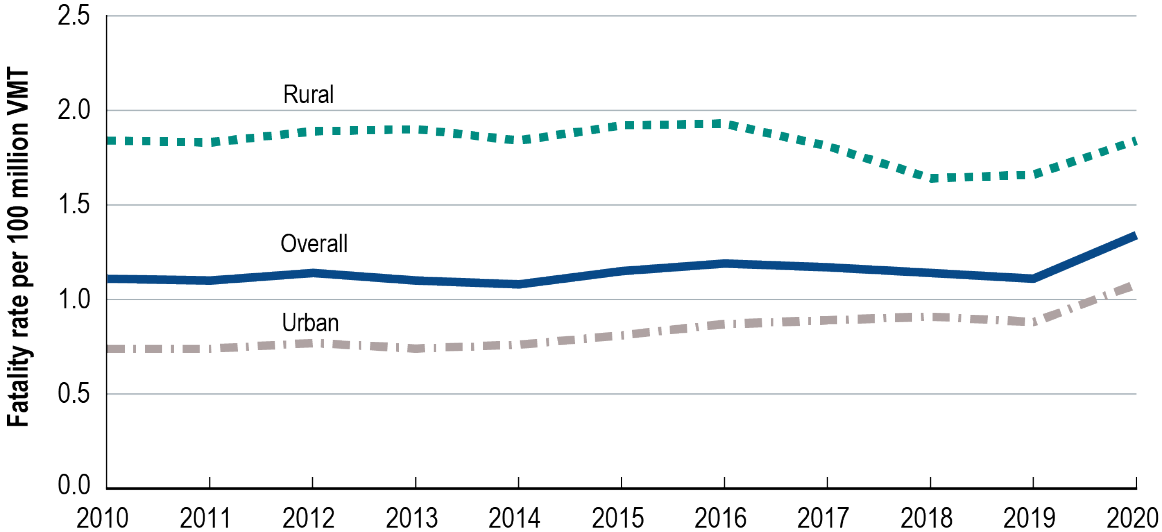
In contrast to the increase in highway fatalities during the pandemic, people injured in motor vehicle crashes dropped appreciably—by 17 percent, from an estimate of 2.74 million to 2.28 million between 2019 and 2020. The reduction in police reported crashes including injury crashes reflects an even greater reduction than people injured—down 22 percent in 2020

Figure 5-3 Motor Vehicle Traffic Fatalities, by Rural or Urban Location: 2010–2020



SOURCE: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, Rural/Urban Comparison of Motor Vehicle Traffic Fatalities (July 2022).

Figure 5-4 Fatality Rates per 100 Million VMT, by Rural or Urban Location: 2010–2020



SOURCE: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, *Rural/Urban Comparison of Motor Vehicle Traffic Fatalities* (July 2022).

over 2019, falling by 1.5 million to 5.25 million. In contrast with the 6.8 percent increase in fatal crashes in 2020, the reduction of 22 percent in injury crashes is consistent with the overall drop in highway transportation activity in 2020.

Even with the injury crash reduction, motor vehicle occupants were the fifth largest category of people treated in hospital emergency rooms for non-fatal injuries in 2020, a change from third largest in 2019 [USDHHS CDC WISQAR]. NHTSA estimates that about 8 percent, or 185,000, of the people injured in motor vehicle crashes in 2020, were incapacitated [USDOT NHTSA a]. In 2016, NHTSA redesigned the nationally representative sample of police-reported traffic crashes, which estimates the number of police-reported injury and property-damage-only crashes. Thus, it is not appropriate to compare data for 2016 and beyond with earlier year estimates. Also, for the data year 2020, NHTSA began reporting people injured estimates to the nearest whole number, compared to the nearest thousand as in past years. (See Appendix D.)

The human and economic costs of injuries from motor vehicle crashes are great. In 2020, there were over 463,000 motor vehicle related hospitalizations, entailing nearly $36 billion in direct medical costs, work loss costs of $10 billion, and $82 billion in lost quality of life, the latter being an effort to quantify the impact of injuries from the perspective of pain, lost mobility, and trauma [WISQAR 2022]. Motor vehicle injuries also result in other costs, such as lowered household productivity, and indirect costs arising from traffic stoppage at the crash site—not reflected here. The last comprehensive examination of the total costs of motor vehicle crashes was for data year 2010 ($836 billion) [USDOT NHTSA 2015]. With the costs of motorcycle crashes accounting for $12.9 billion in economic costs and $66 billion in comprehensive societal economic costs.

Other Transportation Modes

Non-highway modes—civil aviation (both commercial air carriers and general aviation), railroads, rail transit, water (including recreational boating), and pipeline—account for slightly over 5 percent of total transportation fatalities and less than 1 percent of injuries in most years. In 2020, 2,027 people died in accidents/incidents involving these non-highway modes compared to 1,879 in 2019.

The safety record of the other modes during the pandemic have been mixed.

Transit[5]

Transit deaths increased during the pandemic, despite the precipitous drop in transit use beginning in March 2020 as is discussed in Chapter 2 - Passenger Travel and Equity. From 268 in 2019, fatalities rose 9 percent to 289 in 2020, and then jumped a further 11 percent to 322 fatalities in 2021, the highest number since 1990 according to data reported to the Federal Transit Administration (FTA) [USDOT FTA]. The reason for the increase in transit fatalities during the pandemic is unknown for now. The number of reported collisions of transit vehicles dropped from 23,000 in 2019 to about 17,000 in 2020, rebounding to 19,000 in 2021. The data show most of the increases in transit fatalities occurred outside the transit vehicle (e.g., occupants of other vehicles, pedestrians walking along tracks).

Sixty-two percent of the 2021 fatalities involved transit rail, and about 38 percent involved bus. Most of the fatalities in transit-related accidents are not passengers or transit employees/contractors inside the transit vehicle. Onboard fatalities in 2021, 20 passengers (12 on transit rail, 8 on bus) and 3 vehicle operators, together accounted for roughly 7 percent of the transit fatalities (Figure 5-5). There are more people killed who are hit by the transit vehicle while waiting to be picked up or after they have been dropped off than on the vehicle.

In 2021, 23 percent of the transit fatalities were suicides involving transit assets.

Water

Water transportation fatalities increased in the pandemic years 2020 and 2021 as recreational boating deaths increased. Recreational boating (also called boating below) accounts for the lion's share of water transportation fatalities in most years and are sufficient to make the water mode the third highest in transportation fatalities (after highways and railroads). Boating fatalities were declining in the 2017–2019 period. That decline ended in 2020 when the U.S. Coast Guard (USCG) reported 767 fatalities in boating accidents—25 percent more than in 2019, before the pandemic. Boating fatalities fell to 658 in 2021 (but were still more than in 2019) [USDOT BTS NTS table 2-1].

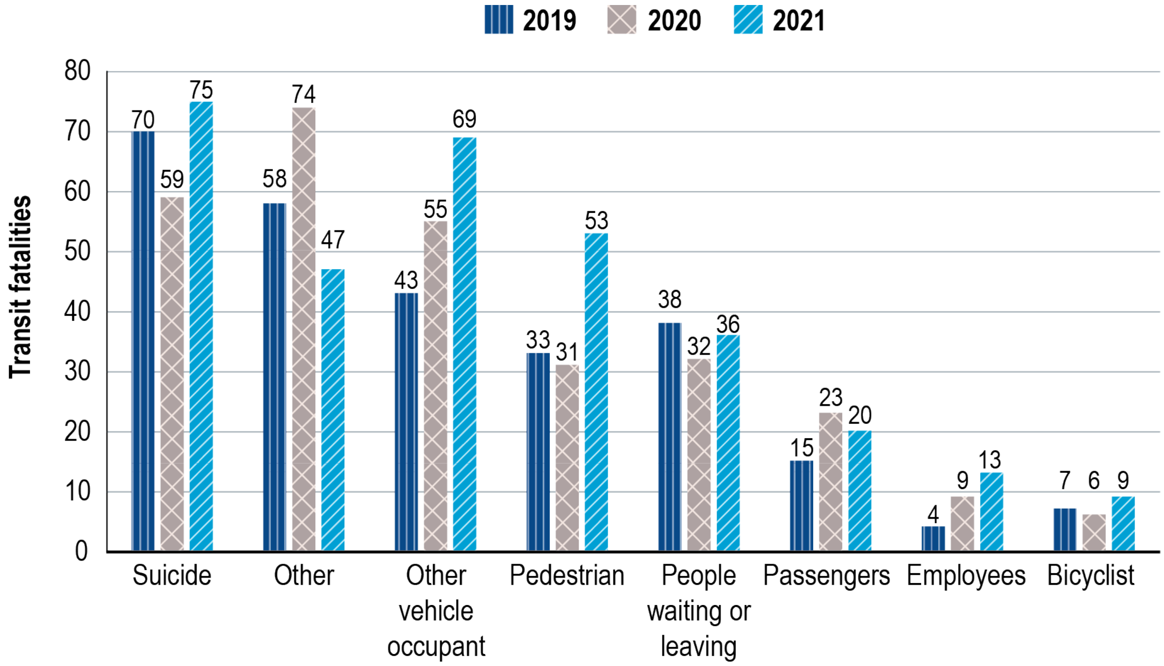
In addition to the 658 people who died in 2021, an additional 2,641 people were injured, and $67.5 million in property damage was reported. The USCG notes that non-fatal accident statistics are "severely" underreported because people may be unaware that they are supposed to report these incidents or are unwilling to report.

Nearly all boating fatalities happen while the vessel is engaged in or transporting people to and from a recreational, fishing, or watersport activity [USDHS USCG 2022].

Many boating fatalities occur on calm, protected waters; in light winds; or with good visibility. Alcohol use, operator distraction, failure to wear life jackets, and lack of operator training continue to play key roles in fatal recreational boating accidents. Where power source was reported, just under two-thirds of the deaths in 2021 boating accidents involved motorized craft; the remaining one-third involved kayaks,

[5] Rail transit accounts for slightly more than half of the transit fatalities reported to the Federal Transit Administration: however, commuter rail and Port Authority Trans Hudson heavy rail safety data are counted in Federal Railroad Administration data.

Figure 5-5 Transit Fatalities by Category: 2019, 2020, and 2021



NOTE: The number of transit patron fatalities includes both passengers on the vehicle and those transit patrons at stations who are struck while waiting to get on or who have just gotten off the vehicle.

SOURCE: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, available at https://www.transit.dot.gov/ntd as of August 2022.

canoes, rowboats, and other non-motorized boats [USDHS USCG 2022]. In terms of number of fatalities, recreational boating has become clearly safer over the decades. In 1980, there were twice as many fatalities as in 2021—1,360 vs. 658 [as cited in USDOT BTS NTS table 2-1]. As measured by the amount of boating activity per fatality, however, it is less clear that recreational boating is safer, due in part to a lack of adequate risk exposure measures. The USCG currently measures the number of fatalities per 100,000 registered boats, but it is not known how many boats in use are unregistered, creating uncertainty about using registered boats as an exposure metric.

As for commercial waterborne transportation, such as excursion boats, freighters, and fishing vessels, there were 84 vessel-related fatalities in 2020, down from 94 in 2019.[6]

Railroad

Railroad fatalities declined 15 percent overall between 2019 and 2020, reflecting a one-third decline in fatalities at rail-highway grade crossings. Rail fatalities rose in 2021 as both trespassing and grade crossing fatalities increased. Most fatalities associated with railroad operations occur outside the train, such as people struck by trains while on track rights-of-way or people in cars struck at highway rail-grade crossings. Very few train passengers or crew members die in train accidents in most years. Nearly all railroad-related fatalities were “trespasser” and grade crossing fatalities

[6] This does not include people who died in incidents judged not to involve the vessel, such as slips and falls. Suicides, homicides, and some other causes of death are excluded.

discussed further in the ignoring risks and warnings section of the chapter.

Of the people who died in railroad-related accidents in 2021, the Federal Railroad Administration (FRA) attributes about 27 percent of the fatalities to passenger train operations and the remaining fatalities to freight train operations, which accounted for far more train-miles than passenger train-miles [USDOT FRA OSA].

Aviation

Air transportation fatalities totaled 349 in 2020, which were below the 2019 level (452).

Aviation safety statistics can be separated into commercial (for-hire aviation, including freight and passenger air carriers, commuter air carrying 10 or fewer passengers, and air taxis) and general aviation. There were 7 years between 2010 and 2020 with no passenger fatalities on U.S. passenger airlines, with a total of 11 fatalities reported over the entire 11-year period. U.S. air carriers that only carry freight had 3 fatalities in 2019. Commuter air had 6 years with no fatalities over this period, with 21 total fatalities over the other 5 years. Air taxis, an on-demand service, registered fatalities in every year, averaging about 22 per year. This compares with annual averages of 21 between 2010 and 2018, 44 fatalities per year between 2000 and 2009, and about 54 fatalities annually between 1990 and 1999 [as cited in USDOT BTS NTS, table 2-1].

General aviation (GA) fatalities fell from 414 in 2019 to 332 in 2020. Two other measures of general aviation safety trends showed a mixed record. One measure, the number of fatal accidents, continued its steady decline from over 400 per year in the early 1990s to 227 in 2019 and 205 in 2020. The number of fatal crashes differs from the number of fatalities due to year-to-year variation in the number of plane occupants who died. The other measure, the GA fatal accident rate per 100,000 flight hours, which had been trending downward for several years to less than 1 in 2016 and 2017, has subsequently ticked upwards and was slightly over 1 in 2018, 2019, and 2020 (1.049) [NTSB no date b].

Unmanned aircraft systems (UAS), or “drones,” pose several challenges for aviation safety, but as of this writing no crashes in the United States have resulted. While there have been numerous sightings of unauthorized drones from planes in the air and near airports, information is currently too limited to determine the risks of collision with planes piloted by humans or damage on the ground to people or facilities.[7]

Oil/Hazardous Liquid and Gas Pipelines

In 2021, 13 people died and 32 were injured in 631 pipeline incidents. Gas pipelines (especially gas distribution pipelines) account for most of the fatalities in most years and all the 2021 fatalities [USDOT PHMSA portal]. Pipeline incident costs averaged $525.2 million per year over the period, most of which involved oil or other hazardous liquid spills [USDOT PHMSA portal].

As for injured people, air, railroad, water, and pipeline injuries fell from about 10,500 in 2019 to roughly 9,300 in the pandemic year 2020 (Table 5-2). People injured on transit rail fell from about 6,600 in 2019 to just under 4,100 in 2020. On the bus and other non-rail transit modes (e.g., ferry) injured people averaged slightly less than 17,000 per year between 2016 and 2019, but then declined to slightly more than 11,000 in 2020 when far fewer people took transit, and then rose again to about 12,000 in 2021 [USDOT BTS NTS table 2-2 and USDOT FTA].

[7] UAS sightings and near misses are further discussed in USDOT BTS Transportation Statistics Annual Report 2018, p. 6–8.

On-the-Job Transportation-Related Facilities and Injuries

Transportation incidents accounted for the most frequent cause of on-the-job fatalities in 2020.

There was a drop in overall on-the-job fatalities in 2020, reflecting the impact of the pandemic on employment. While transportation accounts for about 40–45 percent of on-the-job fatalities in most years, that share fell to 37.3 percent in the first year of the pandemic. Some 1,778 workers died in job-related transport incidents in 2020, down from 2,122 fatalities in 2019, according to the latest census by the Bureau of Labor Statistics (BLS) [USDOL BLS 2022].

Motor-vehicle operators accounted for roughly half of on-the-job transportation-related fatalities (993); of that total, heavy or tractor trailer truck drivers accounted for 776 fatalities. Drivers had the eighth highest occupational fatality rate (25.8 deaths per 100,000 workers). There were 50 fatalities among aircraft pilots and flight engineers, giving them the third highest occupational injury fatality rate per 100,000 full time equivalent workers—34.3 (the fatal injury rate for all workers was 3.4 per 100,000 workers). Transportation events accounted for under 6 percent of the non-fatal occupational injuries and illnesses in 2018 [USDOL BLS 2019].[8]

Construction and maintenance of the Nation's highways often take place while traffic is flowing in close proximity, creating dangerous conditions for highway workers and for people in passing vehicles. Short of stopping traffic altogether, all measures used to separate work zones from traffic present risks to both workers and those in vehicles, whether concrete barriers separating traffic lanes, barrels filled with sand or water, or workers holding handheld flags to route traffic on two-lane highways.

In 2020, 857 people died in work zones, a 14 year high. Of these, 51 were work zone workers. About 44,000 people were injured in crashes in work zones in 2020, including roughly 600 pedestrians. The data suggest that most of those injured or killed in crashes in work zones are people in vehicles, not workers in the work zone [USDOT NHTSA].

Harassment and Crime in Transportation Facilities and Vehicles

People using any transportation mode are to some extent vulnerable to harassment and crime, whether when walking on a sidewalk, parking a car, leaving a bike at a place of work, or waiting for or sitting on a bus or light rail train. While such risks always accompany transportation trips, they have received wide attention during the pandemic, especially in the air and transit modes, as highlighted below.

Unruly Airline Passengers

Interfering with a crewmember's ability to carry out duties is a violation of Federal law. Firm data on the number of such incidents are not available, but the Federal Aviation Administration (FAA) does investigate incidents reported by crewmembers. The number of new investigations jumped to 1,099 in 2021 from 146 in 2019. A high proportion of these incidents involved mask wearing [USDOT FAA].

Crimes on Transit Vehicles or at Transit Facilities

Data indicate that murders increased from 18 in 2019 to 31 in 2020, before falling to 24 in 2021. Rapes declined as did robberies and assaults. The data are from jurisdictions serving at least

[8] Includes non-fatal occupational injuries/illnesses requiring at least 1 day away from work.

50,000 people and operating 30 vehicles or more [USDOT BTS NTS table 2-38].[9]

Suspected Crimes on Cruise Ships

Cruise ship companies that pick up or drop off passengers in the United States are expected to report suspected on-board criminal activity to the Federal Bureau of Investigation (FBI) and to make quarterly reports to USDOT. Of the 130 alleged crimes reported to the FBI in 2019, 101 involved sexual assaults, 15 were property thefts of $10,000 or more, and 5 were serious assaults. While no homicides were reported, there was 1 report of a suspicious death, and 2 missing U.S. nationals. There was very little cruise ship activity in 2020 and 2021, due to the pandemic, with few incidents reported by the cruise lines [USDOT]

Harassment

A recent survey of 892 students at San Jose State University found that 63 percent of the participants that rode transit experienced some form of harassment while using transit. The most common form was obscene/harassing language (41 percent), but 22 percent had been stalked, 18 percent subjected to indecent exposure, and 11 percent had been groped or subjected to inappropriate touching. Women were especially, although not exclusively, harassment victims, reporting roughly twice as much harassment as male respondents, and were much more likely to say that they were less likely to take transit as a result—45 vs. 7 percent [MINETA 2020].

Potential Contributing Factors to Transportation Crashes and Accidents

Many factors have been identified that may contribute to transportation crashes, accidents, and outcomes, such as operator inattention, mechanical problems, hazards in the environment or infrastructure, and risky behaviors. Most of these apply to some degree to all modes of transportation.

Numerous human (e.g., operator) factors and vehicle-related factors, as well as circumstances in the surrounding environment, may contribute to crashes. The most commonly cited human factors noted in accident reports involve driver or operator errors or risky behaviors, such as speeding, not using available safety equipment, and operating vehicles or carrying out transportation operations while under the influence of alcohol or drugs, or while distracted or fatigued. These often occur in combination.

In 2020, at least one driver-related factor was cited in 54.6 percent of fatal crashes, with speeding, under the influence of alcohol, drugs, or medication and operating vehicle in a careless manner as the top 3 factors. In contrast, about one-third (31.6 percent) of large truck drivers in fatal crashes had at least one driver-related factor, with speeding, distraction, and impairment (including fatigue) the top 3 in 2019 [USDOT FMCSA 2021].

Vehicle-related factors also play a role. These include equipment- and maintenance-related failures (e.g., tire separations, defective brakes or landing gear, engine failure, and worn-out parts) [USGAO 2003]. In 2019, vehicle factors, most commonly tires, were recorded for 5.3 percent of large trucks and 2.6 percent of passenger vehicles involved in fatal crashes [USDOT FMCSA 2021].

Factors related to the surrounding environment include roadway or bridge condition, infrastructure design (e.g., short runway, no road shoulders), hazards (e.g., utility poles at the side of the road, hidden rocks under water),

[9] Security events must meet the National Transit Database reporting threshold i.e., injury requiring immediate transport away from the scene, fatality, an evacuation for life-safety reasons, or estimated property damage equal to or exceeding $25,000.

and operating conditions (e.g., fog, turbulence, choppy waters, wildfire, wet roads). About 10 percent of fatal highway vehicle crashes take place in adverse weather.

In some cases, a single factor is the clear cause of the accident (e.g., cars falling into a river due to a sudden bridge collapse or a tree falling on a passing car). But often it is hard to delineate among the various factors. In the case of general aviation, many accidents occur in bad weather when the consequences of human error are magnified by outside conditions. The same is true with recreational boating, where operator inattention, inexperience, and alcohol use may act in combination to lessen reactions to, say, an impending storm.

Speeding

Excessive speed is the fifth greatest known factor contributing to boating accidents, and excessive speed is often found in National Transportation Safety Board (NTSB) investigations of transit and railroad mishaps.

Speeding tops the law enforcement notation list for drivers of both passenger vehicles and large trucks in fatal crashes. In 2020, 11,258 out of the 38,824 people killed in motor vehicle crashes involved speeding. This was 1,666 more than in 2019, and a 17 percent increase. Prior to this increase, speeding-related fatalities had been falling, dropping by over 1,000 and from 31 to 26 percent of highway fatalities in the prior 10 years. About 34 percent of motorcyclists in fatal crashes in 2020 were speeding, the highest share among vehicle driver types, as were 22 percent of passenger car drivers, 16 percent of light-truck drivers, and 7 percent of large-truck drivers. With the exception of large truck drivers, the percentage of speeders increased for all vehicle types between 2019 and 2020.

Males, especially young males, account for a high proportion of speeding drivers in fatal crashes. In 2020, 35 percent of male drivers involved in fatal crashes in the 15- to 20-year-old age groups were speeding at the time of the crashes, compared to 18 percent of the female drivers in the same age group. This difference among the sexes was evident in all age groups, even for those 75 and older, albeit the difference narrows with age.

Speeding coupled with drinking is common in highway crashes. Specifically, 37 percent of speeding drivers in fatal crashes in 2020 were found to have a BAC of 0.08 g/dL or above compared to 17 percent among non-speeding drivers in fatal crashes. About 53 percent of the passenger vehicle drivers involved in fatal crashes who were speeding in 2020 were not wearing seat belts at the time of the crash, versus 24 percent of passenger vehicle drivers in fatal crashes who were not speeding, based on known restraint use [USDOT NHTSA 2022a].

Alcohol Abuse

Forty-nine States, Puerto Rico, and the District of Columbia make it illegal to drive when an adult has a blood alcohol concentration (BAC) of 0.08 grams per deciliter (g/dL). One state, Utah, has a more stringent limit of 0.05 g/dL. A lower threshold exists for commercial vehicle operators—0.04 g/dL. All states have more stringent thresholds for drivers under the age of 21—ranging from zero alcohol to 0.02 g/dL [USDHHS NIH NIAAA].

Drivers whose BACs are at or above these thresholds are considered to be alcohol-impaired or inebriated. Using the 0.08 g/dL as a criterion, National Highway Safety Administration (NHTSA) estimates that, in 2020, an average of one alcohol-impaired-driving fatality occurred every 45 minutes [USDOT NHTSA 2022h].

As shown in Table 5-3, in 2020, 11,654 people died in motor vehicle crashes in which at least one driver had a BAC of 0.08 g/dL or higher; this

Table 5-3 Fatalities by Highest Blood Alcohol Concentration (BAC) in Highway Crashes: 2010 and 2017–2020

Mode	2010	2017	2018	2019	2020
TOTAL fatalities	**32,999**	**37,473**	**36,835**	**36,355**	**38,824**
BAC = 0.00					
Number	21,005	24,589	24,186	24,251	25,038
Percent	64	66	66	67	64
Fatalities in alcohol-related crashes (BAC = 0.01+)	**11,906**	**12,775**	**12,560**	**12,029**	**13,695**
Percent	36	34	34	33	35
BAC = 0.01–0.07					
Number	1,771	1,895	1,850	1,834	2,041
Percent	5	5	5	5	5
BAC = 0.08+					
Number	10,136	10,880	10,710	10,196	11,654
Percent	31	29	29	28	30

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)..

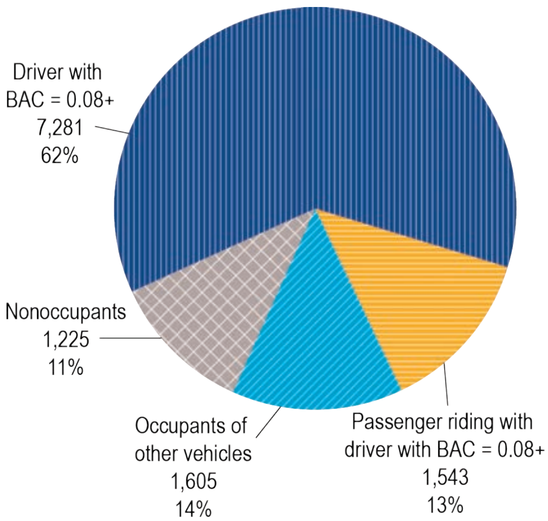
was an increase in deaths of nearly 1,500 from 2019 and the most since 2008. Fatalities in alcohol-impaired-driving crashes remain below the 2000 level, which was above 13,000.[10]

Many inebriated drivers have a BAC that greatly exceeds the 0.08 g/dL level and/or are repeat offenders. In 2020, two thirds of the fatalities in alcohol-impaired driving crashes had a driver with a BAC of 0.15 g/dL or above—nearly twice the inebriation threshold. Impaired drivers in fatal crashes were also 4 times more likely to have a prior DWI conviction in the last 5 years then drivers in fatal crashes in which no alcohol was involved [USDOT NHTSA 2022h].

The nationwide effort to reduce drunk driving has gained momentum over decades through concerted efforts at the local, state and federal levels by many organizations. Broad acceptance of the 0.08 g/dL standard dates to the 1990s as increasing numbers of states adopted this standard and a federal law-imposed penalties on states that did not adopt this standard. New measures continue to be put forward to further reduce fatalities related to drunk driving. According to the Governors Highway Safety Association, 44 states, the District of Columbia, and 1 territory have adopted additional penalties that kick in when a driver has a BAC substantially higher than 0.08 g/dL, most commonly 0.15 g/dL. Some 19 states require all DUI offenders to use ignition interlocks (requiring use of a breathalyzer before the vehicle will start), while 11 others require interlocks for repeat offenders. A majority of states have adopted laws restricting open containers and

[10] According to the USDOT National Highway Traffic Safety Administration, an alcohol-impaired crash involves at least one driver or motorcycle rider with a Blood Alcohol Concentration (BAC) of at least 0.08 grams per deciliter (g/dL). Crashes where the BAC of the driver or rider measures over 0.01 are considered alcohol-related or alcohol-involved crashes.

Figure 5-6 Fatalities, by Role, in Crashes Involving at Least One Driver with a BAC of 0.08 or Higher: 2020



NOTE: Nonoccupants includes pedestrians, pedalcyclists, and others not listed.

SOURCE: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, Traffic Safety Facts: Alcohol-Impaired Driving 2020 (April 2022).

repeat offender requirements that meet federal standards [GHSA no date a].

Figure 5-6 displays categories of people who died in fatal crashes when the driver had a BAC of 0.08 g/dL or higher in 2020. Drivers accounted for 7,281 (62 percent) of the fatalities; 3,148 (27 percent) were either passengers in a vehicle with an impaired driver or occupants of other vehicles, and 1,225 were pedestrians or other nonoccupants (11 percent). Some 27 percent of motorcycle riders in fatal crashes were alcohol-impaired, the highest share among highway motor vehicle driver types.

The estimated economic costs of alcohol-impaired crashes in 2010 was $44 billion, and $201.1 billion when quality of life considerations were included. This is nearly one-fourth of the $836 billion estimated total societal cost of motor vehicle accidents in 2010 [USDOT NHTSA 2018c].

The U.S. Coast Guard (USCG) found alcohol use to be the primary contributing cause in 16 percent of fatal boating accidents in 2021, resulting in 113 fatalities; drug use was the primary contributing factor in 5 accidents, resulting in 4 fatalities [USDHS USCG 2022]. As of January 1, 2019, 48 States and the District of Columbia limit BAC to 0.08 g/dL for operators of recreational boats. The remaining two States—North Dakota and South Carolina—have a 0.10 g/dL standard [USDHHS NIH NIAAA].

Drugs and Fatal Crashes

Many states test drivers for presence of alcohol and drugs after fatal crashes.[11] A study by the Governors Highway Safety Association analyzed the results of these tests in 2016, finding that among drivers in fatal crashes that were tested for drugs and/or alcohol, about 44 percent tested positive for drugs and just under 38 percent tested positive for alcohol. More than half of those testing positive for drugs were positive for two or more drugs, and over 40 percent were also positive for alcohol. The tests were for any presence of alcohol or drugs in the driver's system. The study noted that presence of drugs does not imply impairment [GHSA 2018]. Since 1991,[12] Federal transportation agencies have required testing on the job for safety-sensitive transportation operators and workers in many industries.[13]

[11] Driving while under the influence may include by any legal or illegal substance such as alcohol, marijuana, opioids, methamphetamines, or any potentially impairing prescribed or over the counter drugs.

[12] The testing is required by the Omnibus Transportation Employee Testing Act of 1991, Public law 102-143.

[13] For citations to Federal regulations and minimum standards for required random testing rates under regulations issued by the USDOT operating administrations and the U.S. Coast Guard, see Bureau of Transportation Statistics, Transportation Statistics Annual Report 2018, box 6-C, page 6-17.

Distraction and Fatigue

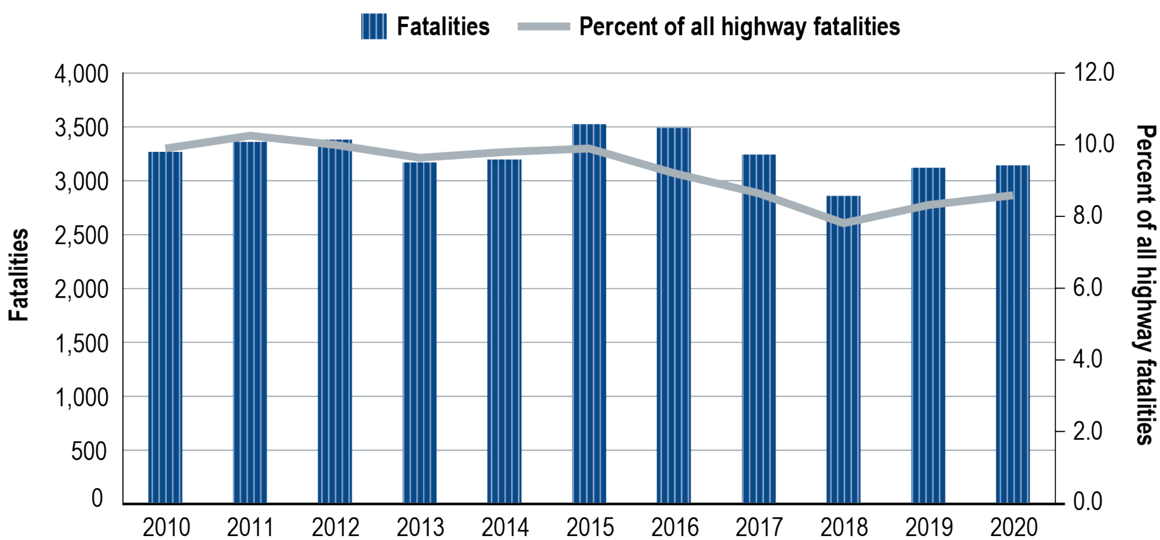
Distracted and fatigued vehicle operators are found in all modes of transportation, including airline pilots, bus drivers, train engineers, and tugboat operators [NTSB 2016]. In the case of recreational boating, operator inattention was cited as the top contributing factor in all boating accidents (non-fatal as well as fatal) in 2021, according to the U.S. Coast Guard—resulting in 41 deaths and 398 injuries [USDHS USCG].

As for motor vehicles, the number of fatalities in distraction-affected highway crashes declined from 2015 to 2020, from 3,526 in 2015 to 3,142 or 8 percent of total motor vehicle related fatalities in 2020 (Figure 5-7). Drivers aged 25 to 35 represent 25 percent of all distracted drivers involved in fatal crashes [USDOT NHTSA 2022f]. Vehicle occupants comprised 81 percent of fatalities in distraction-affected crashes in 2020. In addition, 587 nonoccupants, mostly pedestrians, died in these crashes. It is not known how many nonoccupants were also distracted when struck (e.g., walkers using a cell phone while crossing a street).

Although many activities (e.g., eating, sipping coffee, smoking, grooming, tending to a child) are distracting to drivers, such activities can also distract bicyclists, pedestrians, and other vehicle operators. Cell phone use and texting have received the most attention as these devices have attained nearly universal usage in the last few years. Eight percent of all fatal crashes in 2020 (2,880) were affected by driver distraction. In 354 of these, a cell phone was in use at the time of the crash. Twenty six States, the District of Columbia, and Puerto Rico prohibit drivers' use of handheld cell phones, and 48 states plus the District of Columbia and Puerto Rico ban texting while driving.

Drowsy driving was found to be a factor in 579 fatal crashes (about 1.6 percent), resulting in 633 fatalities in 2020 [USDOT NHTSA online a]. However, it is likely that the role of fatigue in crashes has been underestimated [AAA 2018].

Figure 5-7 People Killed in Distracted-Driving Crashes: 2010–2020



NOTE: 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.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts, Research Note, Distracted Driving 2020 and previous editions, available at www.nhtsa.gov as of August 2022..

New research, facilitated by use of dash-cam video, may make more accurate estimation possible. In 2018, the AAA Foundation for Traffic Safety examined dash-cam footage of drivers in the moments before 589 crashes and found drowsiness in about 11 percent of crashes [AAA 2018].

Distracted or inattentive driving by commercial motor vehicle drivers was a contributing factor in approximately 5.3 percent of fatal crashes involving large trucks in 2019. In addition, truck driver impairment (e.g., fatigue, drugs/alcohol, illness, etc.) was a factor in 4.7 percent of these fatal crashes [USDOT FMCSA 2021a].

Ignoring Risks and Warnings

Ignoring warnings is a problem common across all transportation modes, whether a changing traffic light, a railroad crossing signal, or instructions to wear life jackets on boats. The sheer number of railroad trespassers dying each year equal or exceed the number of deaths in the transit or air modes in most years. After reaching an historic low of 399 in 2011, trespasser fatalities have since risen, averaging about 530 per year. In 2020, the first full year of the pandemic, trespasser fatalities fell to 520, but then increased to 625 in 2021, the most since at least 1975. While trespassers accounted for about 61 percent of the total railroad fatalities between 2010 and 2019, the 2021 number comprised 69 percent of the 902 railroad deaths that year.

A report by the USDOT Federal Railroad Administration (FRA) found that about three-fourths of fatalities in the 10 counties with the highest trespasser fatalities occurred within 1,000 feet of a highway rail-grade crossing [USDOT FRA 2018].

Highway rail-grade crossing fatalities averaged about 247 per year in the 10 year span ending in 2021, or roughly one-third of all railroad-related fatalities. This compares to 550 deaths per year in the 1990s. In 2021, there were 237 fatalities at grade crossings, [as cited in USDOT BTS NTS].[14]

Suicide accounted for an even higher proportion of transit fatalities—23 percent in 2021, with all but 6 of the 74 suicides involving transit rail (see Figure 5-5).

Suicides involving motor vehicles are seldom officially reported and data are insufficient to determine their frequency. Crash investigations sometimes identify suicide as a cause of plane crashes, but frequency data are seldom compiled. Better data on the number and circumstances of transportation-related suicide could be useful in devising approaches and countermeasures for addressing this sizeable and continuing problem.

Countermeasures to Reduce Safety Risks

Many studies over the years have concluded that safety devices, such as flotation devices for boaters, seat belts, frontal air bags, child restraints, and motorcycle helmets, help save lives and reduce injuries in crashes and other transportation incidents. About 81 percent of people who died in boating accidents in 2021 drowned, and 83 percent of those who drowned were not wearing a life jacket [USDHS USCG 2022].

Over time, occupant protection devices, advances in vehicle design, improved road and infrastructure design, graduated driver licensing for teenagers, safety campaigns, enforcement of drunk-driving laws, and many other preventative measures contributed to declines in highway

[14] Counts of highway grade-crossing fatalities are reported to both rail and highway agencies. In table 5-1, to avoid double-counting, these fatalities are included in the overall count for highways, but not for rail.

vehicle and other transportation fatalities and injuries [KAHANE, MASTEN]. Advancements in emergency medical response capabilities and treatment also played important roles. Installation of crash avoidance technologies in new vehicles and conveyances are also working to ensure vehicles are becoming safer than ever before.

Seat Belt Use

About 90 percent of front seat occupants of passenger cars, pickup trucks, vans, and sport utility vehicles (SUVs) used safety belts in 2020 and 2021, up from 71 percent in 2000 and 85 percent in 2010 [USDOT NHTSA 2021]. Rear seat occupants had a lower rate of seat belt use—about 80 percent in 2020 and 78 percent in 2021. Pickup truck occupants had the lowest usage at 85 percent in 2020 (Table 5-4).

Fifty-one percent of passenger vehicle occupants killed in 2020 were unrestrained. As for fatal crash survivors in 2020, 84 percent used restraints, while 16 percent did not (based on cases where restraint use was noted by officials at the crash scene) [USDOT NHTSA 2022m]. NHTSA estimated that seat belts saved about 14,955 lives in 2017 [USDOT NHTSA 2019].

Among states and territories in 2020, observed seat belt use ranged from a low of 68.3 percent in South Dakota to a high of 97.1 percent in Hawaii. States with primary enforcement laws, allowing police to ticket vehicle occupants solely for not wearing seat belts, have higher belt usage (91 percent in 2021) than states with weaker or no enforcement (88 percent) [USDOT NHTSA 2021].

Helmet Use

Good helmets can be effective in protecting people from head injuries when riding motorcycles, bicycles, and the increasing number of human powered or motorized personal transportation devices, such as two-wheel scooters, skateboards, and e-scooters [MINETA]. Helmets not only protect riders in collisions, but from falls, which are common.

Table 5-4 Safety Belt and Motorcycle Helmet Use: 2010 and 2018–2021

Mode	2010	2017	2018	2019	2020	2021
Overall safety belt use[a]	**85**	**90**	**90**	**91**	**90**	**90**
Drivers	86	90	90	91	91	91
Right-Front Passengers	83	88	89	90	**90**	89
Passenger cars	86	91	90	91	**91**	91
Vans and sport utility vehicles	88	92	92	93	**92**	92
Pickup trucks	75	83	84	86	86	85
Motorcycle helmet use[ab]	**54**	**65**	**71**	**71**	**69**	**65**
Operators	55	68	71	75	**69**	67
Passengers	51	51	69	48	**72**	52

[a]Seat belt use is as of the Fall each year. Motorcycle helmet use is as of the Fall each year.

[b]Only those operators and riders wearing safety helmets that met U.S. Department of Transportation (DOT) standards are counted. Those safety helmets that do not meet DOT standards are treated as if the operator/rider were not wearing a helmet.

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 August 2022 as cited in USDOT, Bureau of Transportation Statistics, *National Transportation Statistics*, table 2-30, available at http://www.bts.gov as of August 2022.

NHTSA estimates that DOT-compliant helmets[15] are 37 percent effective in preventing fatal injuries to motorcycle riders and 41 percent effective for motorcycle passengers [USDOT NHTSA 2022c]. In 2017, according to NHTSA, helmets saved the lives of 1,872 motorcyclists [USDOT NHTSA 2019]. Overall usage of DOT-compliant helmets has fluctuated in recent years (table 5-4), reaching a high of 71 percent in 2018 and 2019 before falling to 65 percent in 2021 (with a 4 percent drop between 2020 and 2021) [USDOT NHTSA 2022b].

In 1975, 47 states and the District of Columbia had adopted universal helmet use laws that required motorcycle helmets for all riders, but many states subsequently made their helmet laws less restrictive [COSGROVE]. In 2021, only 18 states and the District of Columbia continued to have universal helmet use laws—29 states required helmet use for only a subset of riders, such as people under 21, and 3 states (Illinois, Iowa, and New Hampshire) had no helmet requirements [NHTSA 2022b] (Figure 5-8).

Helmet use has long been advocated for bicycle riders, and many states have laws requiring children riding bicycles to wear helmets but no similar requirement for adults, who account for the most fatalities and injuries. A study of 76,000 bicyclists treated in hospitals and intensive care units for head and neck injuries between 2002 and 2012 found only 22 percent of the adult bicyclists wore helmets, and only 12 percent of injured children under 17 wore helmets [SCOTT ET AL].

Helmet use (or lack thereof) is also a prominent issue in many cities where battery powered e-bikes, e-scooters, and a range of other so-called micromobility devices are in use. Many of these devices are for rent, and often used by novice riders in traffic or on sidewalks. Due to apps on smart phones, the rental location is often wherever the last rider left the micromobility device, and helmet use by new riders often is not monitored. Box 5-B describes the safety issues associated with the emergence of e-scooters and other powered mobility devices in U.S. cities.

Training and Refresher Training

For all transportation modes, operator training can enhance safety. Driver education courses for high school students under the age of 18 are a prerequisite for a driver's license in many states, and a certain degree of proficiency is expected. Commercial driving licenses require training on the type of highway equipment the driver seeks to operate.

The Federal Aviation Administration requires pilots to have not only pilot licenses but also currency (i.e., recent flying experience), even in general aviation. In the case of general aviation, loss of control of the aircraft while maneuvering is the single biggest cause of fatal general aviation crashes, and pilot error is a major reason [USDOT FAA].

Many general aviation crashes occur each year when pilots who are not instrument rated (licensed to fly using instruments in the plane when visibility is limited) or who are deficient in their instrument flying skills unexpectedly encounter adverse weather conditions that they are ill-prepared to handle [SKYBRARY].

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). About 43 percent of U.S. boat owners have taken a boating safety course. Most boating fatalities occur on vessels in which the operator had no formal instruction in boating safety. Only 16 percent of deaths in fatal boating

[15] DOT-compliant helmets provide a standard of protection specified in Federal Motor Vehicle Safety Standards No. 218, which includes standards for energy attenuation, penetration resistance, chin strap structural integrity, and labeling requirements.

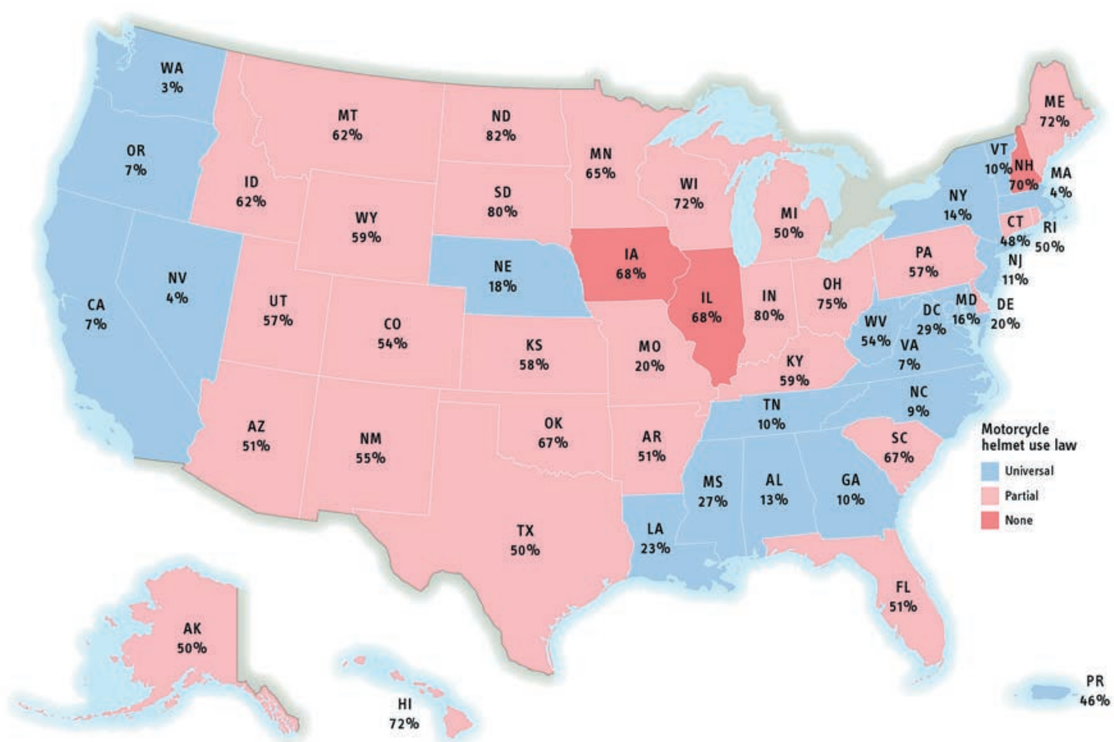
accidents in 2021 occurred in boats operated by a person known to have received a certificate for boating safety from a nationally approved provider [USDHS USCG 2022].

Monitoring and Enforcement of Safety Standards

Traffic safety enforcement can encourage good driving habits (e.g., wearing a safety belt) and discourage unsafe behaviors (e.g., speeding, impaired driving). According to the Bureau of Justice Statistics, about 8.1 percent of the Nation's 231 million drivers in 2018 were stopped by police. In 2015, speeding was the leading reason, accounting for about 41 percent of stops, followed by vehicle defects (e.g., broken taillight) at around 12 percent. Among many other reasons given for stops were seatbelt violations (about 3 percent), cell phone violations (about 2 percent), and sobriety checks (about 1 percent).

In 2017, according to the FBI, law enforcement agencies across the country made just under 1 million arrests for driving under the influence (DUI). Males accounted for three out of four DUI arrests [USDOJ FBI]. Studies have shown sobriety checkpoints are an effective countermeasure to reduce alcohol-impaired driving. Such checkpoints reduce alcohol-related crashes by roughly 20 percent [USDHHS CDC 2015]. Not all states authorize these checkpoints, however.

Figure 5-8 Percentages of Motorcyclists Killed Not Wearing a Helmet, by State Helmet Use Law: 2021



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Motorcycle Helmet Use in 2021—Overall Result*s. DOT HS 813 70. March 2022. Available at www.nhtsa.gov/ as of August 2022.

Box 5-B Micromobility Safety and Shared Travelways

Before the pandemic, the number of bikeshare and e-scooter systems reached almost 300, serving more than 200 cities, but many suspended operations at least temporarily in 2020. These devices are seen by some transportation planners as a solution to the "last mile problem," making it easier for people to get to and from their homes to transit stations and to their ultimate destinations. Speed is an issue as riders on some of these mobility devices can cruise at 15 miles per hour or even faster—a speed too fast for most pedal bicyclists to maintain, too slow for highways, and too fast for sidewalks.

Rider safety, and to some extent pedestrian safety, are a concern as rental opportunities for these devices have proliferated. Some users don't wear helmets and training even for first time users is often limited to tutorials presented on the app. Sidewalk and road maintenance is also an issue, as riders can be bumped off by cracks and other imperfections in the sidewalk or potholes. Scooters and other devices left on sidewalks can also be a tripping hazard for pedestrians, especially the el-derly and vision impaired.

Data on injuries from these fast-growing transportation options are limited. A study by the Federal Consumer Products Safety Commission (CPSC) examined injury, fatality, and hazard patterns covering just e-scooters, e-bikes, and hoverboards in the 2017 through 2020 period. It found that injured riders of these devices who were treated in emergency departments increased from 34,000 in 2017 to 57,700 in 2020. The number of fatalities increased from 5 to 24 over this period [US CPSC].

CPSC conducted follow up on 142 e-scooter visits to emergency departments, finding that renters comprised 28 percent of the visits; 57 percent of injuries were on paved roads, and 79 percent were wearing a helmet.

Micromobility mishaps often go unreported to police unless a motor vehicle is involved. Riders often go to hospital emergency rooms for treatment of their injuries if they fall or run into something, but many hospitals do not separately keep data on scooter injuries. Some cities with widespread scooter use, such as Austin, TX, are collecting data, but coverage is spotty. As more e-scooters and other kinds of personal or micromobility devices appear on sidewalks, streets, and other public ways, complete data about safety risks will be crucial to developing strategies to reduce injuries.

The USDOT Federal Motor Carrier Safety Administration (FMCSA) is responsible for reducing crashes, injuries, and fatalities involving commercial motor carriers such as trucks and buses. In 2020, there were roughly 590,000 interstate freight carriers (including a large number of self-employed truckers), 36,600 intrastate hazardous material (HazMat) carriers (in addition to those HazMat carriers counted in the interstate freight carrier category), and 10,800 interstate passenger carriers (e.g., bus companies). That year, there were about 2.5 million roadside inspections of trucks and buses conducted by state and federal inspectors, about a million fewer inspections then in 2019 before the pandemic, and the number of safety inspectors fell from 13,588 to 12,760, with the number of inspections declining from 3.5 million to 2.6 million [USDOT FMCSA 2021b].

In 2020, regulators sent 14 percent fewer warning letters to motor carriers whose safety data showed a lack of compliance with safety regulations and whose safety performance was unacceptable. The number of warnings fell from 26,379 in 2019 to 22,686 in 2020 [USDOT FMCSA no date]. Inspections may reveal violations that must be corrected before the driver or vehicle can return to service. In 2019, vehicle violations, such as defective lights, worn tires, or brake defects, put about 21 percent of inspected trucks out-of-service until corrected. Truck driver violations put about 5 percent of drivers out-of-service, often due to non-compliance with hours-of-service regulations. Comparable numbers for motor coaches (e.g., intercity buses) were about 6.5 percent for vehicle violations and 4.8 percent for driver violations. FMCSA estimated that carrier interventions saved 212 lives and prevented 7,136 crashes and 3,965 injuries in fiscal year 2014, the last year of published data [USDOT FMCSA 2018].

U.S. railroads, most of which are privately owned and operated, are responsible for maintaining their own track and rolling stock in a state of good repair adequate to meet public safety requirements. Railroad operators must comply with detailed track inspection standards promulgated by the Federal Railroad Administration. As is discussed in the section on the deployment of innovations, some railroads are exploring technology to partially automate the inspection process.

Hazardous Materials Transportation

Special precautions are needed when handling, packaging, and transporting hazardous materials (chemicals or items that pose a risk to public safety, property or the environment when transported in commerce). Specialized safety regulations, standards, and reporting systems apply to hazardous materials transported by rail, highway, air, and marine vehicles. A separate reporting system applies to oil, gas, and other hazardous liquid pipelines.

There are about 1 million daily shipments of hazardous materials by land, water, and air transportation modes. Table 5-5 shows that, in 2021, over 23,700 hazardous materials incidents (excluding pipeline incidents) associated with these shipments were reported to the USDOT Pipeline and Hazardous Materials Administration (PHMSA)—up about 2,000 from 2020 [USDOT PHMSA portal].

Most hazardous materials incidents occur during the storage or handling of the materials, such as manipulating containers or loading and unloading them for transport. Of the total incidents shown in Table 5-5, about 4,500 occurred during loading and 11,000 during unloading. Spillage during transport accounted for additional incidents. Vehicle crashes or train derailments account for a relatively small share of the incidents—PHMSA's database shows 7 vehicular crashes and 8 rollovers in 2021—although these may have major community impacts.

The above incidents do not include pipelines, which are reported separately to PHMSA. In 2018, the United States had 215,993 miles of oil pipeline and 2,542,504 miles of gas pipeline. Table 5-6 shows the severity of pipeline incidents from 2010 through 2021 in terms of fatalities, injured people, property damage, and liquid spilled. Year-to-year variation in the number of hazardous liquid incidents is evident, with no consistent trend apparent. The number of barrels of oil moved by pipeline increased from 594 million barrels in 2010 to 1,484 million in 2019, 1,159 in 2020, and 1,165 in 2021. [USDOT BTS NTS].

Table 5-5 Hazardous Materials Transportation Incidents: 2010 and 2017–2021

Mode	2010	2017	2018	2019	2020	2021
TOTAL Incidents	**14,805**	**17,485**	**19,725**	**22,565**	**21,542**	**23,706**
TOTAL vehicular accident/derailment incidents	**358**	**290**	**312**	**256**	**168**	**106**
Vehicular accident-related percent of total incidents	**2.4%**	**1.7%**	**1.6%**	**1.1%**	**0.8%**	**0.4%**
Air	1,295	1,159	1,327	1,489	1,443	951
Vehicular accident-related	2	15	5	10	4	2
Highway	12,658	15,744	17,882	20,648	19,717	22,372
Vehicular accident-related	320	251	280	220	133	79
Rail	747	573	507	422	380	378
Vehicular accident-related/derailment incidents	35	24	27	26	31	25
Water[1]	105	9	9	6	2	5
Vehicular accident-related	1	0	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). *Accident-related* are the result of a vehicular crash or accident damage (e.g., a train derailment).

SOURCE: U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Hazardous Materials Safety, *HAZMAT Intelligence Portal*, available at https://hip.phmsa.dot.gov/ as reported in National Transportation Statistics, table 2-6, as of October 2022.

Rail Tank Car Safety

The rapid growth in crude oil shipments by freight rail was a surprising transportation trend in the second decade of this century. Rail shipments grew from 23.7 million barrels in 2010 to a peak of 382.0 million in 2014, before declining to a 2021 level that was still roughly 5 times that of 2010 (117.6 million barrels) [USDOE EIA]. Great concern arose over the suitability of rail tank cars used to transport this oil, after a series of dramatic oil train accidents between 2013 and 2016. At least 13 oil train derailments or other accidents took place in that period that resulted in explosions, fires, oil spills, and/or community evacuations in the United States or Canada [AP NEWS]. In Canada, a 2013 rail catastrophe in Lac-Marantic, Quebec, involving Bakken crude oil being transported to a refinery in Maine, resulted in 47 deaths and substantial property destruction in the town.

Under a 2015 law,[16] the Bureau of Transportation Statistics (BTS) assembles and collects data on rail tank cars transporting Class 3 flammable liquids[17] in order to track the progress of upgrades to the rail tank car fleet to meet new safety requirements. By the end of 2029, rail tank cars carrying class 3 flammable liquids must

[16] Section 7308 of the Fixing America's Surface Transportation Act (FAST Act; P. L. 114-94; Dec. 4, 2015).

[17] A flammable liquid (Class 3) is a liquid with a flash point of not more than 60 °C (140 °F) or any material in a liquid phase with a flash point at or above 37.8 °C (100 °F) that is intentionally heated and offered for transportation or transported at or above its flash point in a bulk packaging. This includes liquids such as refined petroleum products, crude oil, and ethanol.

meet the DOT-117 or DOT-117R (retrofitted) specification or equivalent.[18]

In 2020, new and retrofitted DOT-117 rail tank cars grew to 54 percent of the entire fleet used to carry Class 3 flammable liquids, compared to 8 percent in 2016. Of these, 52 percent (30,883 tank cars) are new, and 48 percent (28,803 tank cars) are retrofitted. It is expected that by the end of the transition period in 2029, all Class 3 flammable liquids will be carried in rail tank cars that meet or exceed the new standards [USDOT BTS 2021].

Future Development of Innovations

NHTSA data on new car safety have shown that new vehicles are safer than older vehicles, but these data are not fine-tuned enough to take automated driver assistance and automated driving technologies into account. Several high-profile crashes involving vehicles equipped

[18] DOT-117 (TC-117 in Canada): A non-pressurized tank car with a shell thickness of 9/16 of an inch and insulating material that provides thermal protection. Additionally, DOT-117s have a skin that holds the insulation and thermal protection in place and doubles as additional protection from punctures. The tank cars have protected top fittings, a fully protected head shield, and a bottom outlet valve with an enhanced handle designed to prevent the tank car from emptying its contents in an incident. All the enhancements are designed to protect the tank from being punctured and to prevent the valves from being disrupted. DOT-117R tank cars are cars that have been retrofitted to meet the 117 specifications

Table 5-6 All Reported Hazardous Liquid and Gas Incidents: 2010–2021

Year	Number of Incidents	Fatalities	Injuries	Property Damage As Reported (M$)	Barrels Spilled (Haz. Liq.)	Net Barrels Lost (Haz. Liq.)
2010	577	22	108	$1,690	100,558	49,452
2011	578	13	55	$425	89,110	57,375
2012	558	12	57	$227	45,884	29,247
2013	611	9	44	$367	117,464	85,595
2014	694	19	94	$269	48,383	22,155
2015	705	11	48	$348	102,226	81,100
2016	629	16	87	$376	86,135	46,221
2017	625	7	32	$334	89,700	45,008
2018	625	7	78	$2,174	108,300	70,600
2019	643	11	35	$344	58,869	26,287
2020	560	15	39	$277	156,310	105,559
2021	534	13	32	$199	53,998	31,532

KEY: Haz Liq = Hazardous Liquid, LNG = Liquefied Natural Gas.

NOTES: *Hazardous Liquid* includes crude oil; refined petroleum products (e.g., gasoline, diesel, kerosene); highly volatile, flammable, and toxic liquids (e.g., propane); liquid carbon dioxide; and biodiesel. *Gross Barrels Spilled* is the amount before clean-up, whereas *Net Barrels Lost* is the amount after clean-up is attempted. *Incident* means any of the following events: 1) An event that involves a release of gas from a pipeline, or of liquefied natural gas, liquefied petroleum gas, refrigerant gas, or gas from an LNG facility, and that results in one or more of the following consequences: i) A death, or personal injury necessitating in-patient hospitalization; ii) Estimated property damage of $50,000 or more. *Accident* is a failure in a pipeline system in which there is a release of the hazardous liquid or carbon dioxide transported resulting in any of the following: a) Explosion or fire not intentionally set by the operator. b) Release of 5 gallons (19 liters) or more of hazardous liquid or carbon dioxide. Please see the Pipeline and Hazardous Materials Safety Administration's Incident Report Criteria History for a complete definition of past and present reporting requirements, which is available at https://hip.phmsa.dot.gov/Hip_Help/pdmpublic_incident_page_allrpt.pdf as of November 2019.

SOURCE: U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Hazardous Materials Safety, *Pipeline Incident 20 Year Trends*, available at https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends as reported in National Transportation Statistics, Table 2-50, as of October 2022.

with advanced driver assistance systems have occurred in which a human driver may not have been playing an active role as driver, leading to concern that these systems may not be fail-safe.

To obtain better data, NHTSA issued a standing order in June 2021 requiring manufacturers and operators of vehicles equipped with certain levels of advanced driving systems to immediately report certain kinds of crashes in which the advanced system deployed within 30 seconds of the crash. NHTSA released initial data in June 2022. One set of data are for Society of Automotive Engineers (SAE) Level 2 Advanced Driver Assistance Programs and the other for SAE Levels 3–5 automated driving systems (currently, vehicles now being road tested that are capable of car control without a human driver). (See Chapter 1 - State of the Transportation System for discussion of SAE levels.)

Of the 130 incidents involving automated driving systems in the data posted in June 2022, 108 involved crashes with another vehicle, and 11 involved a pedestrian or bicyclist or other vulnerable road users, such as motorcyclists, but no serious injuries were reported. As for vehicles equipped with advanced driver assistance systems, 116 involved collisions with another vehicle, and 4 involved a pedestrian or other vulnerable road user. Serious injuries or a fatality occurred in 11 of the 98 episodes in which crash severity was reported [USDOT NHTSA b].

These initial data are not sufficient for conclusions to be reached. NHTSA is now planning to post new data on a monthly basis on its website [NHTSA 2022g]. The U.S. National Transportation Safety Board in a May 2022 letter to NHTSA on a proposed revamp of the U.S. New Car Assessment Program (NCAP) called on NHTSA to add more emerging technologies to the NCAP program and noted that several technologies proposed to be included in NHTSA's 10-year road map for future steps are currently available [NTSB a].

While data are lacking to support a full analysis of innovative safety technologies, all USDOT operating administrations have programs underway, such as:

- A range of inspection technologies and approaches are being phased in to identify problems affecting infrastructure, such as bridges, highways, and pipelines. These could assist in setting priorities for limited maintenance funding. Robotic inspection devices and drones are increasingly in use.
- The pipeline industry is adopting many technical innovations, several of which involve easier and less intrusive means for detecting existing pipelines, a key concern in areas where new construction might result in damage to gas distribution pipelines. Other innovations focus on leak detection, detecting corrosion or other pipeline defects, and advanced welding techniques for the repair of in-service pipelines.

Transportation Safety Data Needs

Data gaps and needs related to transportation safety include the following:

- Given the large number of non-traffic fatalities and injuries involving motor vehicles that occur off the public roadways—over 3,100 in 2020—more frequent and detailed data need to be collected on the circumstances of these incidents. This “non-traffic surveillance” data was published in 2022 for the years 2016–2020. These incidents do not get the detailed reporting that is typically collected in police accident reports. More frequent data collection and publication is needed to bring greater attention to this major contributor to transportation fatalities and injuries every year.
- Fatal and serious-injury crashes involving pedestrians, pedalcyclists, and other vulnerable road users are increasing. More data on these crashes are necessary

to develop appropriate countermeasures and evaluate related vehicle safety technologies. NHTSA's expansion of the Crash Investigation Sampling System will add amendments to collection protocols in other systems that will help provide this critical information.

- Collecting more country level comparative data and conducting analyses to reveal the factors behind the decline in U.S. road safety record since 2011 could help to identify corrective measures. Once the world leader in road safety, the U.S. highway safety record now contrasts poorly with many of the 27 EU countries, and with the EU as a whole, both in the two decades before and again during the pandemic. One area that could be fruitful to explore would be whether the different safety outcomes in comparable countries to the United States reflect different levels of deployment of advanced driver assistance features in their passenger vehicle fleets.
- Much new data will be needed to ascertain the safety implications of advanced driving systems, which is in the early stages of collection. There will be a continuing need to obtain more and better safety data from crashes (and crash precursors or close calls) involving advanced driver assistance technologies and automated driving systems as they are increasingly deployed in new vehicles and to analyze resulting safety implications.
- As e-scooter and other "micromobility" devices have become pervasive on city streets, better data on the extent of their use and their interactions with walkers and traffic will be an important data need, as will their users travel behaviors (such as helmet and other protective gear usage).
- It has been more than a decade since a comprehensive analysis has been done of the economic and social costs of motor vehicle crashes. In addition to updating earlier data, compiling new data and conducting a new analysis could help determine whether the total cost to society has risen or fallen since 2010, and could assist in the allocation of limited resources.
- One of FMCSA's top data gaps is exposure data. VMT totals are released nationally from FHWA by vehicle type (combination truck, straight truck, and bus) but it is not released by State or major road segment (i.e., interstate, major arterials, etc.) which would be helpful to ongoing initiatives on truck safety.
- FMCSA Large Truck Causation Study is groundbreaking in the large truck industry safety data. The study will determine the causes of, and contributing factors to, crashes that involve commercial motor vehicles. Results from this study will help policy makers, regulators, and law enforcement identify activities and measures to improve commercial motor vehicles safety.
- Additional data gaps include carrier usage of exemptions (e.g., covered farm vehicle exemptions, emergency exemptions) and how they impact driver performance and safety. Finally, a database of work zones that is kept up to date to account for daily, or weekly, changes would be beneficial. Within the work zone database, information on not only where the work zone is (and if it is active) but also the queue leading into and out of the work zone has been of interest to the FMCSA to better determine where in the work zone crashes involving large trucks are occurring.
- The Infrastructure Investment and Jobs Act (IIJA) of 2021 has included measures that will be obligated to help States carry out activities to support progress toward safety performance targets. New data collected will support analysis for projects, activities, and strategies for IIJA funding.

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CHAPTER 6
Energy and Sustainability

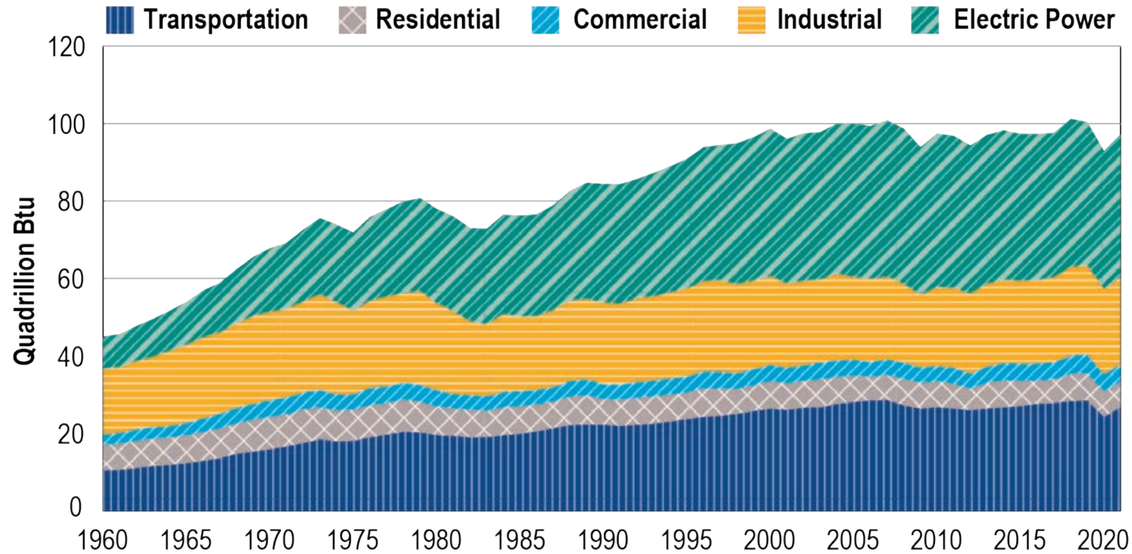
Introduction

Energy used by cars, trucks, buses, planes, ships, trains, and pipelines accounted for 27.6 percent of total U.S. energy use in 2021, making transportation the second largest user of energy in the economy, behind only electricity generation (Figure 6-1); China and the Russian Federation are the only two countries that consumed more energy for transportation [BP 2022]. Specifically, the U.S. transportation system used 26.9 quadrillion Btu of energy to generate five trillion passenger-miles of travel and five trillion ton-miles of freight. From the global perspective, the U.S. accounts for about 17 percent of world energy use and 15 percent of global greenhouse gas (GHG) emissions [EIA 2022d; EPA, 2022d].

Highlights

- Transportation energy use in 2021 rebounded from the 15.6 percent decrease experienced in 2020 due to steep reductions in vehicle travel caused by the COVID-19 pandemic but remained 6.5 percent below 2019 energy use.
- Data for the first six months of 2022 indicate a continuing increase of transportation energy use to 95.8 percent of the 2019 level despite the increased fuel prices.
- Transportation remains the largest source of carbon dioxide (CO_2) emissions: 28.1 percent of U.S. emissions in 2021.
- U.S. transportation remained dependent on petroleum for 90.1 percent of its energy in 2021.
- Electricity remains a minor source of energy for transportation. Sales of electric vehicles (EV) and charging stations have increased rapidly driven by technological progress, public policy incentives and industry support.
- In 2021, 1.4 million hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV) were sold in the United States. Compared with 2020, sales increased 153 percent for PHEVs, 93 percent for BEVs, and 76 percent for HEVs.
- A typical 200-mile range all-electric vehicle sold in the United States today will use about half as much energy and emit about half as much carbon dioxide as a comparable gasoline-powered vehicle.
- In a decades-long trend, the U.S. air quality continued to improve due in large part to reductions in motor vehicle pollutant emissions, 80–85 percent drop over 2000 rates.

Figure 6-1 U.S. Consumption of Energy from Primary Sources by Sector: 1960–2021



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 4-2, available at www.bts.gov as of September 2022.

While reductions in transportation air emissions have improved air quality in urban areas, air quality, including impacts on the global climate, remains the biggest consequence of transportation energy use. Transportation also affects the environment via the production and disposal of vehicles and infrastructure, through spillage of transportation fuels and runoff from roads and other facilities, by interactions with wildlife, by the effects of noise from vehicles and aircraft, and indirectly by its influence on the nature and intensity of land use, a complex subject not addressed in this chapter.

Technological innovation, public policy, and decisions by organizations and individuals are constantly changing the relationship between transportation and the environment. Progress has been made towards reducing the environmental impacts of transportation through gains in vehicle fuel efficiency despite increases in passenger and freight transportation. Today, the world's transportation system enters the early stages of an energy transition from fossil fuel-based internal combustion engines to electricity, electric motors, and renewable energy. Reliable, relevant, and timely data are essential for tracking progress, informing decision-making, and planning for the future.

This chapter describes the status, patterns, and trends of transportation energy use in the United States and the environmental effects of the quantity and variety of mobility services provided by our transportation system. The closing section identifies data gaps and information needed to anticipate and plan for changes in transportation's energy requirements and their environmental effects.

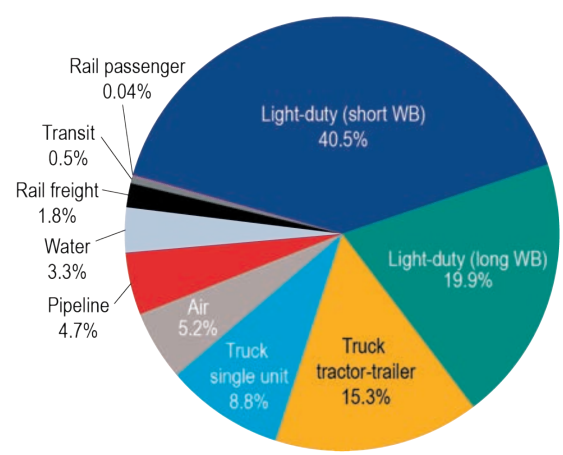
Energy Use Patterns and Trends

The impact of the COVID-19 pandemic is evident in the sudden 15.6 percent decline in energy use in 2020 over 2019, but equally evident is the rapid recovery in 2021. Transportation energy use in 2021 rebounded to within 6.5 percent of the 2019 level. Data for the first six months of 2022 indicate a continuing increase to 95.8 percent of the 2019 level despite prices for gasoline and diesel fuel that were approximate $1.50/gallon higher than in 2019 [EIA 2022a].

The highway travel mode continued to dominate transportation energy use in 2020, the latest year for which data are available, accounting for 84.4 percent of the total 22.4 quads Btu of energy used for transportation [USDOT BTS]. On the highways, passenger cars and light trucks are the biggest energy users at 60.3 percent of total transportation energy use (Figure 6-2). Light-duty vehicle with longer wheelbases, mostly larger sport-utility vehicles (SUVs), pickup trucks, and vans, have been growing in importance and comprised one-fifth of transportation energy use in 2020.

Together, tractor trailers and single-unit trucks accounted for almost one-fourth of transportation energy use, and their share is likely to increase in the future as light-duty vehicle fuel economy improves and the popularity of electric cars and light trucks grows. All non-highway modes combined used 15.6 percent of transportation energy use, reflecting their generally higher energy efficiency on either a ton-mile or passenger-mile basis and their much smaller share of passenger- and ton-miles.

Figure 6-2 Transportation Energy Use by Mode: 2020



KEY: WB = wheelbase.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 4-6, available at www.bts.gov as of August 2022.

Reliance on Petroleum

In 2020 and 2021, transportation relied on petroleum for 90.1 percent of its energy requirements, making it by far the largest consumer of petroleum in the U.S. economy (Figure 6-3). In 2021, the U.S. consumed 24.3 quadrillion (quads) Btu of petroleum, exceeding every other country's petroleum consumption with the exception of China's 29.0 quads [BP 2022].

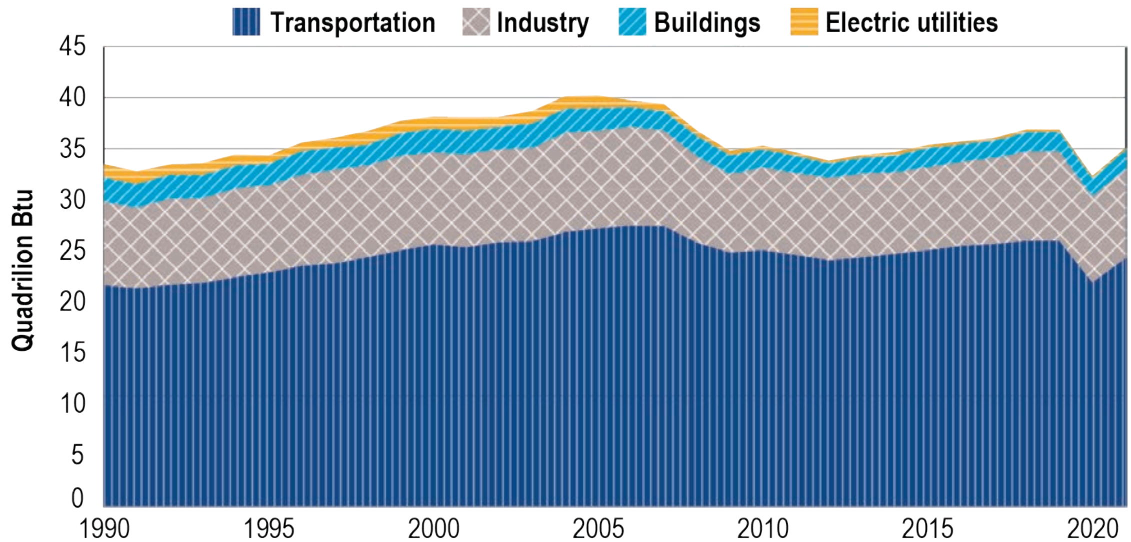
U.S. oil imports are predominantly crude petroleum, while U.S. oil exports are predominantly refined petroleum products. In 2021, the United States imported slightly less than 8.5 million and exported slightly more than 8.5 million barrels of oil per [EIA 2022a], with petroleum exports exceeding imports by 164,000 barrels per day (Figure 6-4).

This dramatic change in the Nation's dependence on imported petroleum was accomplished mostly by a combination of improved vehicle fuel economy, increased domestic oil production, and blending ethanol with gasoline.

Fuel economy improvements to cars and light trucks since 1975 saved over two trillion gallons of gasoline, reducing the rate of gasoline used today by about five million barrels per day over 1975 fuel economy levels [Greene et al., 2020].

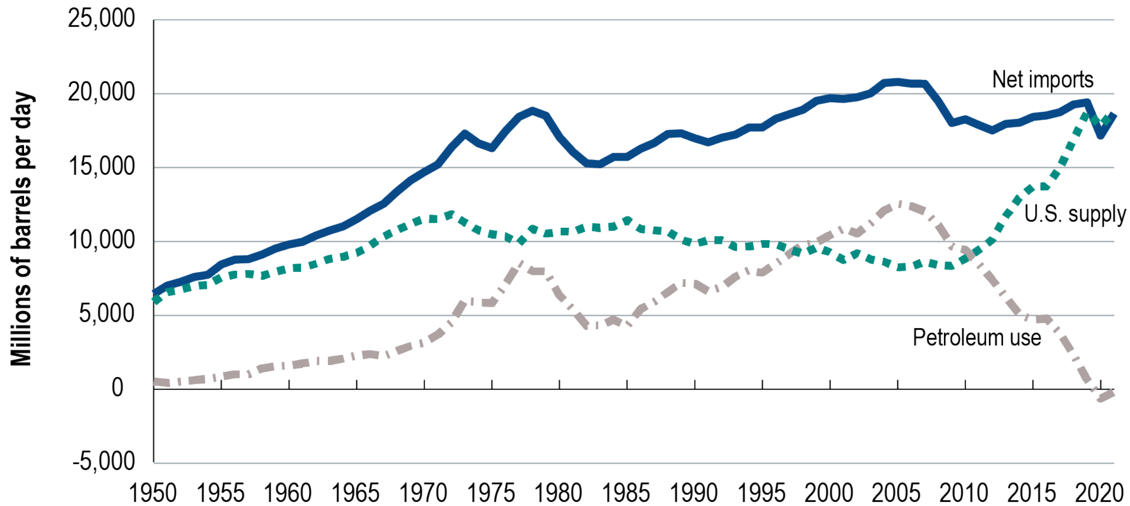
Although transportation relies on petroleum for 90 percent of its energy needs, 90 percent is the lowest level of transportation's petroleum dependence since 1953 (Figure 6-5). Blending biomass-derived ethanol with gasoline at 10 percent by volume has displaced the greatest amount of petroleum. Ethanol and biodiesel supplied 5.5 percent of transportation energy in 2021.

Figure 6-3 Petroleum Use by Sector of the U.S. Economy: 1990–2021



SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, tables 2.2, 2.3, 2.4, 2.5, 2.6, as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 4-3, available at www.bts.gov as of September 2022.

Figure 6-4 U.S. Petroleum Use, Domestic Supply and Net Imports: 1950–2021



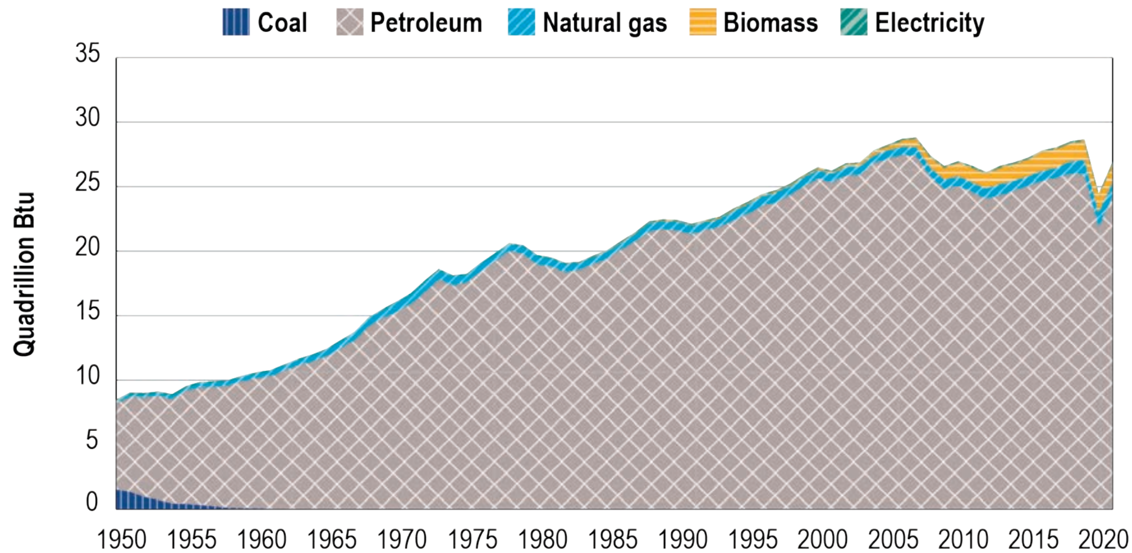
SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 3.1, available at www.eia.gov/ as of September 2022.

The use of domestic natural gas has almost doubled since 2004 and provided 4.1 percent of transportation's energy needs in 2021. Most natural gas used in transportation powers the pumps of natural gas pipelines and to a lesser extent powers cars, trucks, buses, and ships in the form of compressed liquified natural gas.

Statistics on transportation's use of electricity reported by the U.S. Department of Energy, Energy Information Administration (EIA) do not include electricity used by electric cars, trucks, buses, or micromobility vehicles. The *National Transportation Statistics* (NTS) data in Figure 6-2 represent electricity use by transit and intercity rail. At present, there is no direct measurement or statistically validated estimate of electricity use by all highway vehicles, nor are data available on total electricity use for operations of supporting transportation infrastructures, such as streetlights, stations, and airport terminals. The data shown in Figure 6-5 include estimates for highway vehicles in historical years obtained from the EIA's National Energy Modeling System and published in the *Annual Energy Outlook* [EIA 2010-2022]. Because they are model estimates rather than direct measurements, they should be interpreted cautiously. However, according to those estimates, energy use by electric highway vehicles has grown rapidly, from approximately 90 million kilowatt-hours (kWh) in 2010 when the first commercial electric passenger car since the early 20th century was introduced in the United States to over 7 billion kWh in 2021. Despite this rapid growth, including these estimates indicate that electricity accounted for 0.3 percent of transportation's energy use in 2021 versus the 0.2 percent shown in Figure 6-5.

Natural gas use shown in Figure 6-5 includes uses in pipeline compressors and motor vehicles. Over the past decade, natural gas use in pipelines increased from 0.70 to 1.04 quads as a result of increased domestic natural gas production and consumption. Natural gas use by vehicles, whether in compressed or liquefied form is notably smaller. From 2011 to 2021, use by motor vehicles increased from 0.031 to 0.055 quads per year, peaking at 6.3 percent

Figure 6-5 Transportation Energy Use by Fuel Type: 1950–2021



SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 2.5, available at www.eia.gov/ as of August 2022. Estimates of electric vehicle energy use are from the EIA *Annual Energy Outlooks* 2010-2022, table 38.

of transportation's natural gas use in 2017 and declining to 5.0 percent in 2021. The EIA statistics do not distinguish between use by vehicle type. However, the *Annual Energy Outlook* [EIA 2012, 2022] includes estimates of current-year consumption by vehicle type. Those estimates indicate that use by passenger cars and light trucks comprised about 50 percent of motor vehicle use of natural gas in 2011, but that by 2021 light-duty use had fallen to 3 percent, with medium and heavy-duty trucks and buses consuming 97 percent.

Energy Efficiency

The long-term trend of improving energy efficiency was interrupted by the pandemic, dramatically so for air travel. Together with the number of vehicle-miles traveled and ton-miles transported, the efficiency with which transportation fuels are converted into transportation services determines the amount of energy used in transportation. Energy intensity measures efficiency in terms of energy use per unit of service provided (e.g., passenger-mile, ton-mile, and vehicle-mile). Energy intensities are relatively crude measures of efficiency because they do not reflect important qualitative aspects of transportation services, including speed, reliability, trip distances and circuities, and more. The estimates shown in Table 6-1 include only the energy use by transportation vehicles and exclude upstream energy use and energy used in vehicle manufacture and disposal.

Passenger travel has become more energy efficient over time. Air and transit travel in 2020 are exceptions due to the COVID-19 pandemic. The energy intensity of light-duty vehicles (passenger cars and light trucks) has decreased by approximately 30 percent since 1980, due to improved vehicle fuel economies. Non-transit bus, the most energy-efficient passenger mode, delivers more than three times as many passenger-miles per Btu as light-duty vehicles

Table 6-1 Energy Intensities of Transportation Modes: 1980, 2000, and 2020

Passenger Modes	1980	2000	2020
Air, certificated carrier (Btu/passenger-mile)			
Domestic operations	6,029	3,892	4,423
International operations	4,374	3,857	8,353
Highway (Btu/passenger-mile)			
Light -duty vehicle, short wheelbase	4,184	3,454	2,851
Motorcycle	2,045	2,187	2,271
Light-duty vehicle, long wheelbase	5,494	4,339	3,894
Bus	1,567	1,081	920
Transit motor bus	2,742	3,677	4,069
Rail (Btu/passenger-mile)			
Amtrak	2,130	2,665	2,862
Rail transit*	763	923	851
Commuter rail*	NA	1,542	1,583

Freight Modes	1980	2000	2020
Air Freight	NA	NA	NA
Highway (Btu/vehicle-mile)			
Single-unit truck	23,888	18,635	18,017
Combination truck	26,079	26,114	22,027
Rail (Btu/ton-mile)			
Class I railroad	584	347	282
Classes II and III	NA	NA	NA
Water			
Waterborne domestic*	NA	270	NA
Waterborne international	NA	NA	NA

KEY: Btu = British thermal unit; NA = not available.

SOURCE: National Transportation Statistics, Tables 4-20 and 4-22. Waterborne, domestic, Rail Transit and Commuter Rail are from Davis & Boundy, 2022, tables 2.16 and 2.15.

due to higher load factors. The energy intensity of transit motor buses averaged 3,198 Btu/passenger-mile over the decade from 2010–2019, varying by +5.2 to –14.5 percent. Transit bus energy intensity increased by 23.1 percent, due to the loss of ridership and lower load factors during the COVID-19 pandemic that began in mid-March 2020. Passenger-miles traveled by bus and heavy rail, which accounted for 83.6 percent of transit trips fell, by 39.9 and 48.3 percent, respectively [USDOT FTA, 2022]. As a result, heavy rail occupancy rates declined from 48.7 percent to 27.3 percent and bus load factors decreased from 23.1 percent to 17.9 percent. Other transit modes experienced similar reductions. Despite the impacts of the pandemic, rail modes continued to be among the most energy-efficient modes.

The lack of comprehensive national statistics on freight energy efficiency is evident in Table 6-2. Air freight efficiency is poorly understood because of the difficulty of allocating the energy used in commercial airline operations between passengers and freight carried on board the same aircraft. In Table 6-2, the energy intensity of highway freight is measured in Btu/vehicle-mile for separate estimates for single-unit and combination trucks, but truck ton-mile estimates are available only for both truck types combined. The vehicle definitions for the separate vehicle type versus combined estimates are not identical, which results in inconsistent estimates of Btu/vehicle-mile. A combined truck ton-mile energy intensity measure is not ideal because single-unit trucks not only perform different goods delivery functions, but some perform non-freight service functions (e.g., a plumber’s truck or electric utility’s bucket truck). The combined ton-mile and vehicle-mile energy intensity numbers indicate that although vehicles have become more energy efficient (Btu/vehicle-mile decreasing by about 20 percent from 1980 to 2020), ton-miles have become more energy intensive (Btu/ton-mile increasing about 20 percent). Although this is likely due to lower load factors (fewer ton-miles per truck-mile, due either to lighter freight or more empty truck miles) the available data are not adequate for verifying that theory. Energy use per ton transported by Class I railroads is well known, and today is less than half what was required in 1980. Data on the energy intensity of freight rail operations other than Class I are lacking.

Fuel economy improvements to cars and light trucks have saved an estimated two trillion gallons of gasoline since 1975, enough fuel to power every light-duty vehicle in the United States for 15 years. Prior to 1975, vehicle travel and gasoline use increased along the same trajectory [USDOT FHWA 2021, table VM-1; Greene et al., 2020]. After the oil price shock of 1973–74 and the enactment of Corporate Average Fuel Economy (CAFE) standards in late 1975, the growth of fuel consumption became disconnected from the growth of light-duty vehicle travel, as shown in Figure 6-6. Improved fuel economy reduces the cost of fuel required to drive a mile, which causes vehicle travel to increase, a phenomenon known as the “rebound effect.” The National Highway Traffic Safety Administration and the Environmental Protection Agency used estimates of the rebound effect to remove the additional miles attributed to the rebound effect to produce the lower bound of vehicle travel shown by the dashed line in Figure 6-6. Fuel savings due to increased miles per gallon (MPG) are the difference between the adjusted vehicle-miles traveled (VMT) trend and actual fuel consumption, just under 75 billion gallons, as indicated by the green line in Figure 6-6. The sum of all fuel estimated to have been saved is 2.1 trillion, more than all the fuel used by cars and light trucks from 2005–2020.

In 2021, Executive Order 14037 directed the USDOT to set new fuel economy standards, and the Environmental Protection Agency to set new greenhouse gas (GHG) emissions standards for passenger cars, light trucks, and medium- and

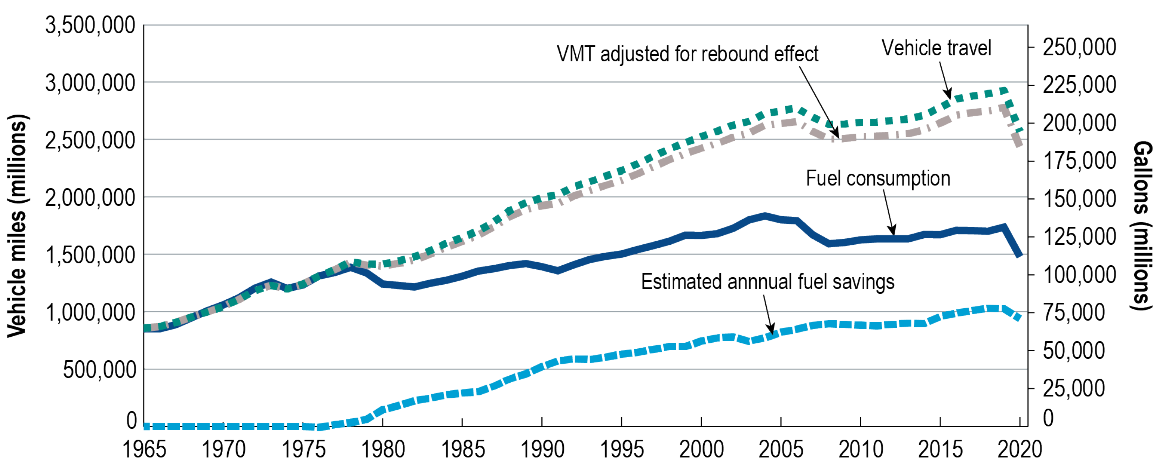
Table 6-2 U.S. Electricity Generation by Energy Source: 2010 vs. 2021

Energy source	Billion kWh 2010	Billion kWh 2021	Percentage 2010	Percentage 2021
TOTAL	**4,112**	**4,103**	**100**	**100**
Coal	1,847	899	44.9	21.9
Petroleum	37	19	0.9	0.5
Natural gas	999	1,587	24.3	38.7
Nuclear	807	778	19.6	19.0
Hydropower	255	255	6.2	6.2
Solar	1	115	0.0	2.8
Wind	95	380	2.3	9.3
Other	71	72	1.7	1.8

KEY: kWh = kilowatt hour.

SOURCE: U.S. Department of Energy, Energy Information Administration, *2022 Monthly Energy Review*, table 7.2a, available at https://www.eia.gov/totalenergy/data/monthly/ as of October 2022.

Figure 6-6 Miles of Travel and Fuel Use by Light-duty Vehicles: 1965–2020



KEY: VMT = vehicle-miles traveled.

SOURCE: Greene, et al., 2020, updated spreadsheet provided by authors, 9/20/22. VMT and fuel consumption data from U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, annual issues, table VM-1.

heavy-duty motor vehicles [Executive Order, 2021]. The light-duty vehicle fuel economy standards were finalized in March of 2022 and require that new vehicle MPG increase by 8 percent per year in 2024 and 2025 and by 10 percent in 2026 [USDOT NHTSA 2021].

Air carriers achieved dramatic reductions in energy use per passenger-mile between 1970 and 1980 by switching from turbojets to turbofans, increasing aircraft size, and filling more seats with customers (Figure 6-7). The period from 1980 to 2019 saw slower but steady progress, as continued technological advances and increased occupancy rates offset the increased use of smaller regional jets. Among the COVID-19 pandemic's impacts on the airline industry was a sudden and dramatic increase in energy use per mile as load factors dropped and normal operations were disrupted. From 2019 to 2020, revenue passenger-miles carried by domestic and international carriers plummeted from 1.1 trillion to 382 billion, a 64 percent loss. Although air carriers reduced the number of flights, aircraft occupancy rates plunged from 84 percent in 2018 to 58 percent in 2020. Since then, passenger traffic has largely recovered, but in May 2022 it still remained 6 percent below the pre-pandemic level in May 2019 [BTS, 2022b].

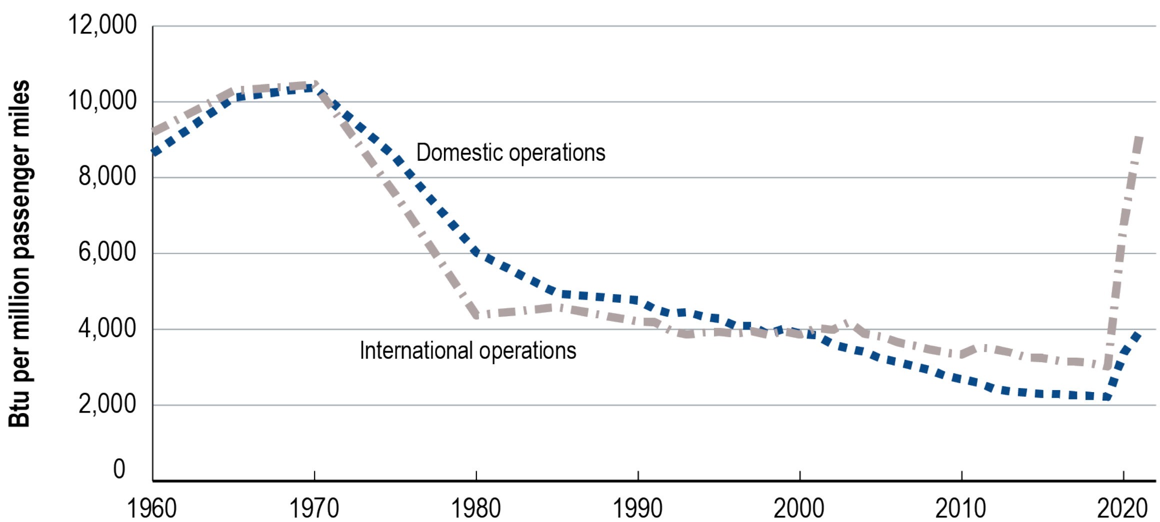
Transition to Clean Fuels and Vehicles

The world's transportation systems have begun a transition to new sources of energy. On August 5, 2021, Executive Order 14037 established a national goal that 50 percent of passenger car and light-truck sales in 2030 be zero-emission vehicles (ZEV): battery-powered electric, plug-in hybrid electric, or hydrogen fuel cell electric vehicles [Executive Order, 2021]. In August 2022, the Inflation Reduction Act was signed into law, providing funding to extend tax credits for ZEVs and charging stations, along with subsidies for the domestic production of electric vehicles and batteries [P.L. 117-169, 2022]. In the same month, the California Air Resources Board adopted a plan to require 100 percent ZEVs in California by 2035 which may be joined by other states that have adopted California's motor vehicle emissions standards [CARB 2022]. Many other nations, including the European Union, China, have adopted similarly ambitious policies [IEA 2022], and the world's largest automobile manufacturers have announced plans to transition to electric vehicles over the next few decades [Motavalli 2021]. In 2021, however, electricity provided a fraction of transportation's energy requirements, similar in magnitude to natural gas and far less than biofuels.

Electricity

The future electric vehicle goals set in 2021 remain uncertain; however, the numbers of plug-in electric vehicle (PEV) makes and models, sales, and charging infrastructure have grown rapidly over the past few years, both in

Figure 6-7 Energy Intensity of Certificated Air Carriers, All Services



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 4-21, available at www.bts.gov as of August 2022.

Box 6-A Electric Vehicle Definitions

Battery electric vehicle (BEV): An all-electric vehicle that receives power by plugging into an electric power source and storing the power in a battery pack. BEVs do not use any petroleum-based or other liquid- or gas-based fuel during operation and do not produce tailpipe emissions.

Fuel cell electric vehicle (FCEV): An electric vehicle that generates on-board electricity with a fuel cell powered by hydrogen rather than relying on electricity from a high-capacity battery.

Hybrid electric vehicle (HEV): Combines an internal combustion engine (ICE) with a battery pack, regenerative braking, and an electric motor to provide high fuel economy. HEVs rely on gasoline or diesel fuel for power and cannot be plugged into an electric power source. The battery packs are charged by the ICE and regenerative braking.

PEV/Electric vehicle (EV): A general term for any on-road licensed vehicle that can plug into an electric power source and uses electric power to move. EVs plug into a source of electricity and store power in a battery pack for all or part of their power needs. Includes Battery Electric Vehicles (BEVs) and Plug-in Hybrid Vehicles (PHEVs). Can also be referred to as Plug-in Electric Vehicles.

Plug-in hybrid electric vehicle (PHEV): A vehicle that can both (1) plug into an electric power source and store power in a battery pack and (2) use petroleum-based or other liquid- or gas-based fuel to power an internal combustion engine.

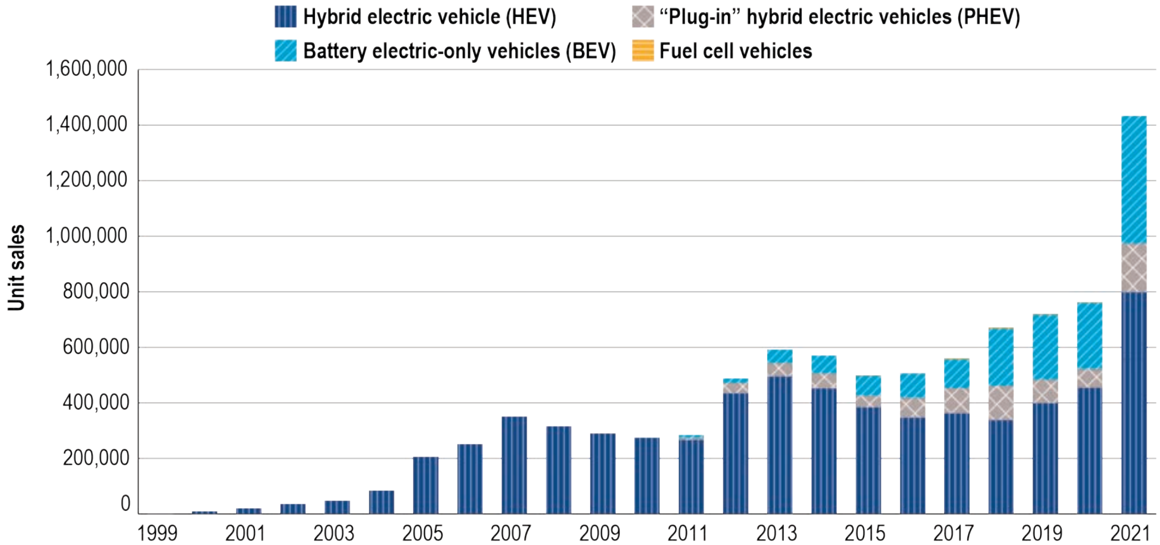
SOURCE: U.S. Department of Energy, Energy Information Agency, Glossary, available as of October 2022.

the United States and worldwide. Worldwide, 450 EV makes and models of vehicles were on the market in 2021, a 15 percent increase over 2020 [IEA 2022]. In the United States, 43 battery electric (BEV) car and light truck makes and models were available in 2021, along with 49 plug-in hybrids (PHEV) makes and models [Davis and Boundy 2022, tables 6.7, 6.8 and 6.9]. The 92 plug-in vehicles (PEV) models compare with 83 in 2020 and 1 in 2010. Five hydrogen fuel cell electric (FCEV) models were available for purchase by the public but only in California, the only state with retail hydrogen refueling stations open to the public. (See Box 6-A for a description of the different types of electric vehicles.)

U.S. sales of BEVs, PHEVs, and HEVs nearly doubled (88 percent) in 2021 over 2020 as the economy rebounded from the pandemic, gasoline prices rose, and manufacturers intensified their marketing efforts (Figure 6-8). Sales of PHEVs increased by the greatest percentage (153 percent), followed by BEVs (93 percent), and HEVs (76 percent). Total Plug-in electric vehicle (PEV) sales exceeded 630,000 in the model year 2021, just over 4 percent of total U.S. passenger car and light truck sales. California's new car buyers purchased 250,000 zero-emissions vehicles (ZEV) in 2021, 12.4 percent of total car and light truck sales in the state and the highest ZEV market share in the United States. [CEC, 2022]. Three-quarters of the ZEVs sold in California were BEVs. Worldwide, 6.6 million BEVs and PHEVs were sold in 2021, again almost twice as many as in 2020 [USDOT EIA 2022]. At the end of 2021, there were a total of 2.4 million PEVs on U.S. roads, of which two-thirds were BEVs.

Vehicle use data from the 2017 National Household Travel Survey (NHTS) indicate that

Figure 6-8 Sales of Hybrid, Plug-in Hybrid and Battery Electric Vehicles: 1999–2021



SOURCE: Argonne National Laboratory, Electric Drive Vehicle Sales, available at www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates as of September 2022.

households drove battery electric vehicles fewer miles per year (9,972) than gasoline-powered vehicles (11,082), despite being newer (more information on household vehicle travel can be found in Chapter 2 - Passenger Travel and Equity). Ninety percent of households owning a BEV owned at least one other vehicle, and 66 percent of those households had a non-BEV that was driven more miles per year than the BEV vehicle [Davis 2022]. However, the median range on a fully charged for BEV models sold in the model year 2015 and earlier was 90 miles or less [USDOE 2021, 2022]. Since 2015, median ranges have averaged well over 200 miles, and more recent evidence indicates that today's BEVs are used in much the same way as gasoline vehicles [Chakraborty et al., 2022].

From electrical outlet to vehicle energy use, electric vehicles are more energy efficient than gasoline-powered internal combustion engine (ICE) vehicles, delivering three to four times the miles per electrical energy equivalent of a gallon of gasoline. However, far more energy is used to produce and deliver electricity to a BEV than is used to produce, refine, transport, and deliver gasoline. The energy in a gallon of gasoline in a vehicle's tank comprises about 83 percent of the total energy used from oil wells to the vehicle's wheels. In contrast, only about 35 percent of the energy in coal and 50 percent of the energy in natural gas is converted into electrical energy at U.S. power plants [Kelly et al., 2022, table 18]. About 5 percent of the electricity generated is lost in transmission and distribution [EIA 2022, table 7.1] so that only 30 to 45 percent of the energy in coal and natural gas, respectively, is delivered to an EV as electricity. Losses in battery charging and discharging used up another 10 percent. Including energy use upstream of the vehicle diminishes an EV's energy efficiency advantage over an ICE vehicle. Over its full lifecycle, including manufacture, use, and disposal, a typical 200-mile range BEV sold in the United States today requires about half as much energy as a comparable gasoline, internal combustion engine vehicle [Kelly et al., 2022, tables 46 and 47].

BEVs sold in the United States today have a clear emissions advantage over internal combustion engine vehicles powered by gasoline and diesel fuel. Not only do BEVs emit zero tailpipe pollutants but upstream emissions have been substantially reduced. Since 2005 U.S. electricity generation has shifted away from coal and towards natural gas and renewable energy. In 2005, 50 percent of U.S. electricity was generated at coal-fired plants, 19 percent by natural gas, and 0.5 percent by solar and wind combined. In 2021, coal produced only 22 percent of U.S. electricity, natural gas generation accounted for 38 percent, and solar and wind generated 12 percent [USDOE EIA 2022, table 7.2a]. As a result, greenhouse gas (GHG) emissions from U.S. electricity have fallen from 2.4 billion metric tons of CO2 to 1.6 billion, a 33 percent reduction, substantially diminishing the upstream emissions due to electricity use [EIA 2022, table 11.6]. Adding greenhouse gas emissions in vehicle manufacturing and disposal, the full lifecycle emissions of a 234-mile range BEV sold in the United States today is about half that of a comparable gasoline vehicle [Kelly et al., 2022, figure ES-1].

The environmental impacts of electricity use by transportation depend on how the electricity is generated, which varies by time and place. National averages provide a high-level overview of patterns and trends. In 2010, 44.9 percent of U.S. electricity was generated by burning coal, while wind power produced 2.3 percent and solar power generation was negligible (Table 6-1). By 2021 coal's share had dropped to 21.9 percent, largely replaced by natural gas, which produces substantially fewer emissions. Generation by renewable energy sources increased, with solar and wind combining to produce 12.1 percent of U.S. electricity (Table 6-2). Carbon dioxide emissions from electric power generation decreased by 31.6 percent, while electricity production remained relatively unchanged, dropping 0.2 percent [EIA 2022a, tables 11.6 and 7.2a].

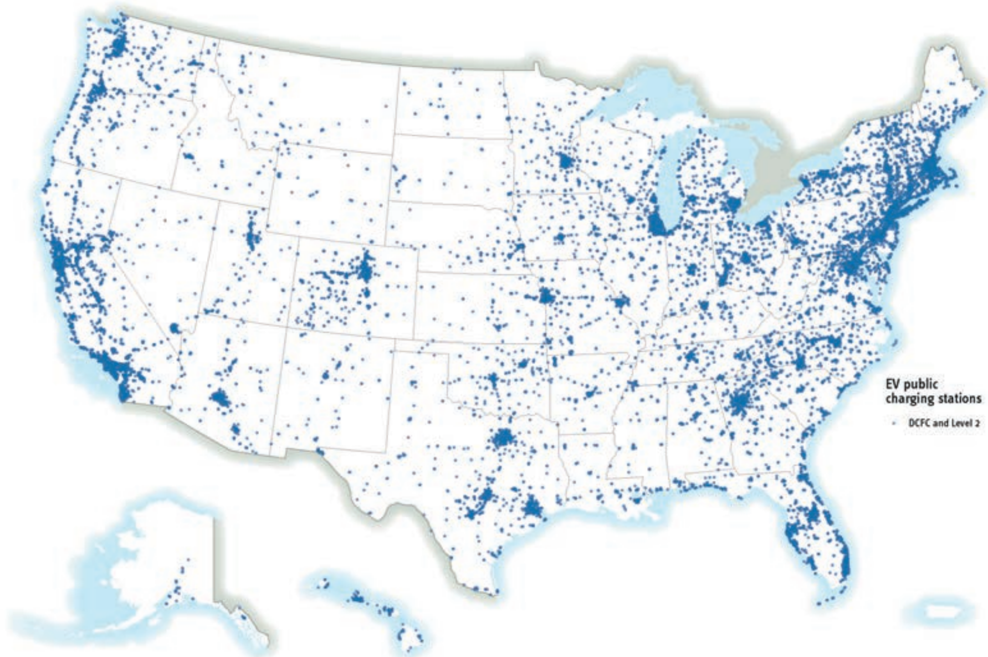
If electric vehicles are to achieve mass-market success consistent with national goals, public charging will have to become as accessible, rapid, and economical as refueling with gasoline. Deploying an effective national charging infrastructure is challenging, chiefly because the EV market is in the early stages of development, and battery and charging technologies are evolving. Today, EV owners do 80 to 90 percent of their charging at home, a major departure from traditional vehicle petroleum refueling [Greene et al. 2020]. In 2011, the year after introduction of the first commercially mass-produced battery electric passenger car, there were 2,100 public charging stations operating in the United States. [USDOE AFDC 2022]. From 2011 to 2022, approximately 11,100 charging stations were added each year to reach 124,088 stations in 2022 (Figure 6-9A). However, the vast majority of public charging stations, 97,410, offer relatively slow "Level 2" charging, capable of delivering only 10–20 miles of driving range per hour spent charging [USDOT 2022]. Only 26,249 stations have direct current fast chargers (DCFC) capable of delivering 240 miles of range in under 20 minutes of charging (Figure 6-9B). This compares with approximately 142,000 gasoline stations capable of refueling ICEs in about 6 minutes [Davis and Boundy 2022, table 4.24].

Natural Gas

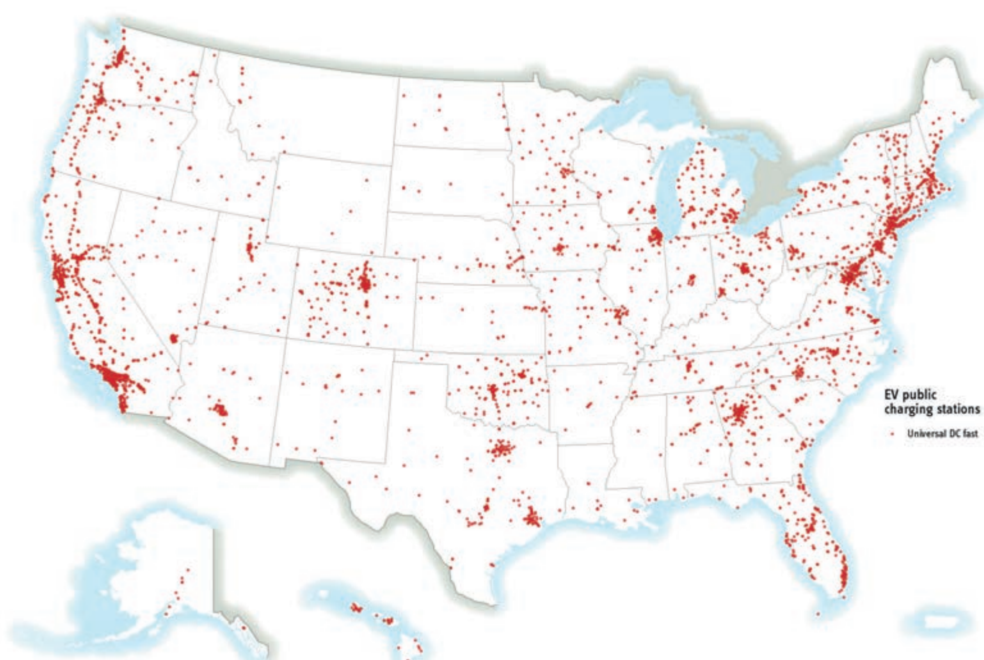
Over 175,000 natural gas vehicles on U.S. roads in 2021 consumed 55 billion cubic feet of gas, the energy equivalent of 459 million gallons of gasoline [EIA 2022b]. Most natural gas vehicles are high mileage, centrally fueled buses or medium- to heavy-duty trucks, which accounts for their relatively high consumption of over 2,600 gallons of gasoline-equivalent natural gas per year [AFDC 2022]. About 40 percent

Figure 6-9 Fast Charging Stations in the U.S.

A. Electric Vehicle Public Unrestricted Direct Current Fast Charging Stations in the U.S.



B. Electric Vehicle Public Level 2 and Direct Current Fast Charging Stations in the U.S.



SOURCE: U.S. Department of Energy, Alternative Fuels Data Center, *Electric Vehicle Charging Station Locations* as of September 2022.

of natural gas used in vehicles is consumed by transit vehicles. Motor vehicle use of natural gas has increased at an average annual rate of 8 percent per year since 1997 (Figure 6-10), encouraged by abundant and economical supplies of domestic gas and lower tailpipe emissions than equivalent vehicles powered by gasoline or diesel fuel. Still, total vehicle natural gas use amounted to only 0.35 percent of total gasoline consumption by vehicles.

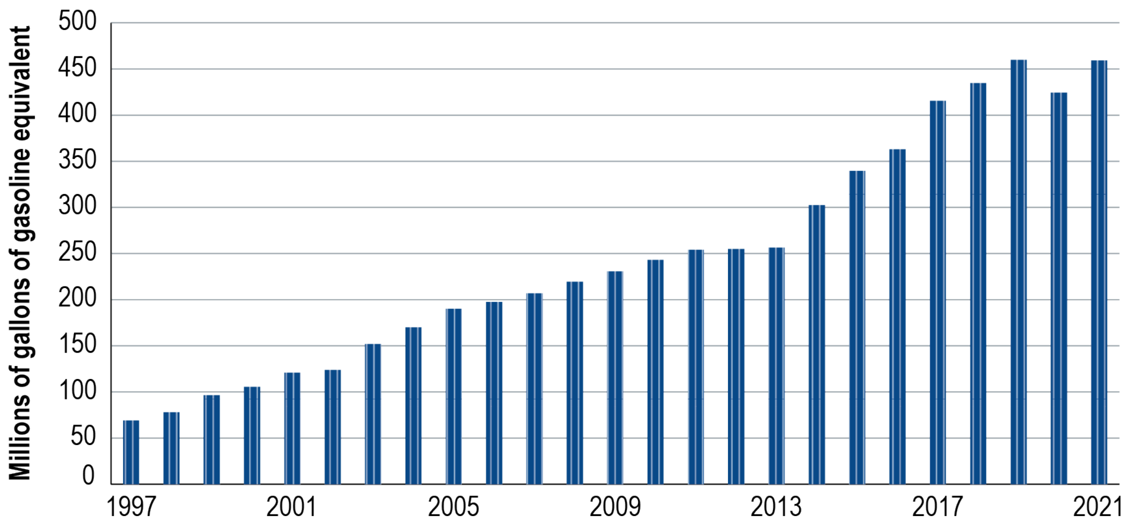
In the United States the great majority of natural gas vehicles are powered by compressed natural gas (CNG) stored on-board at approximately 2,000 psi (pound force per square inch). Some of the larger vehicles are fueled by liquefied natural gas (LNG), whose higher energy content per gallon enables greater range. However, at –260° Fahrenheit, LNG is more expensive to make and store. CNG refueling is supported by 882 public and 661 private refueling stations, while LNG vehicles are refueled at 54 public and 48 private LNG stations.

Small amounts of natural gas are used by ships. Use of natural gas as a maritime fuel is expected to remain minimal due to the low energy density of compressed natural gas and the cost and infrastructure requirements for cryogenic LNG. To date, natural gas has been limited to experimental use in aircraft for much the same reasons [Dubois 2021].

Biofuels

Ethanol and renewable diesel are the most widely used biofuels in transportation, accounting respectively for 88 percent (13.9 billion gallons) and 11 percent (1.8 billion gallons) of transportation biofuel use in 2021 [EIA 2022c]. The majority of fuel ethanol is blended with gasoline at a volume of 10 percent (E10), and almost all gasoline sold in the United States contains up to 10 percent ethanol. Gasoline powered vehicles of model year 2000 and earlier are equipped to handle no more than 10 percent ethanol blends. In 2011, the saturation point for this "blend limit" was reached for U.S. gasoline, and thereafter ethanol use grew at approximately the same rate as overall gasoline use (Figure 6-11). Gasoline-powered vehicles of model year 2001 and later

Figure 6-10 Natural Gas Use by Vehicles: 1997–2021



SOURCE: U.S. Department of Energy, Energy Information Administration, *U.S. Natural Gas Vehicle Fuel Composition*, available at https://www.eia.gov/dnav/ng/hist/n3025us2A.htm as of October 2022.

are capable of using ethanol blends of up to 15 percent, but to date a safe and convenient way of delivering E15 to only vehicles qualified to use it has not been found. Flex-fueled gasoline/ethanol vehicles are capable of using blends of up to 83 percent ethanol, but the market for E85 has not developed beyond several midwestern states.

Medium- and heavy-duty vehicles with diesel engines can purchase biodiesel or renewable diesel blended at 2, 5, or 20 percent with petroleum diesel fuel [EIA, 2022c]. Much of the diesel fuel sold in the United States contains approximately 1 percent biodiesel because of its lubricating properties. Developing economical processes for producing low-carbon fuels for medium- and heavy-duty vehicles is an ongoing development.

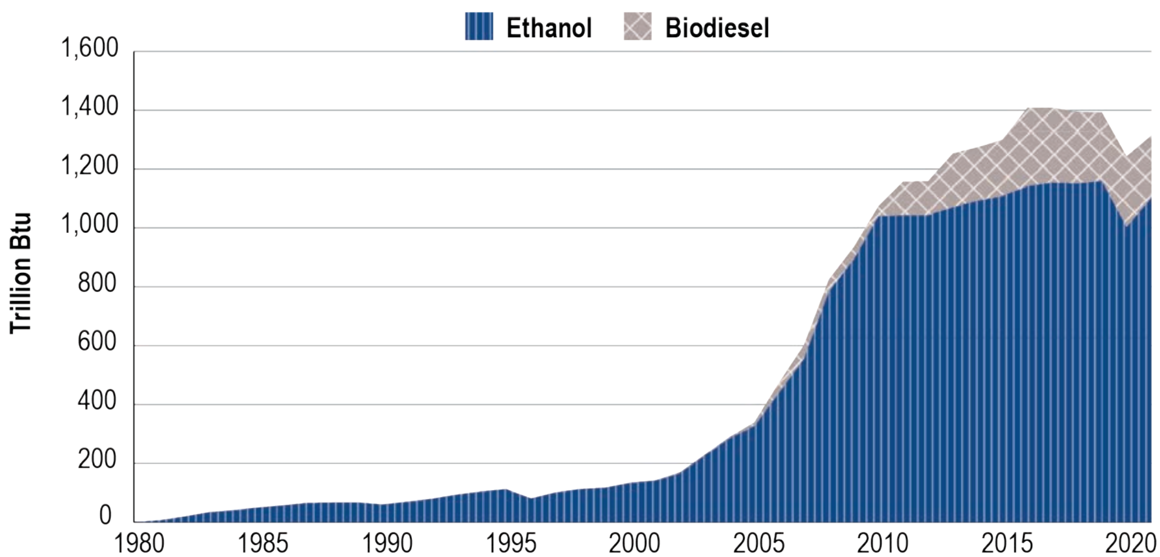
Air travel accounted for 5.2 percent of transportation's energy use in 2020 (1.2 quadrillion Btu), approximately the same quantity of bioenergy used by highway vehicles (1.3 quadrillion Btu) (Figure 6-2 and Figure 6-11).

Because weight is a critical factor for aircraft, air travel relies on energy dense petroleum fuels. If battery-powered aircraft become commercially viable, they will at least initially be limited to short distance flights because of the relatively low energy density of even the best batteries available today [USDOE 2022b]. If aviation is to achieve major reductions in greenhouse gas emissions, low-carbon jet fuel appears to be essential. Today, low-carbon sustainable aviation fuel (SAF) is made from biomass via processes similar to the production of biodiesel. SAF supply is limited, however, with only about 2 million gallons of SAF produced in the United States in 2018, about 0.01 percent of annual jet fuel production. In 2021, the President set goals of producing 3 billion gallons of SAF in 2030 and 35 billion by 2050 [White House 2021].

Transition to Clean Modes

Electrically assisted micromobility modes are small but growing innovative transportation services that include non-motorized and electric pedal-assisted (e-bike) bike-sharing, electric scooters, and electric skateboards. Patterns

Figure 6-11 Transportation Use of Biofuels: 1980–2021



KEY: Btu = British thermal unit.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 10.2c, available at www.eia.gov/as of August 2022.

and trends in micromobility travel are covered in greater detail in Chapter 2 - Passenger Travel and Equity and safety issues are discussed in Chapter 5 - Transportation Safety.

Although accurate sales data for e-bikes and e-scooters are not available, it is estimated that 790,000 e-bikes were sold in the United States in 2021, up from 463,000 in 2020, and 185,000 in 2013 [Boudway 2022]. In 2015, there were 3,372 bikesharing docking stations open to the public in U.S. cities; since then, the number more than doubled to 8,457 in 2021 [USDOT BTS 2022b]. E-scooter systems have grown the most rapidly, from 135 systems when they first appeared in 2018, to 190 systems in 2021, and to 300 systems serving 300 cities in 2022. In 2021, 281 bikeshare and e-scooter systems provided 232,000 vehicles, 57 percent of which were scooters [NABSA 2022].

Substantial growth in micromobility modes occurred despite the temporary suspension and/or closure of many docked bikeshare system operations during the COVID-19 pandemic. A fully charged electric bike will have an electrically assisted range of 40–120 miles, depending on how much electrical assistance a rider uses [ElectricBikeInfo.com]. The average cost of electricity to operate an e-bike is roughly one-tenth of a cent per mile. The battery capacities of e-scooters vary widely, but a typical e-scooter with a 15-mile range, consumes about $0.16 cents worth of electricity per 100 miles (about 6 miles per penny spent on electricity), more than an electrically assisted e-bike because the scooter rider provides little or no power.

An estimate of electricity used by e-bikes and scooters can be derived from the energy intensity estimates and estimates of number of trips and trip lengths [NACTO 2019; NABSA 2021]. The calculations in Table 6-3 apply to e-bikes and e-scooters provided by micromobility services. Estimates of energy consumption per mile for e-bikes are based on the usage of two trips per day, on average, and consume approximately 9 kWh per year, and a full recharge every 2 weeks. E-scooters are estimated to take about 1.3 trips per day and consume about 9 kWh of electricity per year. Based on sales statistics, there were about 3 million e-bikes in the United States in 2021, mostly owned by individuals, 30 times as many vehicles as considered in Table 6-3. Even considering these vehicles, energy consumption by e-bikes and e-scooters is on the order of 1 percent of the 7 billion kWh of estimated electricity use by EVs in 2021, shown in Figure 6-5.

Greehouse Gas Emissions and Air Quality

While pollutant emissions affecting local and regional air quality continue to decline, contributing to cleaner air in metropolitan areas, emissions of greenhouse gases appear to be returning to pre-COVID levels; transportation

Table 6-3 Estimates of Energy Use by E-Bikes and E-Scooters in the U.S.: 2021

E-bike/e-scooter	Vehicles (thousands)	Trips (millions)	Annual Trips per Vehicle	Miles per Trip	Annual Miles per Vehicle	Wh per Mile	kWh per Vehicle per Year	Total Electricity (thousand kWh)
E-bikes	24	18.8	783	1.5	1,175	8	9	226
E-scooters	134	62.2	464	1.3	603	15	9	1,213

KEY: kWh = kilowatt hour.

SOURCE: Bureau of Transportation Statistics' calculations NACTO 2019; NABSA 2021.

remains the largest source of carbon dioxide emissions. Transportation's other effects on the environment are water pollution to wildlife, equipment waste, and noise pollution.

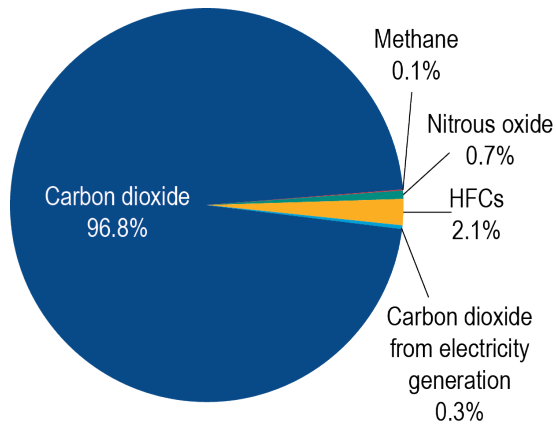
Transportation continues to rely on fossil hydrocarbon fuels for energy and continues to emit more carbon dioxide (CO_2) than the electricity generation, industry, or commercial and residential buildings sectors, accounting for 28.1 percent of total U.S. carbon dioxide (CO_2) emissions in 2021 [USDOE 2022].

Carbon dioxide dominates transportation's greenhouse gas emissions (Figure 6-12). Emissions of hydrofluorocarbons (HFC), the second largest component, are not a result of fuel combustion but leakage from vehicle air conditioners. Because the carbon content of transportation fuels does not vary greatly, the distribution of GHG emissions by mode closely resembles the distribution of energy use by mode shown in Figure 6-2.

Trends in CO_2 emissions by energy sector show similar patterns over time, decreasing for a few years following the energy crises of the 1970s and early 1980s, increasing for the two decades of low energy prices following 1985, then trending downward due to economy-wide efforts to reduce greenhouse gas emissions (Figure 6-13). Also evident are the single-year reductions caused by the Great Recession of 2009 and the COVID-19 pandemic. After 2005 transportation emissions decreased the least of any sector and in fact resumed growth after the Great Recession. Sharp reductions in vehicle and air travel in 2020 are evident, as is an almost equally rapid rebound in 2021 that continued into 2022.

Air quality in the United States has been systematically improving despite population and economic growth. Major pollutants regulated under the Clean Air Act of 1970 have been declining for decades (Figure 6-14). Average

Figure 6-12 Transportation's Greenhouse Gas Emissions by Gas: 2020



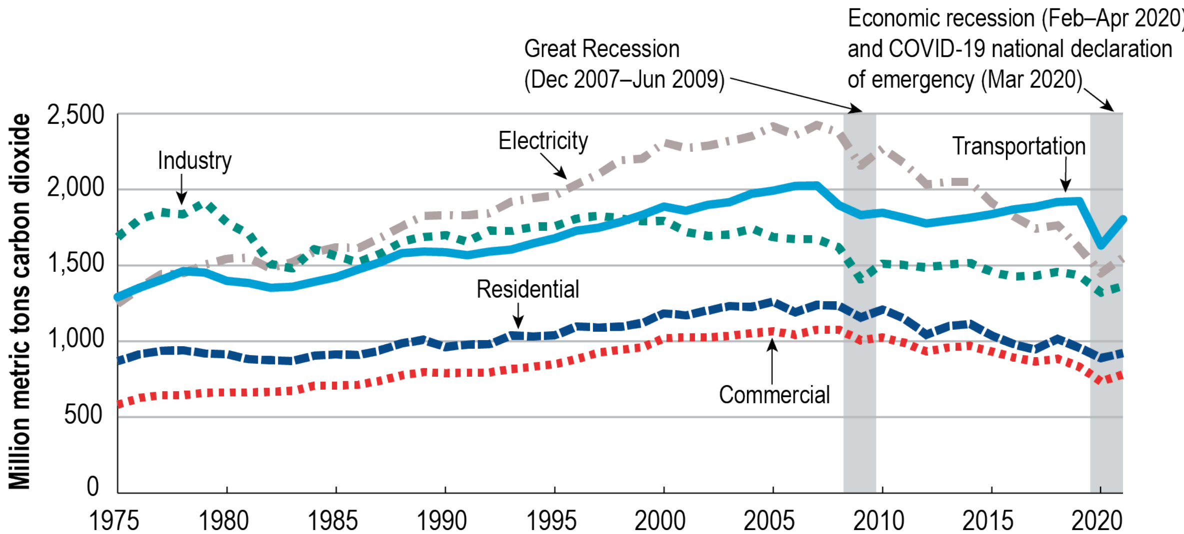
KEY: CH_4 = methane; CO_2 = carbon dioxide; eCO_2 = carbon dioxide from electric power plants; HFCs = hydrofluorocarbon; N_2O = nitrous oxide.

SOURCE: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020*, table 2-12, available at www.epa.gov/ghgemissions/ as of August 2022.

concentrations of nitrous oxides now average 60–80 percent below National Ambient Air Quality Standards (NAAQS); concentrations of particulate matter averaged 30–60 percent below NAAQS; and concentrations of lead, sulfur dioxide, and carbon monoxide (CO) average 80 percent below the current standards [EPA 2022c]. Even so, there are hundreds of days each year in which residents of one of the 35 largest U.S. cities experience unhealthy air. In 2000, there were 2,076 exposure days on which air quality was unhealthy for sensitive groups in the 35 cities, 16 percent of the total days. The number of unhealthy days fell to 1,112 in 2010 and 666 in 2021, 5.2 percent of total days.

Transportation is a major source of air pollution. Transportation vehicles produce 61 percent of carbon monoxide emissions, 53 percent of nitrogen oxides, and 17 percent of volatile organic compound emissions that combine to create ozone pollution, and 13–15 percent of emissions of particulate matter (Table 6-4). As Table 6-4 shows, non-highway transportation

Figure 6-13 U.S. Carbon Dioxide Emissions from Energy Consumption: 1975–2021



SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 11.2-11.6, available at www.eia.gov/ as of August 2022.

Table 6-4 Sources of U.S. Air Pollutant Emissions: 2021 (Percentages)

Air Pollutant	Stationary Fuel Combustion	Industrial and Other Processes	Highway Vehicles	Non-Road Mobile	Total Mobile Sources
Carbon Monoxide	9.1	30.2	34.6	26.1	60.7
Ammonia	1.8	95.9	2.2	0.1	2.2
Nitrogen Oxides	30.3	16.2	29.3	24.2	53.5
PM2.5	44.3	42.2	5.7	7.8	13.5
PM10	32.5	52.5	9.6	5.4	15.0
Sulfur Dioxide	70.1	27.7	0.8	1.5	2.2
Volatile Organic Compounds	4.3	78.4	8.5	8.7	17.3

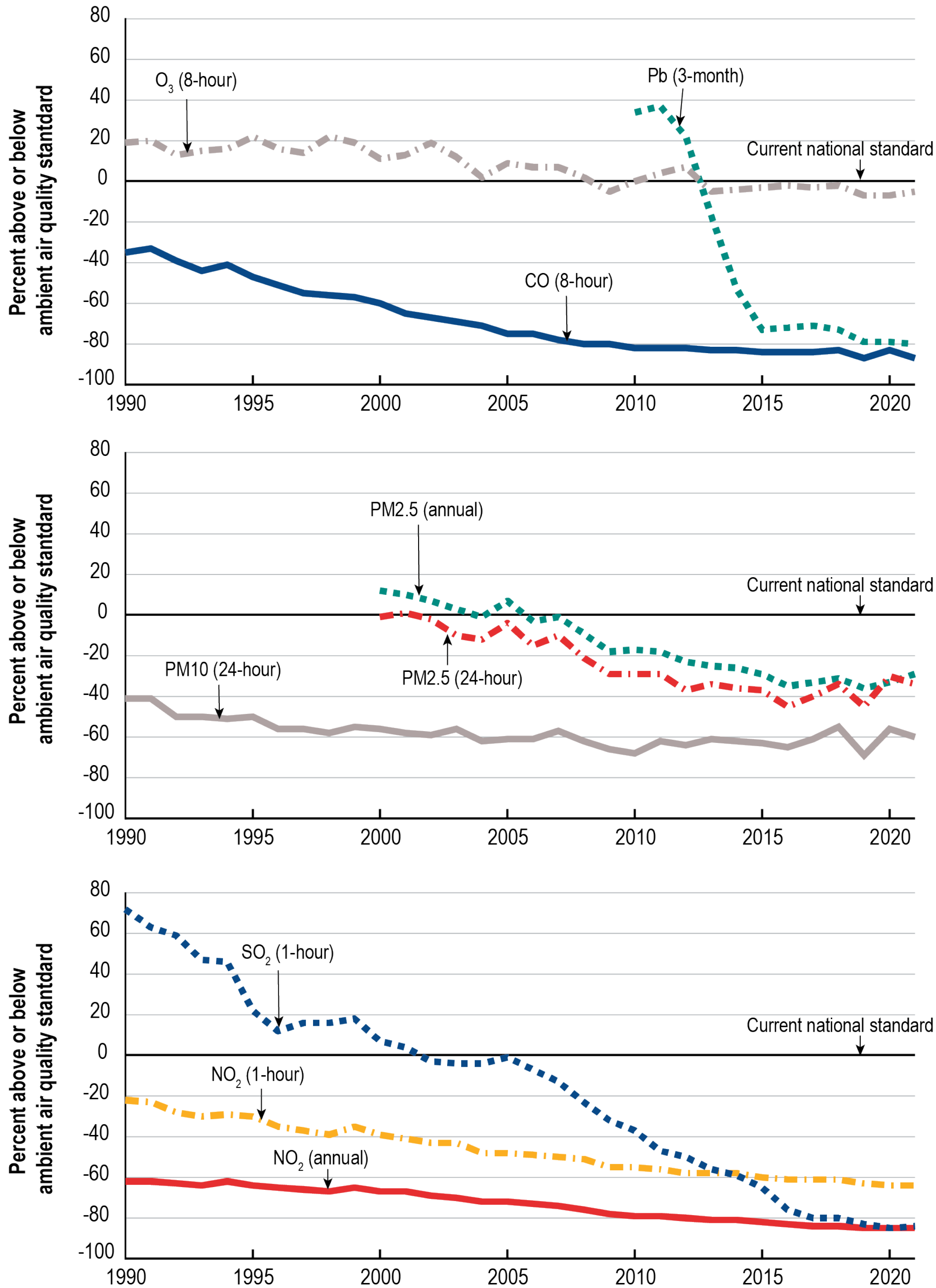
KEY: kWh = kilowatt hour; PM10 = particulate matter with diameter = 10 micrometers; PM2.5 = particulate matter with diameter <= 2.5 micrometers.

SOURCE: U.S. Environmental Protection Agency, 2022. *Our Nation's Air: Trends Through 2021*.

sources produce almost as much pollution as highway vehicles.

Highway vehicles with diesel engines emit more nitrogen oxides and particulates per mile than gasoline vehicles but have lower emissions of hydrocarbons and carbon monoxide (Table 6-5). Medium- and heavy-duty trucks consume the great majority of highway diesel fuel (92.7 percent), light trucks account for 6.7 percent, with passenger cars burning about 0.5 percent. Since 1975, highway use of diesel has grown more rapidly than gasoline use, and more recently increased from 21.6 percent in 2010 to 26.3 percent in 2020 [Davis and Boundy 2022, table 2.12]. In spite of this, vehicle emissions of all types have decreased over time as emissions standards have tightened.

Figure 6-14 National Average Air Pollutant Concentrations: 1990–2021



KEY: CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; PM10 = particulate matter with diameter = 10 micrometers; PM2.5 = particulate matter with diameter <= 2.5 micrometers; SO_2 = sulfur dioxide.

SOURCE: U.S. Environmental Protection Agency, 2022. *Our Nation's Air: Trends Through 2021*, available at https://gispub.epa.gov/air/trendsreport/2022/#home as of October 2022.

Transportation vehicles have emitted fewer pollutant emissions as new gasoline and diesel vehicles meeting stricter emissions standards have replaced older, more polluting vehicles. From 2000 to 2021, the rate of emissions per vehicle-mile of every pollutant for which transportation vehicles are a major source decreased by more than 80 percent (Figure 6-15). Current and future standards are projected to continue reducing vehicle emissions per mile through 2030.

Additional Effects on the Environment and Sustainability

In addition to air pollution, transportation affects the environment in many ways, from runoff into streams and lakes, to waste disposal, impacts on wildlife, unwanted noise, and effects on land use. In some cases, available data are adequate to identify patterns and trends, and assess transportation's progress toward sustainability.

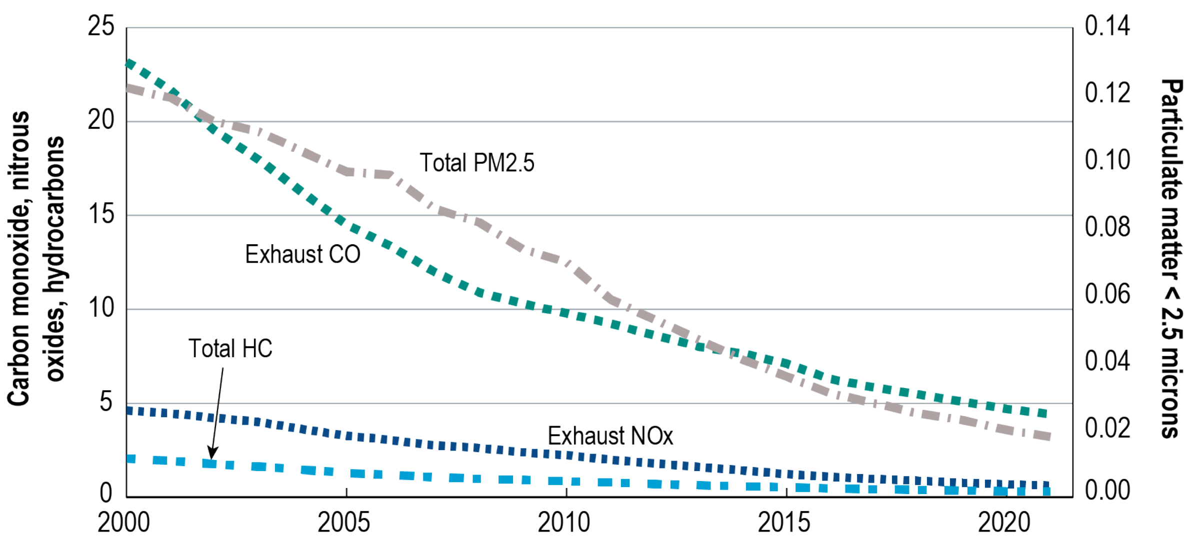
Table 6-5 Emission Rates of Gasoline and Diesel Vehicles: 2020

	Light-duty Trucks			Percentage		
Emission	Gasoline (g/mi)	Diesel (g/mi)	Difference (%)	Gasoline (g/mi)	Diesel (g/mi)	Difference (%)
Total HC	0.339	0.308	-9%	1.161	0.269	-77%
Exhaust CO	5.422	2.458	-55%	14.894	2	-87%
Exhaust NOx	0.376	1.804	380%	0.875	4.169	376%
Exhaust PM2.5	0.007	0.078	1014%	0.026	0.106	308%
Brakewear PM2.5	0.003	0.003	0%	0.006	0.009	50%
Tirewear PM2.5	0.001	0.002	100%	0.002	0.004	100%

KEY: CO = carbon monoxide; HC = hydrocarbons; NOx = nitrogen oxides; PM2.5 = particulate matter with diameter <= 2.5 micrometers.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, Table 4-43, available at www.bts.gov as of August, 2022.

Figure 6-15 Estimated National Average Emissions per Vehicle (g/mi)



KEY: CO = carbon monoxide; HC = hydrocarbons, NOx = nitrogen oxides; PM2.5 = particulate matter with diameter <= 2.5 micrometers.

SOURCE: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, personal communication, April 30, 2021.

In many cases, data are fragmentary and must be gleaned from sources of uncertain statistical validity.

Water Quality

Transportation affects water quality via rainwater runoff from roadways, parking lots, airports, and other infrastructure; spills of transportation fuels into waterways; and leaking underground fuel storage tanks. Water pollutants from vehicles and infrastructure include sediments from construction sites and erosion, lubricants, antifreeze, heavy metals from engine, tire and brake wear, and de-icing salts [EPA 2022a]. Stormwater runoff from state highway rights-of-way alone has been estimated at 8 million-acre feet per year [TRB 2020]. The geographical dispersion and chemical heterogeneity of runoff from transportation facilities makes pollution control challenging.

Road deicing salts are a contributor of runoff, but they reduce vehicle accidents rates by an estimated 78–87 percent under icy conditions, justifying their widespread use on the 70 percent of U.S. roads in cold regions. Common salt, sodium chloride, is by far the most frequently used deicer applied to roadways, accounting for about 95 percent of reported salt use. Despite usage becoming more efficient over time, total tons of deicing salts applied to roads has more than tripled since 1975 and is approximately 20–25 million metric tons per year. As a result, chloride concentrations in lakes, streams, and wetlands, especially in colder regions, have increased dramatically. Road salt use is partly responsible for an eight-fold increase in chloride concentrations in Lake Erie and Lake Ontario since the 1800s [Hintz, et al. 2021]. Contamination of drinking water by road salts has also been documented in numerous case studies. At present there are no ecologically friendly and cost-effective alternatives to deicing with road salts. Best practices are aimed at maintaining the safety benefits of road salt use while minimizing the quantity applied.

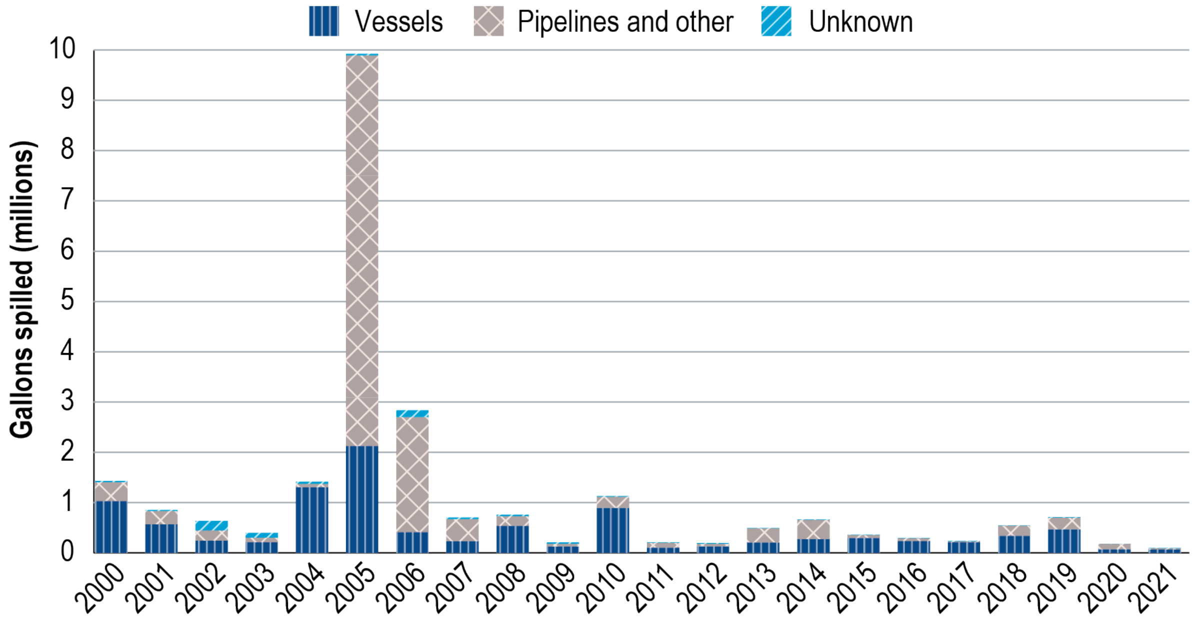
Thousands of oil spills occur in U.S. waters each year, but most involve less than a barrel (42 gallons) and occur, for example, when ships are refueled (Figure 6-16). Major spills that occur when pipelines break, oil tankers leak or sink, and drilling operations catastrophically fail cause extensive environmental damage that can persist for decades. For example, on October 2, 2021, rupture of an underwater pipe from a drilling platform off the coast of Long Beach, CA, released 25,000 gallons of oil, creating an oil slick of 13 square miles. Worldwide, six oil tanker spills of over seven metric tons, releasing a total of over 10,000 metric tons of oil, occurred in 2021 [NOAA 2022].

Petroleum fuels are also released into the ground, potentially contaminating ground water, when underground fuel storage tanks leak. From 1990 to 1995, the number of confirmed releases increased by over 40,000 new releases per year. Since 2015, there have been fewer than 7,500 new releases per year, and fewer than 5,000 during 2021. As of 2021, 502,786 of the 564,767 confirmed releases to date had been cleaned up. The number not cleaned up decreased from 62,493 in 2020 to 61,981 in 2021 [BTS NTS 2022, table 4-55].

Solid Waste and Recycling

Transportation produces solid waste in the form of scrapped vehicles and dismantled infrastructure, the great majority of which is recycled. Available data indicate that 95 percent of automobiles undergo recycling, which recovers over 80 percent of the weight of the vehicle for reuse [USCAR 2019]. In general, only shredded plastic, fabrics, and glass and about 10 percent of used tires [USTMA 2020] go to landfill. Although statistics are scarce, heavy-duty vehicles, aircraft, ships, and locomotives are likely recycled at similar rates (e.g., Gubisch

Figure 6-16 Petroleum Spills Into Navigable Waterways: 2000–2021



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 of approximating 8 million gallons of oil in U.S. waters. The largest spill in U.S. waters began on Apr. 20, 2010, with an explosion and fire on the mobile offshore drilling unit (MODU) Deepwater Horizon. Subsequently, the MODU sank, leaving an open exploratory well to discharge crude oil into the Gulf of Mexico for several weeks. The commonly accepted spill amount from the well is approximately 206.6 million gallons, plus approximately 400,000 gallons of oil products from the MODU. The totals in this table may be different from those that appear in the source, due to rounding by the source.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-54, available at http://www.bts.gov as of October 2022.

2018). Lead-acid batteries appear to be the most recycled consumer product, with 13.5 billion pounds of lead recovered from 99 percent of batteries from all types of transportation vehicles from 2014 to 2018 [Battery Council 2019]. It is probable that the lithium-ion batteries used in electric vehicles will also be extensively repurposed or recycled. The EV battery recycling industry is only just beginning to develop because very few EVs have been scrapped. The first mass-market EV in the United States was introduced in December 2010, automobiles tend to last 15–20 years [Greene and Leard 2022], and EV batteries are expected to outlast the electric vehicle itself [Reid 2022].

Transportation infrastructure is also extensively recycled. In 2020, 96 million tons of asphalt paving was reclaimed and 87 million tons of reclaimed asphalt pavement was incorporated in asphalt paving mixtures, displacing 82 million tons of new asphalt and 4.4 million tons of binder [Williams, et al., 2021]. Reclaimed asphalt comprised about 20 percent of total asphalt production of 420 million tons in 2019 [NAPA, 2021]. Recycling asphalt pavement reduced greenhouse gas emissions by an estimated three million metric tons in 2019 [Shacat et al. 2022].

Collisions with Wildlife

Collisions between vehicles and wildlife caused an estimated 202 human fatalities in 2020 [IIHS 2022] and 2.1 million fatalities to animals between July 2020 and June 2021, a 7.2 percent increase over the same period a year earlier [State Farm 2022]. Two-thirds of the reported wildlife fatalities were collisions with deer, while 111,000 were with rodents, 93,000 with dogs, 58,000 with raccoons, and 190,000 with other unidentified animals. These statistics undoubtedly underreport collisions that kill smaller animals. Total vertebrate roadway fatalities, including birds, reptiles, and amphibians, may number in the hundreds of millions per year [Shilling et al., 2021]. The Infrastructure Investment and Jobs Act, section 11123 [Public Law 117-58] directs the Secretary of Transportation to conduct a wildlife-vehicle collision reduction and habitat connectivity improvement study and to establish data standards to better understand the causes and effects of these collisions.

Transportation Noise

Noise pollution, defined as unwanted or disturbing sound, has a variety of effects on human health including stress-related illnesses, high blood pressure, interference with communication, hearing loss, sleep disruption, and reduced productivity [EPA 2022c]. Noise is also known to adversely affect wildlife [National Geographic 2022].

The Environmental Protection Agency (EPA) regulates noise from highway vehicles and railroads, with most regulations dating to the 1980s. Highway noise is mitigated by constructing noise barriers along high-speed routes. For the past 30 years, between 60 and 120 miles of noise barriers have been constructed per year, with no apparent change in that trend [BTS 2022c].

Aircraft noise is mitigated by managing operations to avoid populated areas during take-off and landing by sound-proofing affected buildings and by improvements to aircraft technology. The correlation between operations at the New York Metropolitan Areas three largest airports and average noise exposure is illustrated in Figure 6-17.

The first regulations limiting noise production by aircraft were imposed in 1973 and since then have been tightened four times, most recently in 2017 [ICAO 2016]. The benefits of regulation and abatement are evident in decreasing population exposure to aircraft noise. In 1975, 3.25 percent of the U.S. population was exposed to noise levels in excess of 65 decibels. Exposure dropped to 1.1 percent in 1990, and to 0.1 percent in 2000, where it remained until the dramatic reduction in air travel caused by the COVID-19 epidemic reduced the exposure level to 0.05 percent [BTS 2022d].

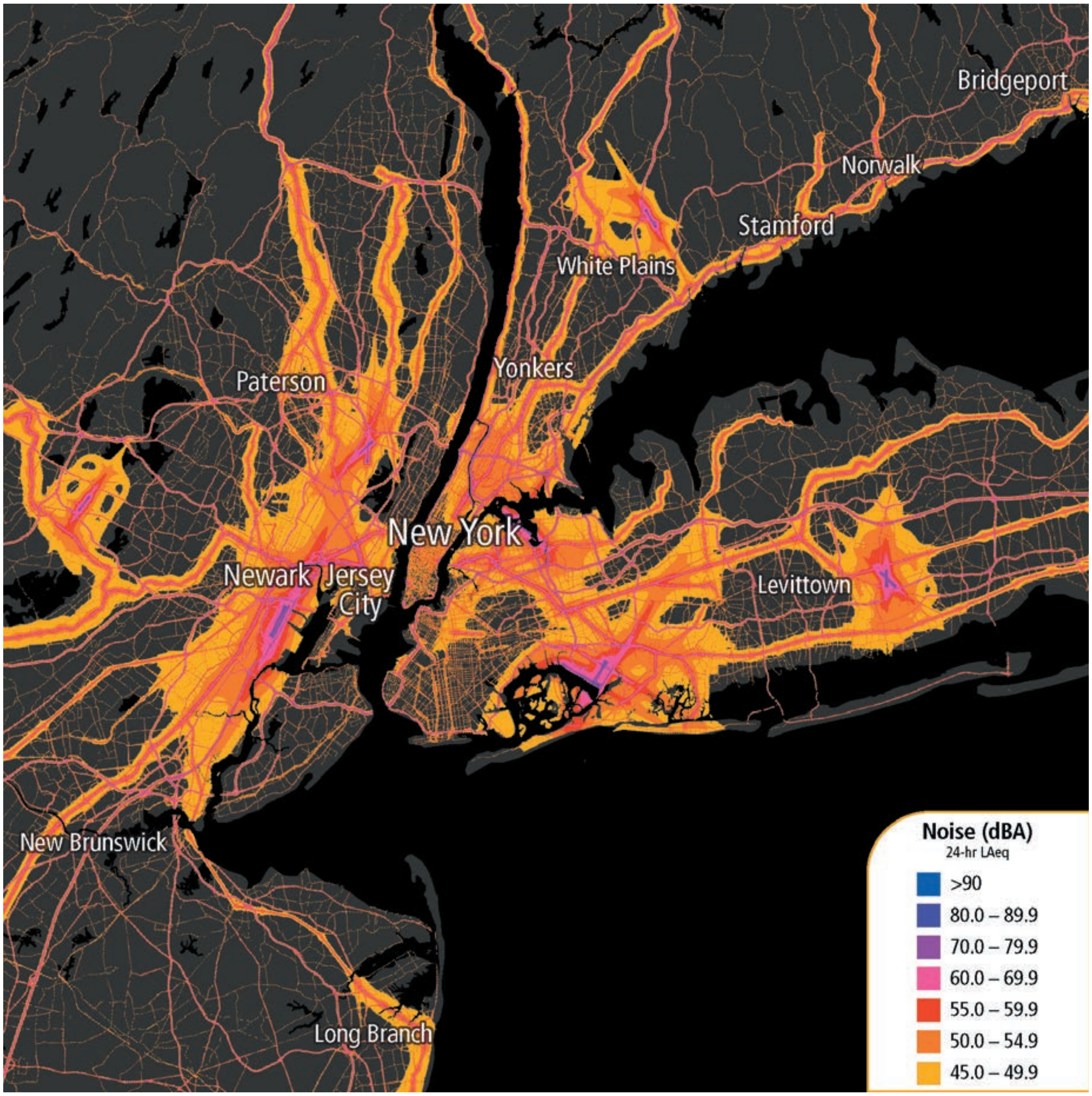
Data Gaps

Data gaps on three major areas are identified:

1. *Transition to Electrified Transportation*

Achieving a transition from a transportation system powered by petroleum to one that relies predominantly on electricity is a massive, lengthy, and complex challenge in which public policy and planning must play an important role. New kinds of data are needed to inform decision-making. Data are needed to inform decisions about deploying and sustaining electric vehicle charging infrastructure. There are important differences between refueling gasoline and diesel internal combustion engine (ICE) vehicles and recharging electric vehicles that affect the types, quantities, and locations of recharging stations necessary to support the widespread adoption of EVs. While ICEs are refueled in minutes at retail stations, current EV owners do 80 percent or more of their recharging at their residences or the EVs home base. Although electricity is already available throughout the United States, not all vehicle-owning households have access to convenient home-based charging, which may make the transition especially challenging for lower-income households and communities and those living in multi-unit dwellings.

Figure 6-17 Geography of Transportation Noise in the New York Metropolitan Region: 2020



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Noise Map: https://maps.dot.gov/BTS/NationalTransportationNoiseMap/ as of September 2022.

Likewise, data are also needed on the availability of workplace recharging stations, especially for workers who depend on curbside parking at home as well as time-of-day recharging demand because overnight charging may stress the grid during peak demand or when solar power is not available. Long-distance trips will be a critical component of the demand for high-speed charging, yet data on long-distance travel by households is scarce and not designed for understanding EV charging behavior. Data on the acquisition, ownership, and use of EVs by households at all income levels are needed to understand the equity effects of the transition to electrified transportation.

While most vehicle owners pay highway user fees (e.g., gas tax) when they purchase petroleum for their vehicles, this is not currently the case for EV owners. The quantity and patterns of electricity consumption by plug-in vehicles are not directly measured, nor are there information systems in place to insure that EVs pay an appropriate share of the costs of highway infrastructure. Data are needed to quantify EV energy use and to inform decisions about assessing cost responsibility to EVs. Understanding how and when EVs are charged is important for assessing their impacts on the environment and the electricity grid [Powell et al. 2022]. Comprehensive and validated data on charging behavior, especially the use of workplace and public charging infrastructure is needed, particularly by households in multi-unit dwellings or lacking off-street parking.

Better data on the use, energy usage, and duty cycles of medium- and heavy-duty vehicles are needed to understand where electrification can be effective and economical and where other solutions might be needed to achieve air quality and climate goals. As noted above, even basic measures of the energy intensity of medium- and heavy-duty truck and air freight are lacking.

2. *Actual Fuel Economy and GHG Emissions of All Vehicles*

As regulation of transportation's greenhouse gas emissions becomes increasingly important, data are needed to better understand what regulatory standards for new vehicles are accomplishing. In the case of ICE motor vehicles, there is a need for accurate data on real-world fuel economy and GHG emissions, not just for light-duty vehicles but for medium- and heavy-duty vehicles, as well.

3. *Environmental Impacts*

Finally, accurate and reliable statistics for many of the environmental impacts discussed in the Additional Effects on the Environment and Sustainability section are missing or must be obtained from industry or interest group sources. This is the case for water pollution from transportation infrastructure, impacts on wildlife and wildlife habitats, and for components of the waste streams from scrapped vehicles and infrastructure. Over the coming decade, significant numbers of EVs will be scrapped. Information on the disposal and recycling of unique EV components, such as batteries, electric motors and controllers, and high-voltage cables, are needed to understand their lifecycle environmental impacts and to inform policies and plans to insure the sustainability of electrified transportation.

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CHAPTER 7
State of Transportation Statistics

Introduction

Evolving transportation issues and the implementation of legislative mandates increase demands on the Bureau of Transportation Statistics (BTS) and its partners to support decisions with objective, accurate, and timely information. Recent disruptions to supply chains place new emphasis on the performance of freight transportation, underscored by requirements in the Ocean Shipping Reform Act[1] for BTS to collect and publish dwell times and out-of-service statistics on maritime containers and chassis. Increased concerns with equity, reflected in the Infrastructure Investment and Jobs Act[2] and part of learning agendas required by the Foundations for Evidence-Based Policymaking Act,[3] place a renewed emphasis on statistics about users of transportation and about the effects of transportation on surrounding communities. Disruptions related to climate change bolster longstanding needs for statistics on topics such as safety. BTS and its partners must mobilize both traditional and new sources of data to understand these issues and inform decisionmakers and the public in a rapidly changing world.

Passenger Transportation and Equity

Data on passenger travel and transportation are needed to help answer three basic questions. Is the transportation system delivering people in a timely, reliable manner and at a reasonable cost to support the needs of individuals and households across all spectrums of society? Is the transportation system delivering workers and tourists to support the national, regional, and local economies? Is passenger movement impeding freight movement, threatening safety, or causing environmental or societal disruption at the national, regional, and local levels? Environmental disruptions include contributions of climate change, and societal disruptions include equity impacts.

Current statistical products do not provide the following:

- Comprehensive measures of the volume of passenger movement, the demographic and economic characteristics of travelers, and the purposes of their travel with geographic specificity.

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[1] Section 16 of Pub. L. 117-146 (June 16, 2022).

[2] Pub. L. 117-58 (November 15, 2021).

[3] Pub. L. 115-435 (January 14, 2019).

- Statistics on timeliness, reliability, and cost of passenger transportation, including the burden of travel costs placed on disadvantaged groups.
- Statistics on workers who work at multiple locations or who telework for portions of the week, potentially causing significant changes in daily travel.
- Estimates of travel affected by disruptions to the transportation system.
- Estimates of passenger movement by travelers from outside the region who place demands on the local transportation system but also contribute to the local economy.

BTS and its partners are tapping new types of data such as anonymized mobile tracking to improve the completeness, timeliness, and geographic detail of passenger movement estimates. These data identify geographic patterns of passenger movements over specific portions of the transportation network that can be used to support resiliency and equity analyses, identify exposure of travelers to safety problems, and understand the performance and impacts of the passenger transportation system. BTS will use traditional surveys to measure the demographic characteristics of transit riders and develop estimation models to measure the cost burden of transportation on subgroups of the population.

Freight Transportation and Supply Chains

Data on freight transportation are needed to help answer three basic questions that parallel the questions for passenger travel. Is the transportation system supporting national, regional, and local economies by delivering goods in a timely, reliable manner and at a reasonable cost? What markets for obtaining supplies and selling goods can be reached with the transportation system? Is freight movement impeding passenger travel, threatening safety, or causing environmental or societal disruption at the national, regional, and local levels? Environmental disruptions include contributions of climate change, and societal disruptions include equity impacts such as exposure to traffic and pollution by chronically impoverished communities next to major ports.

The following ongoing programs answer many of the questions posed:

- The Freight Analysis Framework (FAF) provides a comprehensive picture of commodity movements that must be handled by the freight transportation system, integrating data from sources including the Commodity Flow Survey, Rail Waybill program, Waterborne Commerce Statistics, and Transborder Freight Data Program.
- The Transportation Satellite Account, which tracks the purchase of goods and services among sectors of the national economy to estimate the contribution of transportation to gross domestic product, identifies supply chain interactions that generate commodity movements.
- Forthcoming statistics from the recently resurrected Vehicle Inventory and Use Survey will include essential information on vehicle weights and configurations, commodities carried, fuel type and mileage, economic activities served, and other truck-specific characteristics.

Planned improvements to the FAF will increase the timeliness and geographic detail of data on the value and weight of commodities being moved by mode and region. Models under development that assign freight flows among regions to the multimodal network will support future understanding of freight system vulnerabilities and resilience, assessments of conflicts between freight movement and passenger travel, identification of regional markets to guide economic development, and estimates of freight movement that is passing through a region and affecting local infrastructure needs.

New data collections by the Federal Maritime Commission and BTS in response to the Ocean Shipping Reform Act will provide insight into the role of shipping containers in maritime freight. BTS supports the Freight Logistics Optimization Works (FLOW) initiative, an endeavor among shippers, carriers, terminal operators, and others in supply chains through selected ports to share data on container volumes and capacities to improve operational efficiency. BTS also works with the U.S. Department of Agriculture to resurrect the *Ocean Container Availability Report* to measure equipment capacity for handling export shipments. As these programs mature, BTS will integrate the results into a more robust Port Performance Freight Statistics Program. Experience with the FLOW initiative should lead to strategies for creating comprehensive statistics on the timeliness, reliability, and cost of freight movement beyond ports to the entire freight transportation system.

BTS is exploring more effective uses of probe data, also known as location-based services data, to measure vehicle and vessel activity and enhance understanding of the physical performance of the freight transportation system. BTS is exploring other data-collection strategies to measure last-mile freight delivery and analyze the role of e-commerce in freight movements.

While planned improvements and new data collections provide a useful picture of freight movements and the physical performance of the transportation system in serving those movements, information on the economic cost of freight transportation, observed data on the domestic transportation of international trade, and an understanding of last-mile freight delivery are frequently requested for but remain largely underdeveloped. BTS will explore potential partnerships with private industry and other Federal statistical agencies to find cost-effective solutions to these data shortcomings and provide information that strengthens freight transportation and supply chain resilience.

Safety

Safety is an issue that transcends the passenger and freight transportation systems. Every modal administration has safety data programs, and the data programs for highway safety are larger in budget and staff than the sum of all BTS programs. Rather than duplicate these modal safety programs, BTS provides a comprehensive compilation of safety statistics that accounts for overlaps (e.g., rail–highway grade-crossing crashes appearing in both highway and rail statistics).[4] BTS also collects data on the conversion of the railroad tank car fleet to safer equipment standards and publishes an annual report to Congress.[5]

BTS ensures confidentiality when obtaining sensitive information on precursor safety, including close calls and near misses.[6] The Confidential Information Protection and Statistical Efficiency Act (CIPSEA)[7] authorizes BTS to protect respondents to BTS data collections from direct or indirect identification. CIPSEA exempts data collected by BTS and other Federal agencies from Freedom of

[4] U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, Section 2, available at https://www.bts.gov/topics/national-transportation-statistics as of October 2021.

[5] U.S. Department of Transportation, Bureau of Transportation Statistics, *Fleet Composition of Rail Tank Cars Carrying Flammable Liquids Annual Reports*, available at https://www.bts.gov/surveys/annual-tank-car-facility-survey/fleet-composition-rail-tank-cars-carrying-flammable-liquids as of October 2021.

[6] U.S. Department of Transportation, Bureau of Transportation Statistics, Close Call Data Program at https://www.bts.gov/close-call as of October 2021.

[7] Title III of Foundations for Evidence-Based Policymaking Act of 2018, Pub. L. 115-435 (reauthorizing 2002 E-Gov Act).

Information Act requests and judicial processes such as subpoenas. BTS uses this confidentiality protection in its safety precursor data program to encourage voluntary reports of safety problems from employees and companies without fear of discovery and retaliation. BTS analyzes individual reports and summarizes them into statistical assessments that inform sponsoring organizations of problems while protecting respondent confidentiality.

The Washington Metropolitan Area Transit Authority (WMATA) and the Bureau of Safety and Environmental Enforcement (BSEE) of the Department of the Interior are current sponsors of the BTS safety precursor data program. WMATA, the regional bus and rail transit operator for the Nation's capital and the greater Washington, D.C., area, has sponsored the program since 2012, and BSEE has sponsored the program for offshore petroleum extraction since 2013. Both programs identified safety problems that prompted corrective actions by the sponsors. BTS is working with the Massachusetts Bay Transit Authority to implement a version of the WMATA safety precursor data program in Boston, MA, and with the Maritime Administration to develop a safety precursor data program for the maritime industry.

Transportation Financial Statistics

The influx of funding of transportation through COVID relief and infrastructure investment legislation underscores the importance of a BTS initiative to improve the economic and financial statistics related to transportation. Traditional sources of data on public investment in transportation take years to process, require complicated reconciliations of fiscal and calendar years and authorizations versus obligations versus final spending, and assume a clear distinction between public and private investment. That distinction becomes less clear with the increasing use of innovative financial instruments and public–private partnerships. Working with the National Academy of Public Administration, BTS developed strategies to produce more robust, timely statistics that more accurately account for public and private spending on transportation from capital projects to operations and maintenance. BTS is working with State partners and others to implement those strategies.

Meeting State and Local Data and Analytical Needs

Section 25003 of the Infrastructure Investment and Jobs Act[8] requires BTS to determine data and analysis tools that would assist planning and infrastructure decision-making officials in units of local government, and to develop a roadmap for the Federal government to support local communities with their infrastructure investment decisions. Based on a series of meetings with stakeholders, BTS concludes that the greatest needs of local officials, listed in prioritized order, are as follows:

1. Data-focused technical assistance—ranging from basic assistance on data collection and project development to understanding the correct data and tools to use for different decision-making goals.
2. Complete, timely, and granular benchmark data to tell the stories of their communities, to inform planning and infrastructure investment decisions, and to measure and deliver better investment outcomes.
3. Continued tool refinements to keep pace with technology advancements and mounting decision-making priorities.

To address these needs, BTS proposed a series of work plans for the Federal government to implement the priorities for evidence-based local

[8] Pub, L. 117-58 (November 15, 2021).

infrastructure investment decision-making that would achieve the following:

1. Improve maintenance of existing assets to reduce congestion and strengthen resilience.
2. Create economic development through infrastructure development.
3. Establish freight plans and infrastructure that connect the community to supply chains.
4. Rebuild infrastructure to a state of good repair.
5. Advance transportation equity by increasing options for communities to improve access to jobs, affordable housing, schools, medical services, food, and other essential services.

Improved data and statistics are fundamental to each of the proposed work plans, and the following approaches will be key in assisting local decision-makers:

1. Improve decision-making timeliness, outcomes, and forecast trends using geospatial data automation to provide high-resolution, frequent, and sustainable geospatial products. Cost, technology constraints, and skillsets impact the availability and use of these advanced resources. Coupling primary, automated data-collection streams—imagery, fixed sensors, mobile sensors, and crowdsourcing—with artificial intelligence and machine learning can provide more timely and granular geospatial information, improve data quality, and support better multimodal infrastructure decision-making.
2. Increase data-collection efficiency, enhance data quality, and minimize respondent burden by leveraging administrative data and sensor-based data sources—Global Position System, location-based services, and the Internet of Things—while facilitating frequent, multimodal, and geographic coverage. Sensor-based data sources and administrative records can unlock insights into travel behavior and transportation system use by supplementing traditional survey-based methods or providing new, standalone products. Additional investment, which is critical to advance these programs, should be coupled with research and guidance to substitute standalone sensor data—or blended data and tools should be used—to facilitate thoughtful policy decisions.
3. Develop and access better integrated and coordinated granular freight data and private freight data that will allow decision-makers to establish strategies that adapt rapidly to changing economic conditions and will support a multitude of applications from performance measurement to supply chain management. Local plans will have better potential to connect communities to supply chains and create economic development, while public agencies will have additional tools to help reduce freight-related congestion.

Privacy and confidentiality concerns are a key barrier to local decision-makers collecting and accessing the information they need to make evidence-based decisions. Federal statistical agencies like BTS have the tools to collect and protect the confidentiality of information not available through traditional methods or administrative records. These tools include survey instruments and data analyses with strong privacy protections such as BTS confidentiality provisions and the protections of CIPSEA. Leveraging BTS's powerful and targeted data-collection and -analysis abilities will provide high-quality statistics to local decision-makers that answer their questions about the transportation systems and its users.

Meeting Data Needs of Departmental Priorities

The Department of Transportation has published four priorities: (1) reduce inequities across our transportation systems and the communities they affect; (2) reduce greenhouse gas emissions and transportation-related pollution and build a more resilient and sustainable transportation systems to benefit communities; (3) make our transportation safe for all people; and (4) invest in purpose-driven research and innovation to meet the challenges of the present and modernize a transportation system of the future that serves everyone today and in the decades to come.[9] While all BTS programs directly or indirectly relate to these priorities, BTS launched two initiatives that specifically serve the equity and innovation aspects.

BTS is developing a transportation cost burden measure to help the Department better understand potential inequities across the transportation system. Transportation cost is an aspect of transportation affordability, which characterizes households' ability to purchase basic mobility within their limited budgets to access basic goods and activities such as medical care, basic shopping, education, work, and socializing. Studies show subnational variation in the cost of transportation due to subnational differences in transportation mode availability, housing and job density, and other factors. BTS is developing a model to estimate the cost of transportation to a household at the local level using existing, nonproprietary data that are released regularly so future updates to the model can be made.

BTS is exploring the feasibility of a neighborhood-level transportation cost burden data collection and developing a roadmap to such a potential future data collection. Transportation cost burden measures will help State and local agencies prioritize programs, policies, and investments that target transportation affordability.

BTS is responding to recent supply chain disruptions with support to FLOW, an important example of purpose-driven research and innovation. The freight transportation system includes many private participants who traditionally resist sharing information to protect proprietary advantages. BTS is using its authority under CIPSEA to provide a safe harbor for confidential data, allowing shippers, carriers, and others in supply chains to share data without compromising their proprietary interests. BTS compiles the data and generates measures that participants can use to diagnose and address disruptions, ease supply chain congestion, speed up the movement of goods, and reduce costs for American consumers.

Conclusion

BTS celebrated 30 years of operation on October 19, 2022. When BTS was created, statistics were used primarily as an input to transportation planning and justification for investments and regulations. During the early years of BTS, increased emphasis of public agencies and private companies on managing and operating transportation assets created demands for large amounts of timely data on the condition and performance of the transportation system. The COVID-19 pandemic created even greater demands for timely data to identify large, rapid changes in transportation. The Foundations for Evidence-Based Policymaking Act is creating new demands for data to support continuous improvements to public investments and regulations with learning agendas that combine traditional planning statistics with data on program implementation and outputs. As "plan-and-done" becomes "plan-do-learn-do better," statistics are no longer a static input to forecasts that are used for plans and then shelved; statistics are now a key part of continuous learning and improvement.

The COVID-19 pandemic encouraged BTS's evolution from focusing on annual statistics

[9] https://www.transportation.gov/priorities accessed December 9, 2022.

published through printed reports to that of weekly and monthly statistics continuously updated online. The Foundations for Evidence-Based Policymaking Act will inspire further evolution of BTS and its products in the years ahead.

Throughout its history, BTS has worked with its partners to create increasingly robust, timely, and credible products in each of the topic areas identified in legislative mandates and the goals of the Department of Transportation. BTS endeavors to produce statistics that are relevant and useful throughout the Nation and fulfill Abraham Lincoln's vision that "statistics will save us from doing what we do, in wrong places."[10]

[10] Lincoln, A., "Internal Improvements," Speech of Mr. A. Lincoln of Illinois in the House of Representatives (Washington, D.C.: June 28, 1848), *Congressional Globe*, 30th Cong., 1st Sess., pp. 709–711.

APPENDIX A
Legislative Responsibilities

BTS compiles these and other statistics as required by 49 U.S. Code § 6302 - *Bureau of Transportation Statistics*, which requires information on the following:

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;

IV. Building on the national transportation atlas database developed;

V. Economic efficiency across the entire transportation sector;

VI. The effects of the transportation system on global and domestic economic competitiveness;

VII. Demographic, economic, and other variables influencing travel behavior, including choice of transportation mode and goods movement;

VIII. Transportation-related variables that influence the domestic economy and global competitiveness;

IX. Economic costs and impacts for passenger travel and freight movement;

X. Intermodal and multimodal passenger movement;

XI. Intermodal and multimodal freight movement; and

XII. Consequences of transportation for the human and natural environment.

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.

APPENDIX C
Abbreviations and Acronyms

AAA	American Automobile Association
AAR	American Association of Railroads
AASHTO	American Association of State Highway and Transportation Officials
ABA	American Bus Association
ACEA	European Automobile Manufacturers Association
ACS	American Community Survey
AEO	*Annual Energy Outlook* report
AFDC	Alternative Fuels Data Center
AGS	American Gas Association
AIP	Airport Improvement Program
AIS	Automatic Identification System
AMTRAK	National Rail Passenger Corporation
AQI	Air Quality Index
ARA	Automotive Recyclers Association
ARRA	*American Recovery and Reinvestment Act*
ASR	automotive shredder residue
ATA	American Trucking Association
ATIP	Automated Track Inspection Program
ATUS	American Time Use Survey
ATV	all-terrain vehicle
AV	automated vehicle
BAC	blood alcohol concentration
BEA	Bureau of Economic Analysis
BEV	battery electric vehicle
BLS	Bureau of Labor Statistics

BTS	Bureau of Transportation Statistics
Btu	British thermal unit
CAFCP	California Fuel Cell Partnership
CAFE	Corporate Average Fuel Economy
CBP	Customs and Border Protection
CDC	Centers for Disease Control
CDL	commercial drivers license
CEC	California Energy Commission
CEP	Commission on Evidence-Based Policymaking
CFR	Code of Federal Regulations
CFS	Commodity Flow Survey
CMC	Crisis Management Center
CO	carbon monoxide
CO_2	carbon dioxide
CPI	Consumer Price Index
CPI-U	Consumer Price Index—Urban
CROS	California Roadkill Observation System
CRSS	Crash Reporting Sampling System
CTS	Center for Transportation Studies—University of Minnesota
DBA-A	Weighted Decibel
DOT	Department of Transportation
DUI	driving under the influence
ECI	Employment Cost Index
EDTA	Electric Drive Transportation Association
EIA	Energy Information Agency
ESC	electronic stability control
EU	European Union
FAA	Federal Aviation Administration

FAF	Freight Analysis Framework
FAF4	Freight analysis Framework, 4th generation
FCC	Federal Communications Commission
FCEV	fuel cell electric vehicle
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FTD	Foreign Trade Division
FTSI	Freight Transportation Services Index
FY	fiscal year
GA	general aviation
GAO	General Accountability Office
GDP	gross domestic product
GES	General Estimates System
GHG	greenhouse gas
GHSA	Governors Highway Safety Association
GIS	geographic information system
GPS	global positioning system
GTFS	General Transit Feed Specifications
Haz Liq	hazardous liquid
HEV	hybrid electric vehicle
HFC	hydrofluorocarbon
hh:mm	hours and minutes
IGU	International Gas Union
IIHS	Insurance Institute for Highway Safety
IPCD	Intermodal Passenger Connectivity Database
IRI	International Roughness Index

IT	information technology
IWR	Institute for Water Resources
LAEQ	24-hour equivalent sound level
LNG	liquefied natural gas
MARAD	Maritime Administration
MODU	mobile offshore drilling unit
MPF	multifactor productivity
MPG	miles per gallon
MSA	Metropolitan Statistical Area
NACTO	National Association of City Transportation Officials
NAR	National Association of Realtors
NAS	National Academy of Science
NAS	National Aviation System
NASS	National Automotive Sampling System
NBI	National Bridge Inventory
NCFO	National Census of Ferry Operators
NCO	National Coordination Office
NDC	Navigation Data Center
NEC	Northeast Corridor
NextGen	Next Generation Air Transportation System
NHC	National Hurricane Center
NHS	National Highway System
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NIAAA	National Institute on Alcohol Abuse and Alcoholism
NIH	National Institutes of Health
NIMMA	National Marine Manufacturers Association
NOAA	National Oceanic and Atmospheric Administration

NO_x	oxides of nitrogen
NPIAS	National Plan of Integrated Airport Systems
NPTS	National Personal Travel Survey
NRC	Natoinal Resaerch Council
NTAD	National Transportation Atlas Database
NTD	National Transit Database
NTS	*National Transportation Statistics*
NTSB	National Transportation Safety Board
NTTO	National Travel and Tourism Office
ONI	Office of Naval Intelligence
ORNL	Oak Ridge National Laboratory
OTAQ	Office of Transportation and Air Quality
PEV	plug-in electric vehicle
PHEV	plug-in electric hybrid vehicles
PHMSA	Pipeline and Hazardous Materials Safety Administration
PM	passenger-mile
PMT	person-miles of travel
PNT	Position, Navigation, and Timing
PTC	Positive Train Control
PTSI	Passenger Transportation Services Index
RF	radio frequency
RPM	revenue passenger-mile
RTM	revenue ton-mile
RV	recreational vehicle
SO_2	sulfur dioxide
SUV	sport utility vehicle
TEU	twenty-foot equivalent units
T-M	ton-mile

TNC	transportation network company
TRB	Transportation Research Board
TSA	Transportation Security Administration
TSA	Transportation Satellite Accounts
TSI	Transportation Services Index
TTI	Texas Transportation Institute
UAS	unmanned aerial systems
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDHHS	U.S. Department of Health and Human Services
USDOC	U.S. Department of Commerce
USDOE	U.S. Department of Energy
USDHS	U.S. Department of Homeland Security
USDOJ	U.S. Department of Justice
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
VMT	vehicle-miles traveled
WAAS	Wide Area Augmentation System

APPENDIX D
Why Fatality and Injury Data Differ by Source

Fatality Data

Several federal transportation agencies collect fatality, injury, and accident/incident data from reports by state, local, or corporate (e.g., pipeline companies, railroads) entities for the specific transportation mode under their purview. These agencies, including the National Highway Traffic Safety Administration, the Federal Railroad Administration, the Federal Transit Administration, the Federal Aviation Administration, the Pipeline and Hazardous Materials Administration, and the U.S. Coast Guard in the Department of Homeland Security, often have different reporting thresholds (e.g., the time period after a crash to ascribe the death to a transportation incident, the dollar amount of property damage or injury severity that needs to be reported). Thus, data for different modes may not be comparable in all respects.

Different sources can also produce different estimates even for something as seemingly definitive as death. In the case of motor vehicle fatalities, NHTSA, through its Fatality Analysis Reporting System (FARS), collects a census of fatal motor vehicle traffic crashes provided by the 50 states, the District of Columbia, and Puerto Rico taken from police crash reports and other sources. To be included in FARS, a crash must involve a motor vehicle traveling on a trafficway customarily open to the public and must result in the death of an occupant of a vehicle or a nonoccupant within 30 days of the crash.

NHTSA's fatality data differ from those taken from the National Center for Health Statistics (NCHS), part of the Centers for Disease Control and Prevention, which obtains and annually updates cause of death information from death certificates and other sources. These data may identify people who are fatally injured in transportation crashes many months or up to a year after the incident, not just 30 days later. Also, the NCHS data include transportation-related deaths that occur anywhere, not just those reported on public roadways as in FARS. The differences can be substantial: the National Safety Council (NCS), which uses the NCHS data to obtain its estimates of motor vehicle fatalities, found that there were about 3,500 more deaths in its 2020 estimates using NCHS data than were reported in FARS—42,339 for NCHS compared to 38,824 in FARS. (This TSAR uses the FARS data but also discusses the non-traffic motor vehicle deaths, such as on driveways.)

Injury and Property-Damage-Only Crashes

Millions of highway crashes of all severity levels occur every year in the United States. These range from property-damage-only (PDO) crashes, such as most "fender-benders," which account for the lion's share of accidents, to non-fatal injury crashes (with ascending levels of injury from minor to incapacitating or life threatening) to fatal crashes in which one or more people die, whether inside or outside the vehicle. With the total number of crashes so high—the 5.2 million motor vehicle crashes in 2020 was actually 1.5 million fewer than in 2019 before the pandemic—NHTSA estimates the number of non-fatal crashes using a sampling system subject to variability. (In contrast, FARS contains data collected from all fatal crashes on public trafficways in the 50 states, the District of Columbia, and Puerto Rico).

NHTSA's injury estimates for 2016 and beyond are obtained from a new sample design and are not comparable to prior years estimated from a different sampling system. NHTSA's current estimation procedure is called the Crash Report Sampling System (CRSS); it replaced the National Automotive Sampling System (NASS) General Estimates System (GES), used from1988 through its replacement with CRSS. NHTSA cautions against comparing CRSS estimates (2016 and later) with those made in 2015 and before using the NASS GES methodology. These systems use different sampling designs and were designed more than 30 years apart [USDOT NHTSA 2022j].

Timing of Data Releases

The compilation and vetting of fatality data takes place according to schedules that can take two years or more to finalize from initial estimate reporting. Provisional or initial data may be issued based on projections or estimation procedures, but have greater uncertainty associated with their accuracy.











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