Transportation Statistics Annual Report 2023

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

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Special thanks to all our colleagues throughout the U.S. Department of Transportation who provided data used in this report and critical review of the narrative.

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 facilitates the economic prosperity and the quality of life. It enables people to engage in productive pursuits and experience the social interactions that take full advantage of efficient spatial specialization and distribution. An efficient and resilient transportation system and its seamless operation underpin the overall efficiency and resilience of the entire economy.

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 29th TSAR edition documents the conduct of the duties of BTS as called out in the statute.

Recent events such as the COVID-19 pandemic, unrests in eastern Europe and Middle East, and ongoing geopolitical tensions in Asia and Pacific regions have accelerated changes in domestic and international commerce and passenger flows that normally proceeded at a gradual pace. Manufacturing reshoring, nearshoring, and friendshoring are only some aspects of the overall derisking effort that are already producing unprecedented changes in transportation supply, demand, and performance. The transportation systems and operations must adapt itself to accommodate and facilitate such changes. At the same time, ongoing technological changes, 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 challenges, 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, vulnerability, and resilience; and reporting on equity, sustainability, and climate are critical concerns identified in the FY 2022- 26 USDOT Strategic Plan and are among the current and ongoing efforts 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

[1] Title 49 U.S. Code § 6302.

collection and processing of data are supporting the advancements in data reporting.

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.

A notable addition to this year's TSAR is the coverage of Emerging Issues. Each chapter identifies notable emerging issues in transportation related to the subject areas (refer to the callout box).

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.

BTS welcomes comments 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 the Bureau of Transportation Statistics, U.S. Department of Transportation, 1200 New Jersey Avenue SE, Washington DC, 20590.

Emerging Issues Included in TSAR 2023

Chapter 1 State of the System discusses Recovering from the COVID-19 Pandemic.

Chapter 2 Passenger Travel and Equity discusses COVID Impact on Passenger Travel.

Chapter 3 Freight and Supply Chain discusses Disruptions to the Supply Chains from Drought.

Chapter 4 Transportation Economics discusses Inflation and Transportation.

Chapter 5 Transportation Safety discusses New Normal in Transportation.

Chapter 6 Energy and Sustainability discusses Transition to New Energy Sources for Transportation.

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 2022, the U.S. transportation system served 333 million U.S. residents residing in 124 million households, including people who may not own a vehicle or rarely travel, and millions of foreign visitors (refer to 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 8.1 million business establishments with customers, suppliers, and workers [USDOC CENSUS 2023].

This chapter reviews the extent, usage, condition, and performance of the transportation system. 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

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 48,500-mile Interstate Highway System in 2021 comprised 1 percent of total highway miles available but carried 26 percent of total highway vehicle-miles of travel
- **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. VMT rebounded in 2021, erasing about 64 percent of its drop in 2020.
  - 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.
  - Urban roads have a larger share of VMT on roads with poor pavement condition (14 percent) than rural roads (3 percent).
  - Between 2010 and 2022, the number of the Nation's bridges in poor condition declined by 16,339, from about 10 to about 7 percent of all bridges.

Continued »

Highlights Continued

- 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 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. Since 2020 most measures of congestion have trended back toward their pre-pandemic levels. From 2020 to 2021 congested hours were up 34 percent, Travel Time Index was up 5 percent, and Planning Time Index increased 10 percent.
- **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 4.5 billion in 2020, a 45 percent reduction. While transit ridership is slowly increasing, it has yet to recover to pre-pandemic levels.
- **Aviation:**
  - Total passenger enplanements at U.S. airports were down from 1.05 billion in 2019 to 401 million in 2020, a 62 percent drop and less than the total reported two decades earlier. Traffic rebounded in 2022 to about 89 percent of 2019's record-high enplanements and was on pace in 2023 to exceed the air traffic in 2019.
  - Air freight was 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 2022 Amtrak recovered half the lost ridership during COVID-19 and carried more than three-and-a-half times as many riders between Washington and New York City as all of the airlines combined, and more than all the airlines combined between New York City and Boston.
  - More than 28 million people rode Amtrak nationwide during FY 2023, a 24.6 percent increase over the same period in 2022. However, it is still short of pre-pandemic numbers of 32.5 million people annually.
- **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. Rail traffic has since rebounded to near-normal levels.
- **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. By 2021 waterborne commerce had recovered to over 99 percent of the total in 2019. The average dwell time of container vessels at the top 25 U.S. container ports in 2022 was 34.7 hours, up 2.7 hours from that in 2021.
- **Petroleum Pipelines:** The crude petroleum and products pipeline systems carried 3.3 billion barrels across the U.S. in the pandemic year of 2020, down 10 percent from 3.7 billion in 2019. Pipeline shipments recovered to 3.4 billion barrels in 2021.
- **Disruptions to the U.S. Transportation System:** In 2022, there were 18 weather and climate disaster events with losses exceeding $1 billion each across the U.S. These events included 3 tropical cyclones, 10 severe storms, 2 tornado outbreaks, and one each related to drought, flooding, and wildfires. While hurricanes brought disruption from too much water, drought left the lower Mississippi River with too little water for normal navigation in both 2022 and 2023.

remained largely built out and stagnant. The condition of the system is affected by wear from use, infrastructure age, and damage from 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 the economic costs of transportation, and the resulting costs affect the contribution of transportation to the economy. The chapter also touches on system resilience to withstand traditional disruptions, such as extreme weather delays at the Nation's ports and airports, as well as new disruptions, such as cybersecurity threats.

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 2021. A point of emphasis is the changes in the transportation system brought about by the COVID-19 pandemic.

This year's TSAR also focuses on the emerging issues as it relates to principal areas:

Chapter 2 Passenger Travel and Equity will discuss COVID-19 Impact on Passenger Travel.

Chapter 3 Freight and Supply Chain will discuss Disruptions to the Supply Chain from Drought.

Chapter 4 Transportation Economics will discuss Inflation and Transportation.

Chapter 5 Transportation Safety will discuss New Normal in Transportation.

Chapter 6 Energy and Sustainability will discuss Transition to New Energy Sources for Transportation.

Highways, Bridges, and Vehicles

Expansive Infrastructure Is Required to Meet Demand and Resiliency Needs

Roads

The U.S. road system and 8.8 million lane-miles[1] in 2021 remain virtually the same since pre-COVID-19 2018 year. The number of bridges increased by 0.6 percent from 616,096 in 2018 to 619,622 in 2021 (621,581 in 2023). The mileage of nonexpressway principal arterial streets and collector streets were also up by 0.5 and 0.7 percent, respectively, for the same period.

Local roads continue to be the most extensive component of the highway system, amounting to 2.9 million miles (around 69 percent of total centerline-miles) of public road mileage in 2021 (Table 1-1). However, interstate highways, which accounted for about 48,500 miles (just over 1 percent of total system-miles), handled the highest volumes of traffic as measured by vehicle-miles traveled (VMT)—at about 26 percent in 2021 [USDOT FHWA OHPI 2022]. Rural highways comprise 70.1 percent of the centerline-miles and 68.5 percent of the lane-miles and carry 31.4 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.

[1] 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.

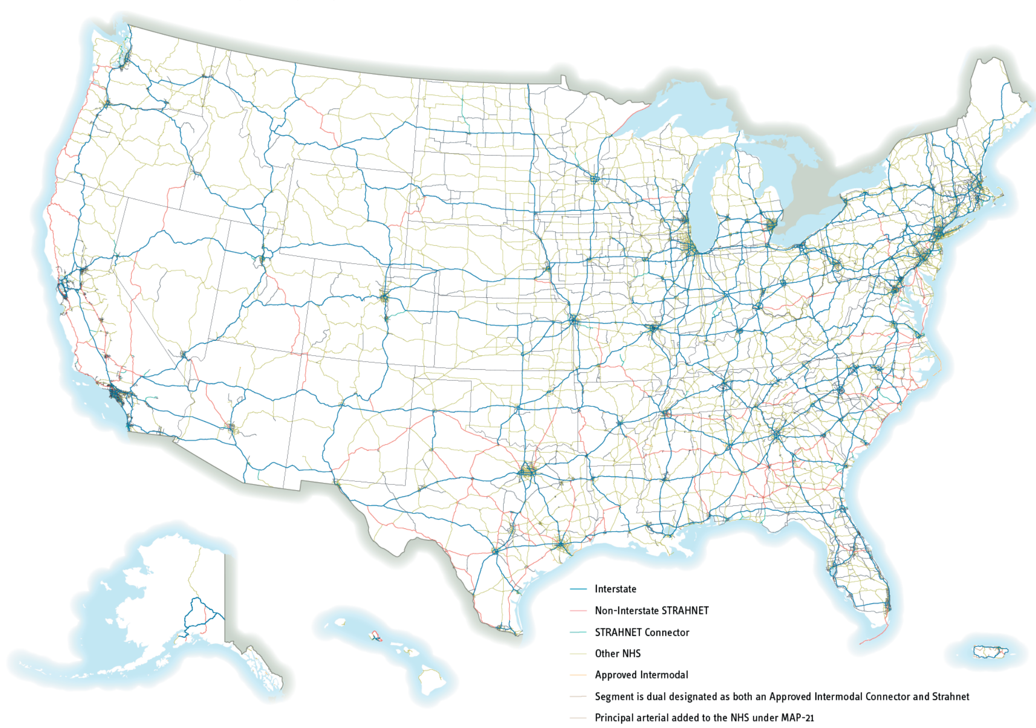
Table 1-1 Public Roads, Streets, and Bridges: 2010 and 2018–2021

Road/street/bridge	2010	2018	2019	2020	2021
Public road and street mileage by functional type (miles)	**4,067,076**	**4,176,915**	**4,171,125**	**4,172,562**	**4,187,440**
Interstate	46,900	48,440	48,481	48,472	48,519
Other freeways and expressways	14,619	18,603	18,631	18,656	18,712
Other principal arterial	157,194	156,614	156,680	157,210	157,398
Minor arterial	242,815	246,214	246,831	246,539	246,303
Collectors	799,226	814,585	815,118	819,025	820,343
Local	2,806,322	2,892,459	2,885,384	2,882,660	2,896,165
TOTAL lane-miles	**8,581,158**	**8,794,569**	**8,785,398**	**8,790,746**	**8,823,515**
TOTAL bridges	**604,460**	**616,096**	**617,084**	**618,456**	**619,622**
TOTAL registered vehicles	**250,070,048**	**273,602,100**	**276,491,174**	**275,936,367**	**282,366,285**
Vehicle-miles of travel (millions)	**2,967,266**	**3,240,327**	**3,261,772**	**2,903,622**	**3,140,088**

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

SOURCE: U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA), *Highway Statistics* (multiple years), as cited in the USDOT. Bureau of Transportation Statistics (BTS). *National Transportation Statistics* (NTS). Tables 1-5, 1-6, 1-11, 1-28, and 1-35. Available at http://www.bts.gov/ as of August 2023.

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 2023.

Condition of Roads and Highways

Interstate Highways Have the Best Pavement Condition

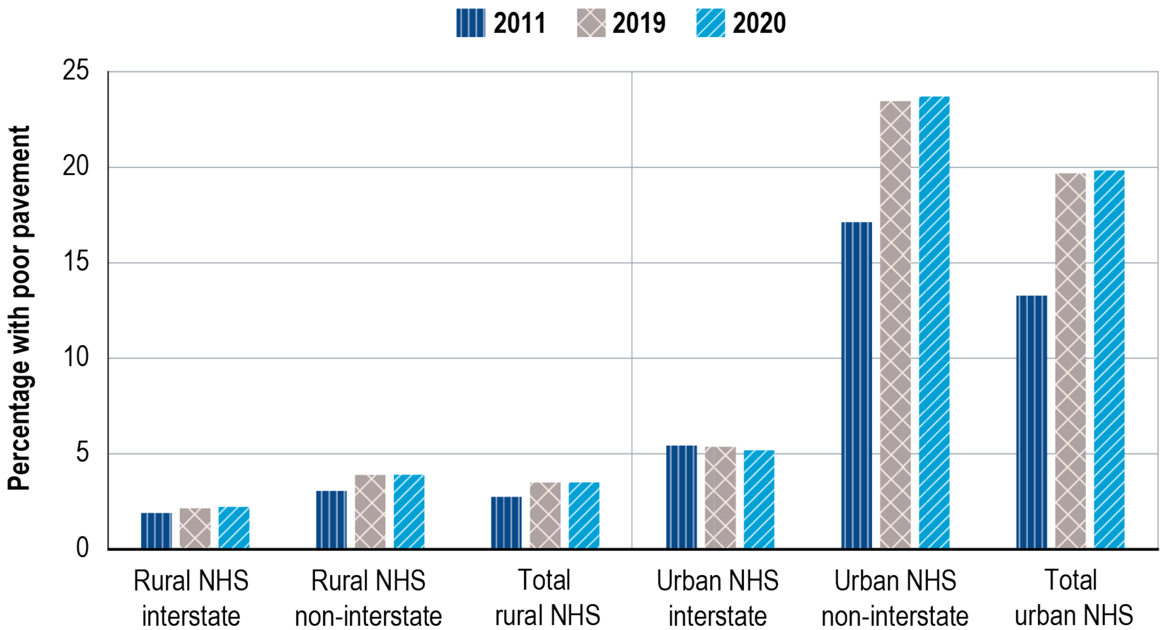
International Roughness Index (IRI) indicates the smoothness of pavement for three major categories:

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.
3. National system performance measures of daily VMT by NHS road pavement condition.

Based on the latest available IRI data, the percentage of pavement in poor condition on the rural NHS has remained relatively stable (under 4.0 percent) since 2011,[2] 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 noninterstate 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 noninterstate highways in each category, including Puerto Rico. Poor condition is defined

[2] 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 2023.

as any pavement with an IRI value greater than 170 inches/mile.

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.

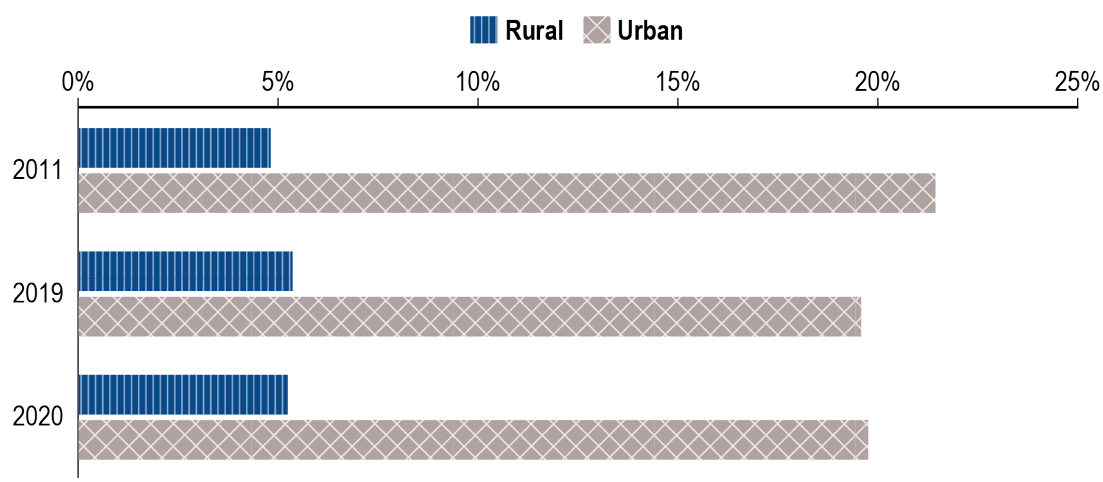
Daily VMT were approximately 4.3 billion in 2020, of which 10.3 percent were over roads with pavement in poor condition. Poor pavement conditions can lead to bumpy rides, vehicle wear, and flat tires in addition to traffic congestion and crashes. Urban roads have a larger share than rural roads of VMT on roads with poor pavement conditions. The percentage of daily VMT on rural NHS roads with poor pavement condition remained stable from 2.4 percent in 2011 to 2.6 percent in years 2018, 2019, and 2020; for urban NHS travel on poor pavement, the percentage increased from about 11 to 13 percent in 2020 (Figure 1-4). There has been little or no change in these results since 2018 [USDOT FHWA OHPI 2022].

Bridges

In most cases, as stated above, 2021 data is the latest year available for complete and final datasets.

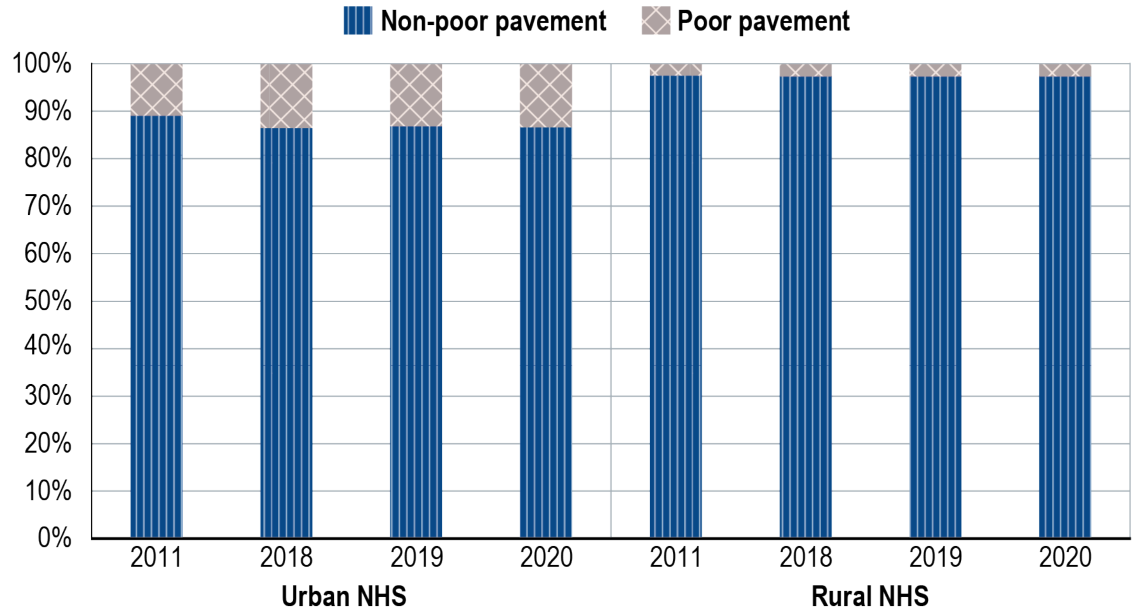
A total of 619,622 highway bridges were in use in 2021 (Table 1-1), continuing the recent trend of roughly 1,000 new bridges added each year. Bridges range in size from rural one-lane bridges crossing creeks to urban multilane and multilevel interstate bridges and major river crossings. Rural bridges, including those on rural interstate highways, accounted for 70.7 percent of the total bridge network [USDOT FHWA 2022a]. While the interstate highway bridges accounted

Figure 1-3 High-Function Roads with Poor Pavement Condition, Rural vs. Urban: 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 2023.

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 2023.

for 9.4 percent of all bridges, they carried 45.5 percent of motor vehicle bridge traffic.

Condition of Bridges

Bridge Condition Has Continued to Improve

The number of the Nation's bridges in poor condition[3] 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[4] or weight restrictions[5] 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.[6,7]

The greatest percentage of poor bridges, determined by the lowest rating of the National Bridge Inventory (NBI) condition ratings for the

[3] 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.

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

[5] 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.

[6] 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.

[7] 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."

bridge deck, superstructure, substructure, or culverts, in rural and urban areas are on local roads (Figure 1-5). Bridges in poor condition on rural roads in 2022 accounted for about 7.8 percent of the total number of rural bridges and 3.4 percent of the throughput (average daily traffic[8]) on rural highways.

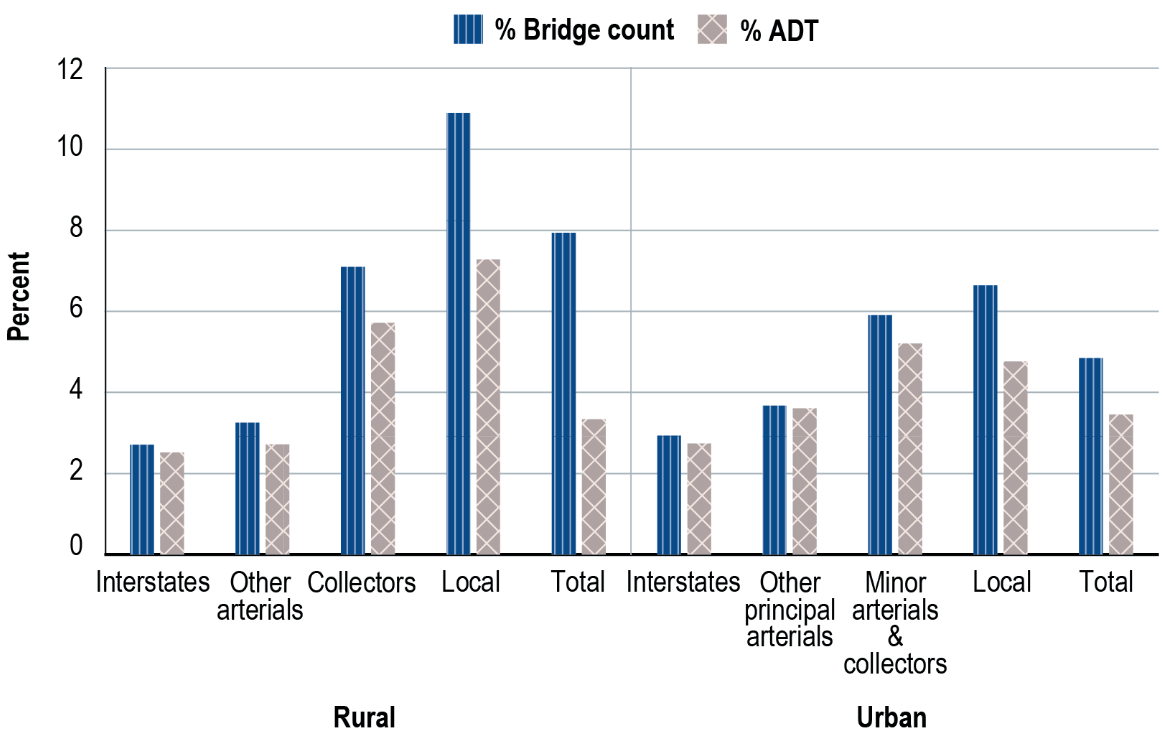
In comparison, bridges in poor condition on urban roads comprised approximately 4.7 percent of urban bridges and 3.4 percent of urban road throughput (average daily traffic). The most used bridges are in better shape than their less-used counterparts, just as interstate and NHS bridges are in better shape than their smaller non-NHS counterparts.

Bridges are an important component of rural transportation infrastructure. Of the 42,966 bridges considered to be in poor condition nationwide in 2022,[9] about 80 percent of them are in rural areas [USDOT FHWA 2022a]. 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

[8] 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

[9] 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 1-5 Bridges in Poor Condition and Average Daily Traffic on Bridges: 2022

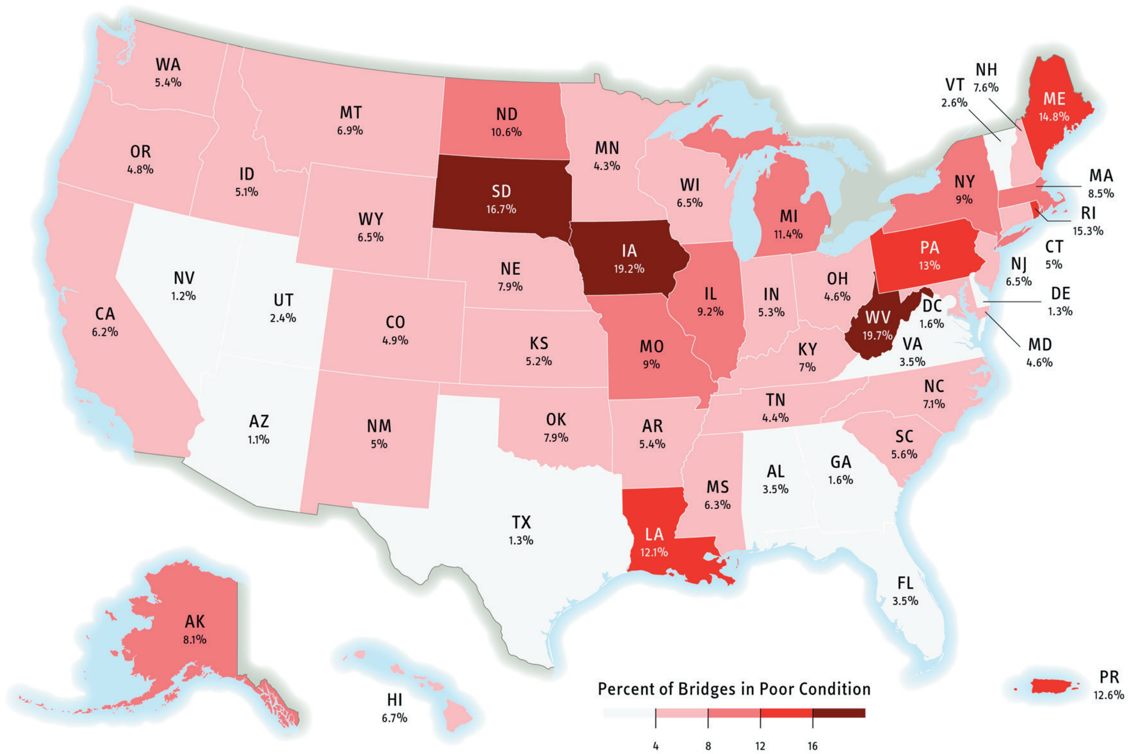


KEY: ADT = average daily traffic.

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 August 2023.

Figure 1-6 Rural Bridges in Poor Condition: 2022



SOURCE: U.S. Department of Transportation, Federal Highway Administration, National Bridge Inventory, available at www.transportation.gov as of August 2023.

with posted load restrictions are in rural areas. Load restrictions on bridges can increase costs (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 (17.8 versus 5.6 miles) [USDOT OST 2023].

In 2022, 66,309 out of the 617,024 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 2022, showing some improvement in bridge condition. Of the 64,564 bridges having some form of posted restriction in 2022, about 29 percent (18,490 bridges) were in poor condition.

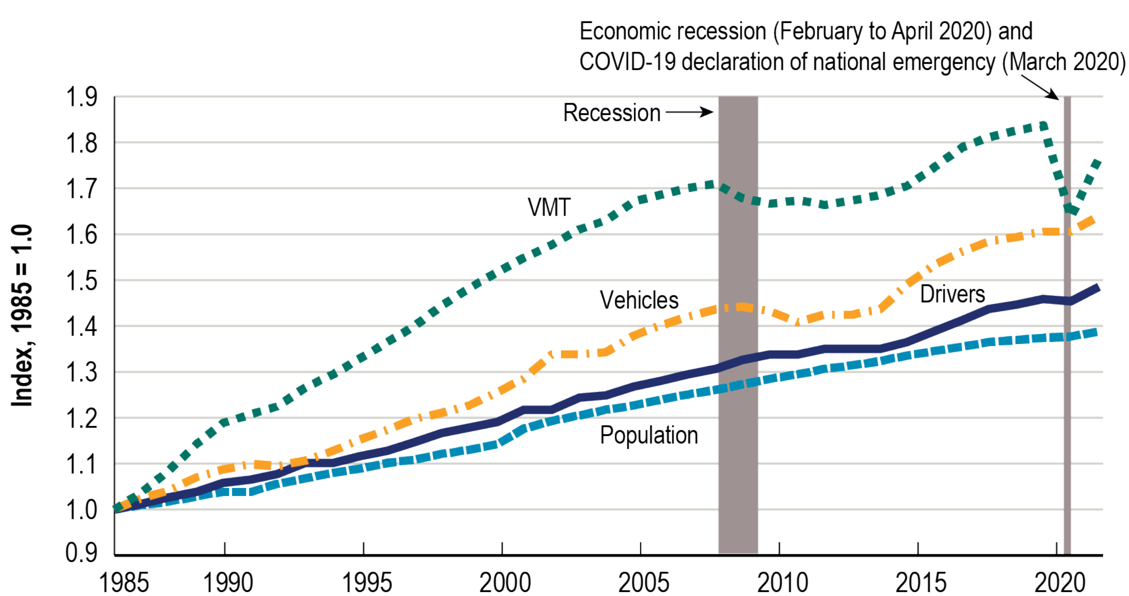
Concerning who owns and is responsible for the upkeep of the 42,966 bridges in poor condition in 2022, about 31 percent of these bridges (13,179) were owned by States, 51 percent (21,949) by counties, 7.1 percent (3,058) by towns, 7.4 percent (3,170) by cities, and 1.8 percent (773) by the Federal Government. The remaining 837 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 282.4 million motor vehicles in 2021 and drove a total of more than 3.1 trillion miles (Table 1-1). 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 2022].

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 flattened and the number of licensed drivers decreased slightly, VMT decreased 11 percent from 2019 to 2020, which was a larger drop than that occurred during the 2008–2009 economic recession. VMT in 2020 was down to the same level as in 2003, which predated the recession years. Both the number of drivers and vehicles increased from 2020 to 2021, to about 2 percent above their values in 2019; and VMT increased sharply in 2021, erasing about 64 percent of its drop during 2020. 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. Registrations include both new and old vehicles, so they can increase even if new car sales decrease, due to older vehicles being kept in use longer. Over that period, new passenger car sales in the U.S. 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.

Figure 1-7 Licensed Drivers, Vehicle Registrations, Vehicle-Miles Traveled, and Population: 1985–2021



KEY: VMT = vehicle-miles traveled.

SOURCE: Vehicles, Drivers, and Population: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2021. Table DV-1C and VM-1, available at https://www.fhwa.dot.gov/policyinformation/statistics/2020/ as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 1-35, available at www.bts.gov as of September 2023.

Most daily personal travel, particularly work commutes, is in privately owned vehicles. According to the National Household Travel Survey [USDOT FHWA 2022d], 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, likely declined during the pandemic and then rebounded a bit in 2021.

Whether for personal or commercial use, 93.4 million sport utility vehicles (SUVs) traveled on average 10,700 miles in 2021, 53.8 million pickups averaged 9,500 miles, and minivans averaged 10,100 miles according to the Vehicle Inventory and Use Survey (VIUS), conducted in 2021 for the first time since 2002 [USDOT BTS 2023e]. The new survey shows that 2.9 million truck tractors traveled on average 48,500 miles in 2021, and 1.6 million other heavy trucks averaged 14,000 miles each. The average age of the Nation's light vehicles (which includes passenger cars and light trucks) continues to increase steadily over time, up from 10.6 years in 2010 to 11.7 years in 2018. The pandemic-induced drop in vehicle sales, noted above, increased the average vehicle age even further, reaching 12.2 years in 2022 [USDOT BTS 2022b]. Vehicle condition usually declines with use and age. Some key data points from both the 2002 and 2021 VIUS datasets include:

- The total number of trucks, operated on U.S. roadways was 169.8 million, compared to 85.1 million in 2002.
- The annual number of miles driven by these trucks was 1.9 trillion miles, a 70 percent increase from 1.1 trillion miles in 2002.
- Light-duty trucks, which have a gross vehicle weight rating (GVWR) of less than 10,000 pounds, had a fuel efficiency of 19.5 miles per gallon (MPG) in 2021, compared to 17.4 MPG in 2002. In 2021, the average annual vehicle miles traveled (VMT) was 9,800 per truck, and in 2002, the average was 12,200.
- Heavy-duty trucks, which have a GVWR over 26,000 pounds, had a fuel efficiency of 6.34 MPG in 2021, compared to 6.23 MPG in 2002. In 2021, the average annual VMT for these trucks was 36,000 per truck, and in 2002, the average was 41,000.

The VIUS details light-duty vehicles that weigh less than 10,000 pounds, mostly SUVs are 34 percent of vehicles according to the Federal Highway Administration table VM-1 [USDOT FHWA 2021], 20 percent of vehicles in VM-1 are pickup trucks, and 4 percent are minivans.

Condition of the Vehicle Fleet

Age of Vehicles Is Increasing

The average age of the Nation's light vehicles (which includes passenger cars and light trucks) continues to increase steadily over time, up from 10.6 years in 2010 to 11.7 years in 2018. The pandemic-induced drop in vehicle sales, noted above, increased the average vehicle age even further, reaching 12.2 years in 2022 [USDOT BTS 2022b]. Vehicle condition usually declines with use and age. Some additional key data points from both the 2021 VIUS datasets include:

- 41 percent of VIUS vehicles below 10k pounds were more than 10 years old and averaged 7,100 miles per year, while newer light-duty vehicles averaged over 10,000 miles per year.
- 47 percent of trucks over 26,000 pounds were over 10 years old and averaged 20,000 miles per year.
- 10 percent of trucks over 26,000 pounds were from model years 2020 and 2021 and averaged over 75,000 miles per year.

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 nonrecession 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 4.3 percent from 2018 to 2022, which spans the COVID-19 pandemic years, extrapolating to an increase of nearly 6 percent by 2023 if the present trend continues.

Highway Congestion

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.[10] 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.
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]. Since then, all three of these measures have trended toward their pre-pandemic values. From 2020 to 2021 congested hours were up 34 percent, TTI was up 5 percent, and PTI increased 10 percent [USDOT FHWA 2023].

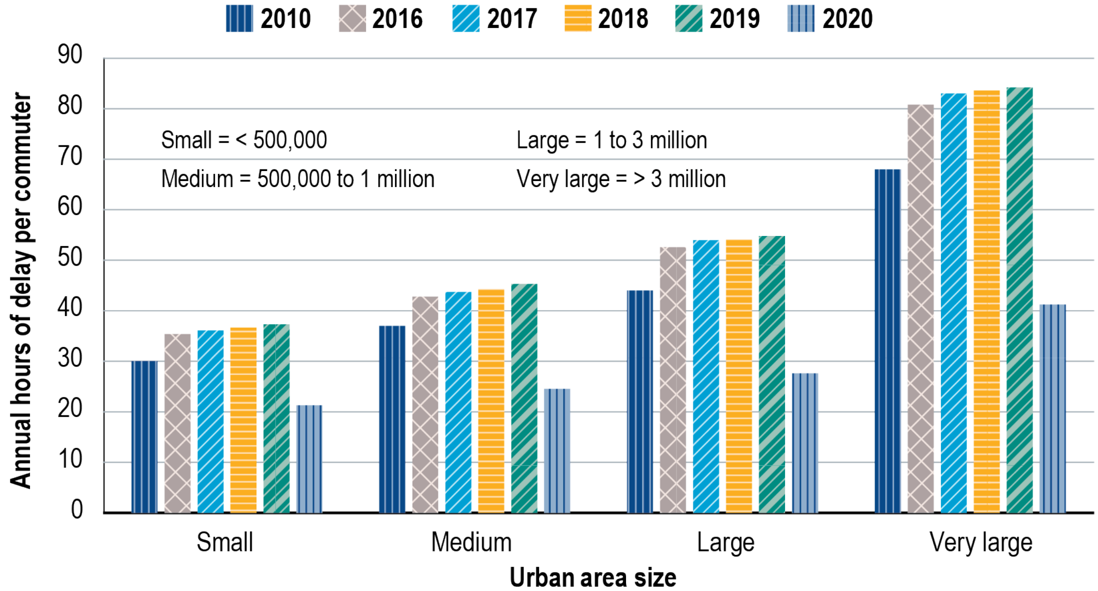
The Texas A&M Transportation Institute's *Urban Mobility Report* provides a comprehensive look at highway congestion [SHRANK, EISELE, LOMAX 2021]. This biennial report, which relies on INRIX[11] data, includes both NHS and non-NHS freeways and arterial roads. The Urban Mobility Report reports show metrics for 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.

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 (Figure 1-8). 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,

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

[11] 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.

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 2023, as reported in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, Table 1-69, available at www.bts.gov as of September 2023.

LOMAX 2021]. As noted above, congestion has increased since 2020, but an updated *Urban Mobility Report* is not yet available.

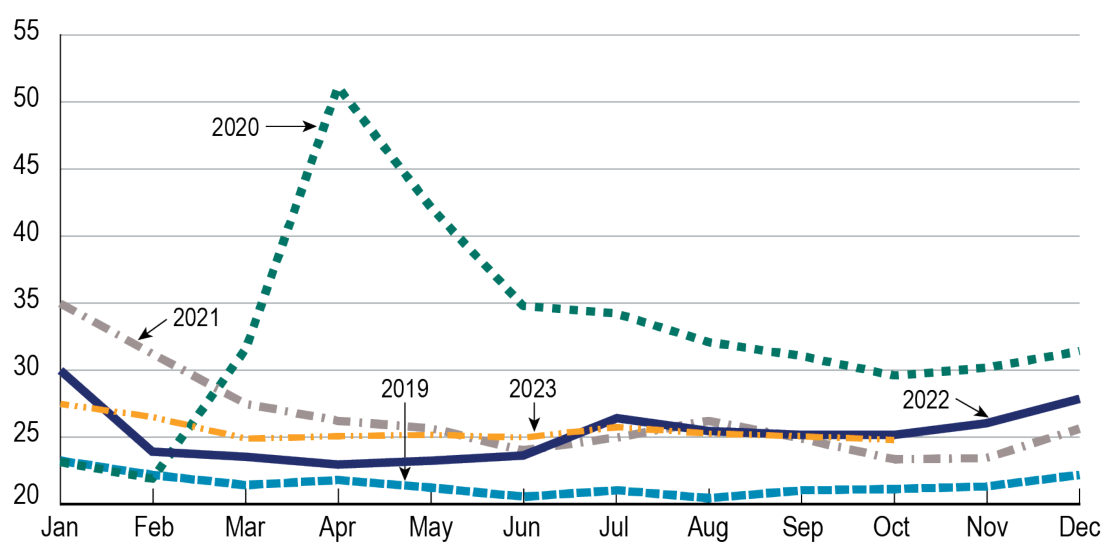
In some respects, truck congestion differed from passenger car congestion in 2020. Truck traffic did not decline as much as passenger vehicle traffic as business and home deliveries increased. As a result, truck congestion was spread over all sizes of urban areas and over more hours of the day than the 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. 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, although some locations have shown minor movements up or down the list [ATRI 2023]. In 2022, the average peak-hour truck speed for the top 100 truck bottlenecks was 36.3 mph, down 6.1 percent from 2021. 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, beginning in January 2019 (Figure 1-10).

Figure 1-9 Peak-Period Congestion on the High-Volume Truck Routes on the National Highway System: 2020

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 2023.

Figure 1-10 Average Truck Speed in MPH at Bottleneck Locations: 2019–2023



KEY: MPH = miles per hour.

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 December 2023.

Public Transit

Transit Ridership Is Slowly Recovering From COVID-19

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 5,800 stations.[12] There were 13,641 fixed-rail-transit track-miles and 4,683 fully controlled or limited-access bus roadway miles in 2021, more research is needed to understand the change from 5,000 in 2020 to 4,683 in 2021 [USDOT FTA 2023].

Transit agencies vary widely in size, ranging from social service agencies operating a single vehicle to the 13,000 vehicles[13] 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 4.5 billion in 2020, a reduction of 50 percent (Table 1-2), which only recovered slightly to 4.68 billing in 2021. Monthly ridership losses during the onset of the pandemic were even

[12] With about 82 percent compliant with the Americans with Disabilities Act (Pub. L. 101-336).

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

Table 1-2 Transit Vehicles and Ridership: Revenue Years 2000, 2010, and 2018–2021

Transit vehicle	2000	2010	2018	2019	2020	2021
TOTAL, transit vehicles	**106,136**	**135,674**	**134,855**	**137,440**	**137,638**	**129,649**
TOTAL, rail transit vehicles	**17,114**	**20,374**	**20,515**	**21,153**	**21,387**	**21,346**
Heavy rail cars	10,311	11,510	10,763	11,198	11,064	10,942
Commuter rail cars and locomotives	5,497	6,768	7,023	7,144	7,524	7,545
Light rail cars	1,306	2,096	2,729	2,811	2,799	2,859
TOTAL, non-rail transit vehicles	**89,022**	**115,300**	**114,340**	**116,287**	**116,251**	**108,303**
Motor bus	59,230	63,679	63,284	64,000	63,903	62,836
Demand response	22,087	33,555	33,253	34,613	34,633	31,553
Ferry boat	98	134	171	183	204	166
Other	7,705	18,066	17,803	17,491	17,511	13,748
Rail transit stations	**2,595**	**3,124**	**3,448**	**3,630**	**3,663**	**3,801**
Person-miles (millions)	**45,100**	**52,627**	**53,830**	**54,097**	**31,547**	**22,371**
Unlinked passenger trips (UPT in billions)	**7.95**	**9.30**	**8.96**	**8.96**	**4.50**	**4.68**
Rail transit UPT	2.95	3.92	4.18	4.24	1.73	1.70
Non-rail transit UPT	5.00	5.38	4.78	4.72	2.77	2.97

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 2023. ***Person-miles traveled:*** USDOT/FTA/NTD as cited in USDOT/BTS/NTS. Table 1-40. Available at http://www.bts.gov/ as of August 2023. *Transit Stations and Unlinked passenger trips:* USDOT/FTA/NTD. Available at https://www.transit.dot.gov/ntd/ntd-data as of August 2023.

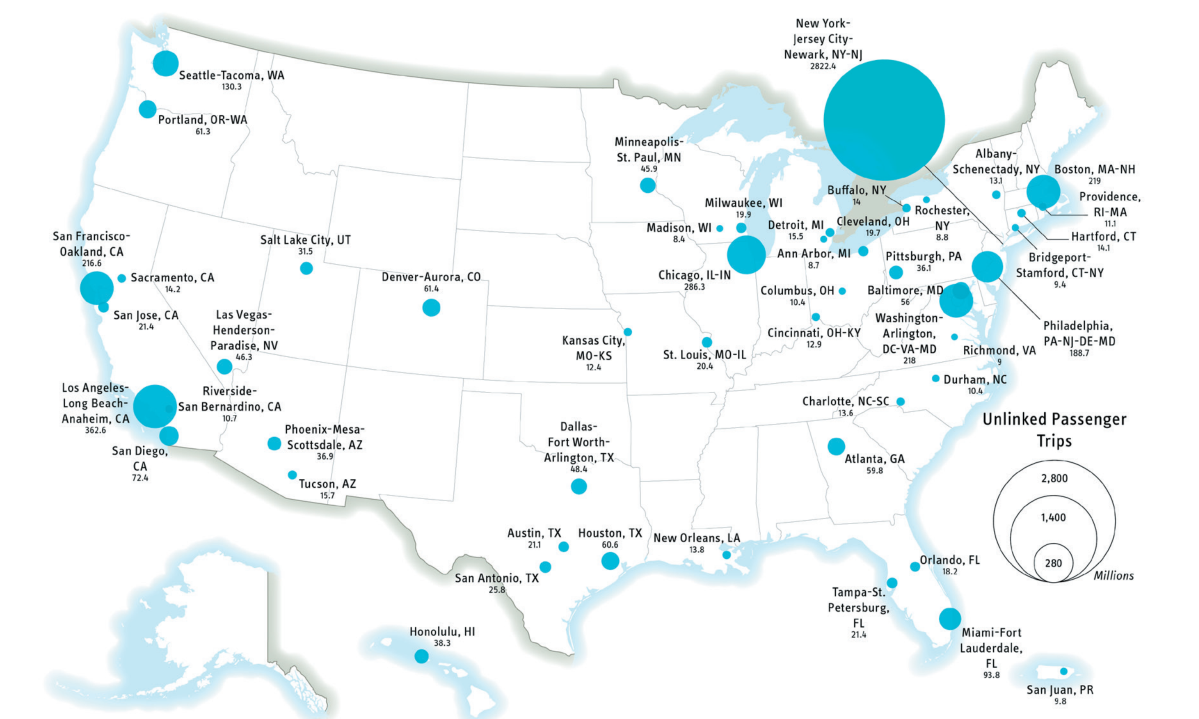
more striking. April 2020 had 158.5 million unlinked passenger trips (UPT)—the lowest ridership on record since 2002—down from 835.1 million UPT in April of 2019, a decrease of 81 percent.

Eight months later, in December 2020, ridership was still down by 62 percent compared to 2019 [USDOT FTA 2023]. While transit ridership is slowly increasing, the pace has yet to recover to pre-pandemic levels. In 2021, passenger trips were still only 52 percent of those in 2019. Figure 1-11 shows transit ridership in the top 50 urbanized areas in 2022.

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 16.5 percent of the transit vehicles but 36.4 percent of transit trips and 54 percent of person-miles traveled (PMT) in 2021 [USDOT FTA 2023]. Buses recorded the highest share of transit trips at 51 percent but only 39 percent of PMT. This can be attributed to the fact that bus passengers generally take shorter trips. Demand-response or paratransit systems, which are largely social service agency trip providers in areas without fixed services or timetables, operated around 24 percent of transit vehicles in 2021 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

Figure 1-11 Top 50 Urbanized Areas of Transit Ridership: 2022



NOTE: Urban Areas (blue 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.transit.dot.gov/ntd as of September 2023.

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 State of Good Repair

Vehicle age is used as a surrogate for condition, with the average lifetime mileage by asset type[14] 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 2021 (Figure 1-12). 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,[15] which have shorter useful life and thus a faster fleet turnover. Reduced transit ridership and revenue during the COVID-19 pandemic had a negative effect on vehicle replacements, as all vehicle types except articulated bus saw an increase in average age of from one-half to one year from 2020 to 2021. The average age of heavy rail passenger cars, at about 24 years, makes them the oldest vehicles in the Nation's transit system [USDOT BTS 2022b]. Motorbuses have an average age of 7.5 years [USDOT FTA 2023]. In general, average transit vehicle age increases with the vehicle's replacement cost because agencies have a financial incentive to maintain 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[16] for buses decreased from about 248,000 in 2010 to 169,000 in 2021, a 32 percent decrease. Transit agencies also report state-of-good-repair information for fixed and mobile assets. Of all assets rated in 2021, 80 percent of revenue vehicles (those that carry passengers) and 90 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 2023].

Aviation

Air Travel Plummeted Due to the Pandemic but Returns to 90 Percent of Pre-pandemic High

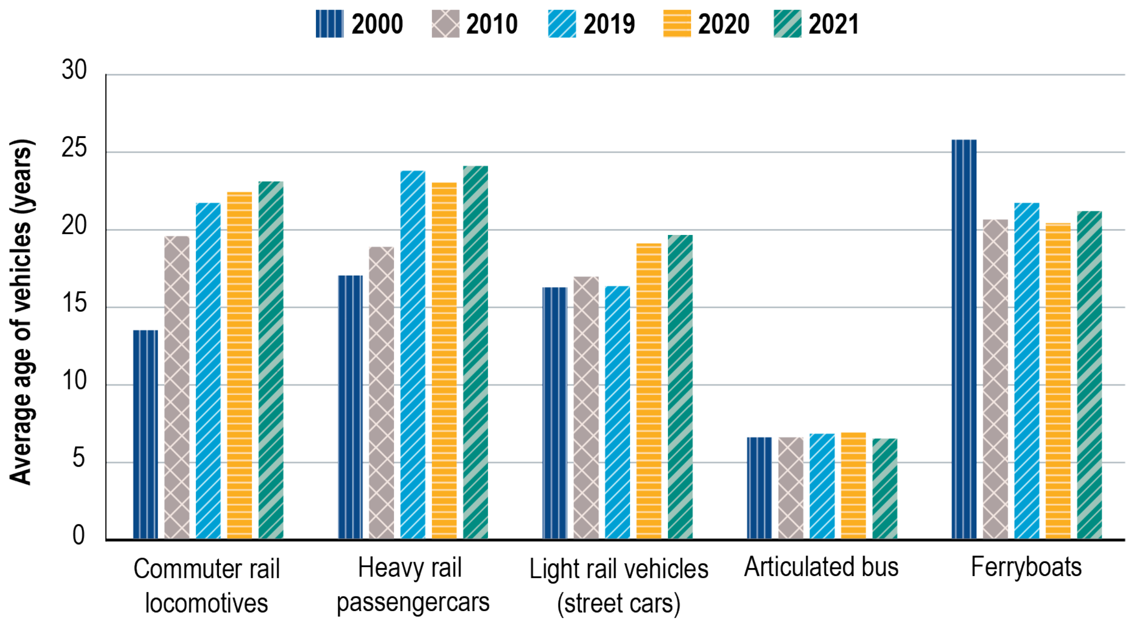
The main elements of aviation system infrastructure include airport runways and terminals, aircraft, and air traffic control systems. In 2021 the United States had about 20,100 airports (Table 1-3), ranging from rural grass landing strips to large paved multiple-runway airports. About a quarter of the 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

[14] 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.

[15] 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.

[16] A major mechanical failure is one 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.

Figure 1-12 Average Age of Urban Transit Vehicles: 2000, 2010, and 2019–2021



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, Federal Transit Administration, Vehicles, available at www.transit.dot.gov/ntd/ntd-data as of September 2023; as reported in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, Table 1-29, available at www.bts.gov as of September 2023.

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 were 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 1.06 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 by 2022 to about 89 percent of 2019's record high 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 was 89 percent of the number of departures in 2019, and load factor was up to 83 percent. For the first eight months of 2023 total enplanements were 696 million, which is 25 percent higher than the total for the same period in 2022 [USDOT BTS 2023c]. If this growth continues for the remainder of the year air passenger traffic is on pace to exceed that in 2019. Air freight was down 4.3 percent from 2021 to 2022 (Table 1-3).

Figure 1-13 shows the U.S. airports with the most revenue passenger enplanements on scheduled flights of U.S. carriers in 2022. Hartsfield-Jackson Atlanta International (45.4 million), Dallas/Fort Worth International (35.3 million), and Denver International (33.8 million) continued to be the top

Table 1-3 U.S. Air Transportation System: 2000, 2010, and 2018–2022

Air transportation system	2000	2010	2018	2019	2020	2021	2022
TOTAL, U.S. airports	**19,281**	**19,802**	**19,627**	**19,636**	**19,919**	**20,061**	**NA**
Public use	5,317	5,175	5,099	5,080	5,217	5,211	NA
Private use	13,964	14,353	14,528	14,556	14,702	14,850	NA
Military	NA	274	305	308	312	313	NA
TOTAL, aircraft	**225,359**	**230,555**	**219,224**	**218,609**	**210,024**	**215,009**	**215,992**
General aviation aircraft	217,533	223,370	211,749	210,981	204,140	209,194	209,140
Commercial aircraft	7,826	7,185	7,475	7,628	5,884	5,815	6,852
Pilots	**625,581**	**627,588**	**633,317**	**664,565**	**691,691**	**720,605**	**NA**
TOTAL, load factor	**72.27**	**81.92**	**83.57**	**84.53**	**58.55**	**73.53**	**82.85**
Domestic flights	71.21	82.10	84.34	85.00	58.65	77.45	84.06
International flights	75.18	81.52	81.71	83.38	58.15	58.86	79.49
TOTAL, passenger enplanements (thousands)	**741,181**	**791,816**	**1,016,834**	**1,056,200**	**400,796**	**703,469**	**941,291**
Enplanements on domestic flights	599,844	632,141	780,034	813,887	336,937	608,209	753,310
Enplanements on international flights of U.S. carriers	70,476	89,198	111,910	115,552	34,797	60,773	103,083
Enplanements on international flights of foreign carriers	70,861	70,477	124,890	126,761	29,062	34,487	84,898
TOTAL, revenue passenger-miles, U.S. carriers (millions)	**708,926**	**809,068**	**1,016,999**	**1,061,006**	**382,346**	**692,557**	**953,019**
Domestic, revenue passenger-miles (RPM) (millions)	515,598	564,695	730,426	762,836	306,119	573,382	711,853
International on U.S. carriers,revenue passenger-miles (RPM) (millions)	193,328	244,373	286,573	298,170	76,227	119,175	241,166
TOTAL, Freight Enplaned (thousand tons)	**5,023**	**14,124**	**17,221**	**17,327**	**18,685**	**20,187**	**19,325**
Domestic, Freight Enplaned (thousand tons)	1,574	10,083	12,412	12,704	13,994	14,692	13,920
International on U.S. carriers, Freight Enplaned (thousand tons)	3,449	4,041	4,809	4,624	4,691	5,496	5,404

KEY: NA = data not available 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 nonscheduled 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 2023. ***General aviation aircraft and Pilots:*** USDOT/FAA. FAA Aerospace Forecast, Fiscal Years (multiple issues). Available at www.faa.gov as of November 2023. *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 2023. ***RPM and Freight Enplaned:*** USDOT, BTS, OAI, T-100 Segment data. Available at http://www.transtats.bts.gov/ as of November 2023.

three airports in 2022. The top 50 airports accounted for 83 percent (about 707 million) of the U.S. airport passenger enplanements[17] in 2022.

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). The number of commercial flights rebounded to 7.6 million in 2021 and 8.7 million in 2022. Total pre-pandemic commercial flights have varied between 9.5 and 10.0 million since 2010 but remain below the high point of 11.3 million in 2005 [USDOT BTS 2023c]. At least some of this reduction is due to the trend for airlines to use larger aircraft and reduce the number of flights.

Condition

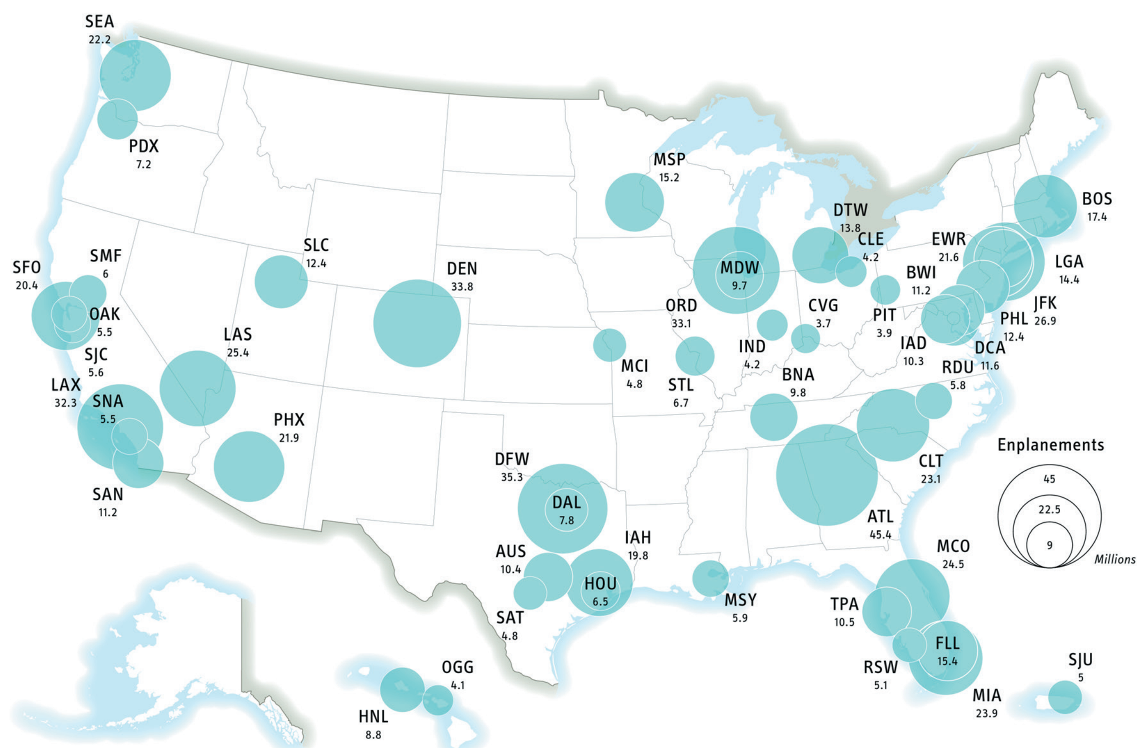
Runway Pavement Condition Remains Stable

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

[17] There were 847 million revenue passenger enplanements on U.S. air carriers at U.S. airports in 2022. This is less than the total enplanement shown in Table 1-3 since those include foreign air carriers and non-revenue passengers

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

Figure 1-13 Enplanements at the Top 50 U.S. Airports: 2022



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 2023.

pavement condition is classified by the FAA as follows [USDOT BTS 2023g]:

- 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, 2022 runway pavement conditions continued to be 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 $62.4 billion in Airport Improvement Program (AIP)-eligible projects at 3,395 public-use airports during fiscal years 2023 to 2027 [USDOT FAA 2022]. This is an increase of $18.8 billion over the plan issued 2 years prior. Although there is some overlap in how the types of investments are categorized, about 68 percent ($43 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 2022].

The average age of U.S. commercial airline aircraft increased nearly 11 percent between 2019 and 2022, going from 13.7 to 15.2 years [USDOT BTS 2023d]. In 2022 the average aircraft age for the largest airlines (called majors[20]) was 14.5 years, up from 13.4 years in 2019. For the next level of airlines (called nationals[21]), the average aircraft age increased from 12.7 years in 2019 to 17.4 years in 2022. Regional airlines[22] achieved a reduction in average aircraft age, from 27.5 years in 2019 to 23.6 years in 2022. No public data are currently available to indicate the condition of the aircraft fleet.

Performance

Aircraft Delays Exceed Pre-pandemic Levels

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 percent in 2019 to 85 percent in 2020. The percentage of on-time departures experienced a similar increase, from 80 percent in 2019 to 86 percent in 2020. As air traffic began to recover, both on-time values dropped, to 81 percent in 2021 and 77 percent in 2022. Further declines in 2023 do not seem to be as big based on data up to September 2023.

In 2020, DOT received 102,560 complaints about airline service from consumers, which was more than 6.5 times greater from the 15,342 complaints received in pre-pandemic 2019 [USDOT BTS 2023a]. 2021 complaints dropped to 49,991 but then increased 55 percent to 77,656 in 2022. Of the 2022 total complaints received, 30.4 percent concerned cancellations, delays, and misconnections from airlines' schedules, and 25.7 percent concerned refunds.

The causes for flight arrival delays (Figure 1-15) remained relatively constant from 2010 to 2019. Air travel and operational changes due to the COVID-19 pandemic resulted in some significant

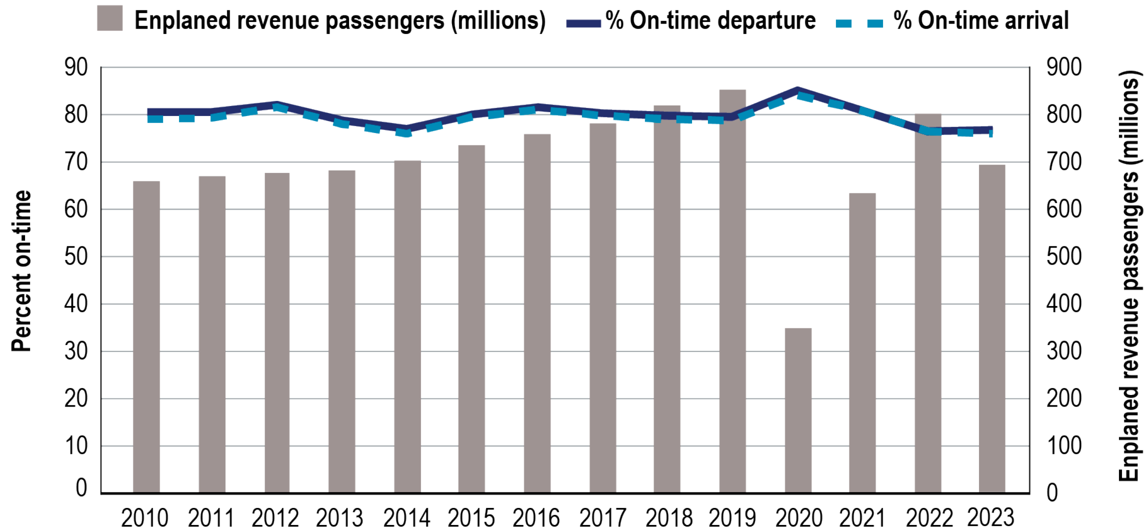
[19] The National Plan of Integrated Airport Systems (NPIAS) contains all commercial service airports, all reliever airports, and selected public-owned general aviation airports identified by FAA Order 5090.3C. An airport must be included in the NPIAS to be eligible to receive a grant under the Airport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

[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.

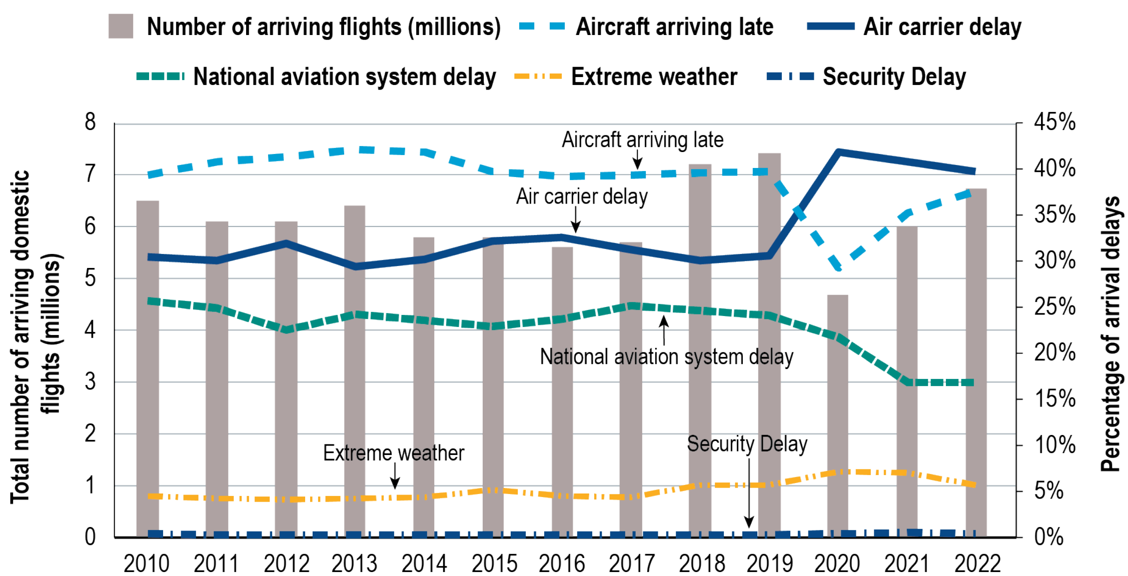
Figure 1-14 Percent On-Time Flight Departures and Arrivals: 2010–2023



NOTE: 2023 data are through September. 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 and T-100 Market Data, available at https://www. transtats.bts.gov/ as of August 2023.

Figure 1-15 Percent of Flight Delay by Delay Cause: 2010–2022



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 nonextreme 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: Department of Transportation, Bureau of Transportation Statistics, Airline On-Time Statistics and Delay Causes, available at https://www.transtats.bts.gov/ot_delay/OT_DelayCause1.asp as of September 2023.

shifts since 2019. Due to reduced air traffic, aircraft arriving late as a delay cause dropped from 40 percent in 2019 to 29 percent in 2020 but increased to 38 percent in 2022 as traffic levels rose. Conversely, air carrier problems with staffing and other factors as a cause of air carrier delay increased from 31 percent in 2019 to 42 percent in 2020, dropping to 40 percent in 2022. National aviation system delay (e.g., due to ground holds and other flow control measures) as a cause dropped from 24 percent in 2019 to 17 percent in 2021 and 2022. Extreme weather as a cause of delay edged up from 4 percent in 2010 to 6 to 7 percent in recent years. Security issues have accounted for only 0.1 to 0.3 percent of delay since 2010.

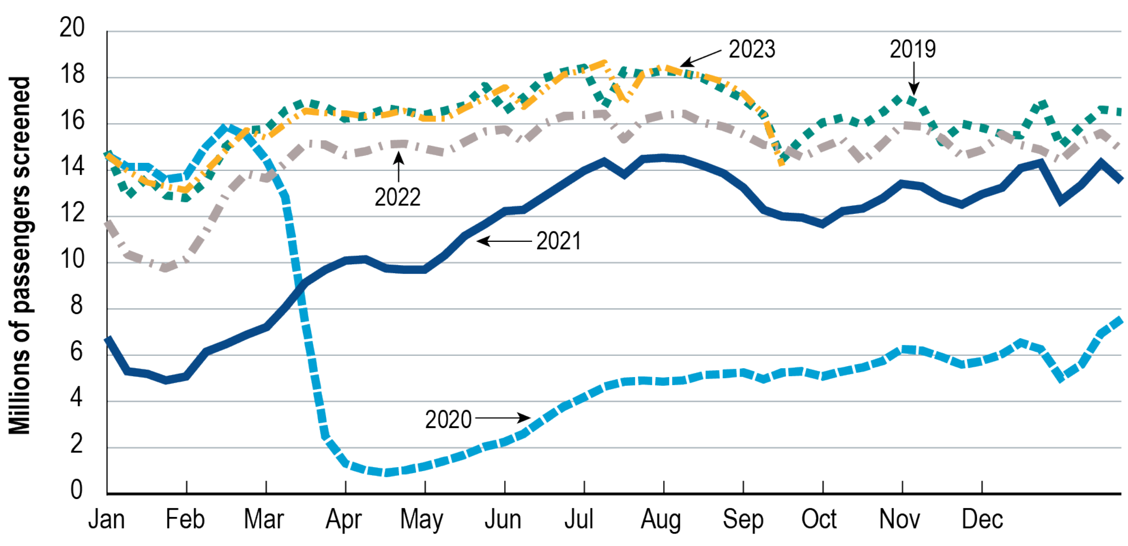
In 2018, 814 million people passed through the Nation's security check points. After the COVID-19 pandemic spread in 2020, TSA people screenings (which are used as a proxy for "throughput" or air travel demand) dropped to about 11,000 per day by April 2020, representing a drop of 2.2 million passenger screenings or 95 percent from the same month a year earlier [USDHS TSA 2020]. Passenger screenings in 2023 (through September) are tracking closely the pattern of screenings in 2019 (Figure 1-16). The 3-year recovery of air traffic is clearly shown in the same figure.

Passenger Rail

Amtrak Transports Passengers Across the United States; Ridership Highest 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 21,124 route-miles in 2021 and more than 500 stations that served 46 states and Washington, DC. The number of passengers went from 23 million in 2022 to 29 million in 2023, a significant increase but still below the pre-pandemic level of 32 million in 2019 (Table 1-4). On an average day, Amtrak operates more than 300 trains, using a fleet of approximately 1,500 passenger cars and nearly 400 locomotives. Amtrak has a particularly strong presence in the Northeast Corridor (NEC) between Boston, MA, and Washington, DC. In FY 2022 Amtrak carried more than

Figure 1-16 Average Daily Number of People Screened at TSA Checkpoints by Week: 2019–2023



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics Administration, COVID-19 Transportation Statistics, as of August 2023.

three-and-a-half times as many riders between Washington and New York City as all the airlines combined, and more than all the airlines combined between New York City and Boston [AMTRAK 2023].

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 reflects a downward adjustment by the corporation from an earlier estimate, compared to 12.2 million in FY 2021. This was a 62 percent reduction in total ridership between 2019 and 2021 More than 28 million people rode Amtrak nationwide during FY 2023, a 24.6 percent increase over the same period in 2022. However, it is still short of pre-pandemic numbers of 32.5 million people annually. [AMTRAK 2023].

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, DC. Ridership is also high around Chicago as well as at several locations in California and the Pacific Northwest. In FY 2022, the busiest Amtrak Station was Penn Station in New York City (8.0 million passengers) followed by Union Station in Washington, DC (3.6 million passengers) and Philadelphia's 30th Street Station (3.1 million passengers).

Amtrak Condition

Amtrak owns 363 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 2022]. 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 73 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 and freight rail.

The average age of Amtrak locomotives in FY 2022 was 19.2 years, about the same age as 12 years prior. The average age for Amtrak passenger cars was 34.3 years, 8.7 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.

Table 1-4 Passenger Rail Transportation System: Fiscal Years 2000, 2010, and 2018–2023

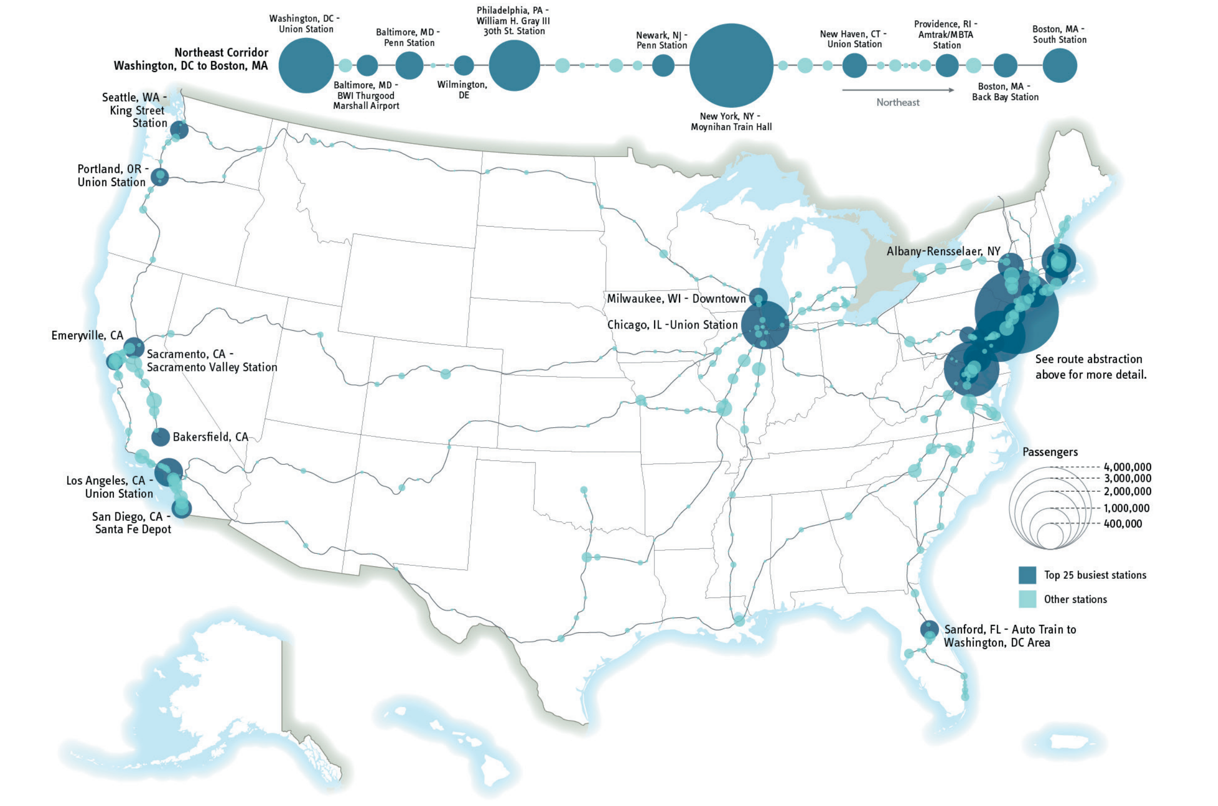
Equipment and mileage operated by Amtrak	2000	2010	2018	2019	2020	2021	2022	2023
Locomotives	378	282	431	403	384	395	NA	NA
Passenger cars	1,894	1,274	1,403	1,415	1,313	1,529	NA	NA
System mileage	23,000	21,178	21,407	21,407	20,787	21,124	NA	NA
Stations	515	512	526	526	526	526	528	NA
Passengers (millions)	20.9	28.7	31.7	32.0	16.8	12.2	22.9	28.5
Passenger-miles traveled (millions)	5,574	6,420	6,361	6,487	3,450	2,860	4,888	5,823

KEY: NA = data not available at time of publication.

NOTE: 2023 data are estimated. 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 December 2023.

Figure 1-17 Busiest Amtrak Stations: 2022



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, State Transportation Statistics, Amtrak Ridership, available at https://www.bts.dot.gov/product/state-transportation-statistics as of August 2023.

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 2022].

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). Delay dropped again in 2021, to 59,000 hours, in line with the continued decline in ridership. In 2022 delays rose to 83,000 hours as rail passenger traffic increased. The percentage of systemwide on-time arrivals 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. Those values dropped to 74 and 79 percent, respectively, in 2022. On-time arrivals on routes longer than 750 miles have ranged from 43 to 72 percent since 2013 [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 nonrailroad causes, such as customs inspections.[23] Delay caused by host railroads remains the major source of Amtrak delays, accounting for between 54 and 60 percent of total delay over the past decade [USDOT BTS 2022b].

Freight Railroads

New Efficiencies Help Railroads Carry More Cargo in Fewer Cars

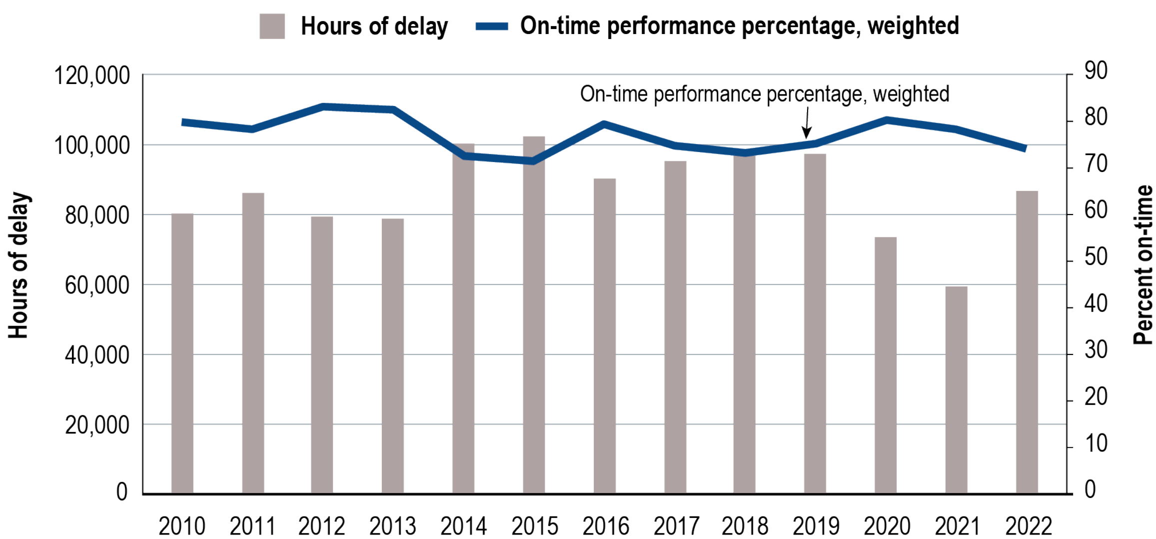
The United States had 136,729 railroad route-miles in 2019, including 92,190 miles owned and operated by the seven Class I freight railroads [AAR 2022].[24] About 626 local and regional railroads operated the remaining 44,539 miles. In 2021 Class I railroads provided freight transportation using 23,264 locomotives (Table 1-5) and 1.66 million railcars [AAR 2022]. 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 2022]. 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. Total rail nonintermodal carloads in 2021 and

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

[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. Amtrak is also classified as a Class I railroad.

Figure 1-18 Hours of Delay and On-Time Performance of Amtrak: 2010–2022



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 November 2023.

2022 (Figure 1-19) were at about 92 percent of the totals for the same months in 2019. 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 2022 was about the same as in 2019 [USDOT BTS 2022a].

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

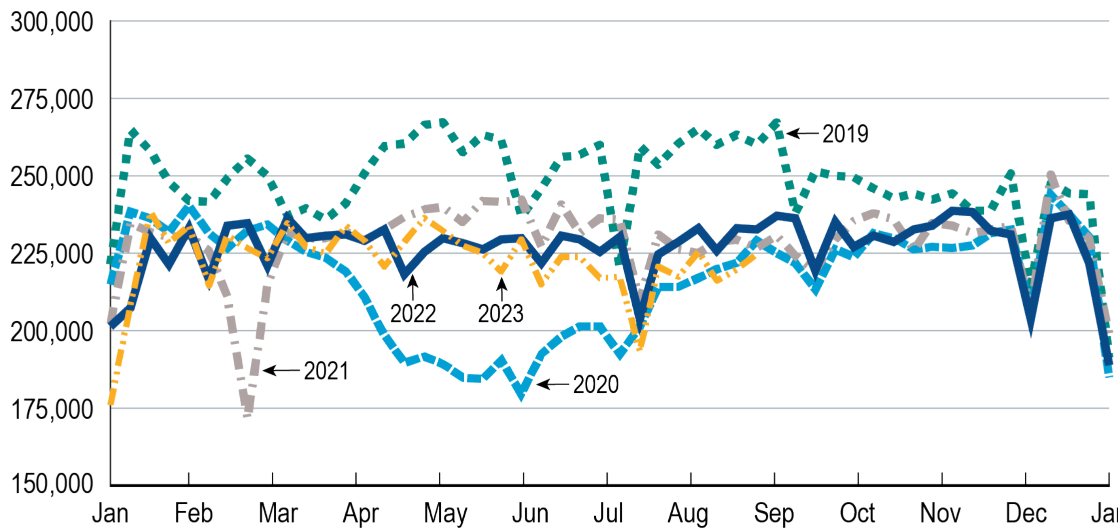
Item	2000	2010	2018	2019	2020	2021
Equipment and mileage operated by Class I						
Locomotives	20,028	23,893	26,086	24,597	23,544	23,264
Freight cars[a]	560,154	397,730	293,742	270,378	252,400	243,087
Average freight car capacity (tons)	92.7	101.7	104.6	103.3	105.1	104.9
System mileage	99,250	95,700	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.

NOTES: *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 2023. ***Capital expenditures:*** Association of American Railroads, Railroad Facts (Annual issues), as of November 2023.

Figure 1-19 U.S. Total Rail Nonintermodal Carloads by Week: 2019–2023



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Railroad Administration, Supply Chain Indicator, available at https://www.bts.gov/freight-indicators#carloads as of September 2023.

Over the past 60 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. The system mileage of Class I railroads in 2018 was less than 45 percent of the mileage in 1960 (Figure 1-20).[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 railroads continue to carry more ton-miles per system mile than they did 30 years ago.

The railroads, which are private companies, invested over $10 billion in both 2020 and 2021 to improve their facilities (Table 1-5). This investment is down from the $13 billion invested in 2019 and is in line with traffic and revenue reductions but is higher than the investment as recently as 2010.

Freight Rail Condition

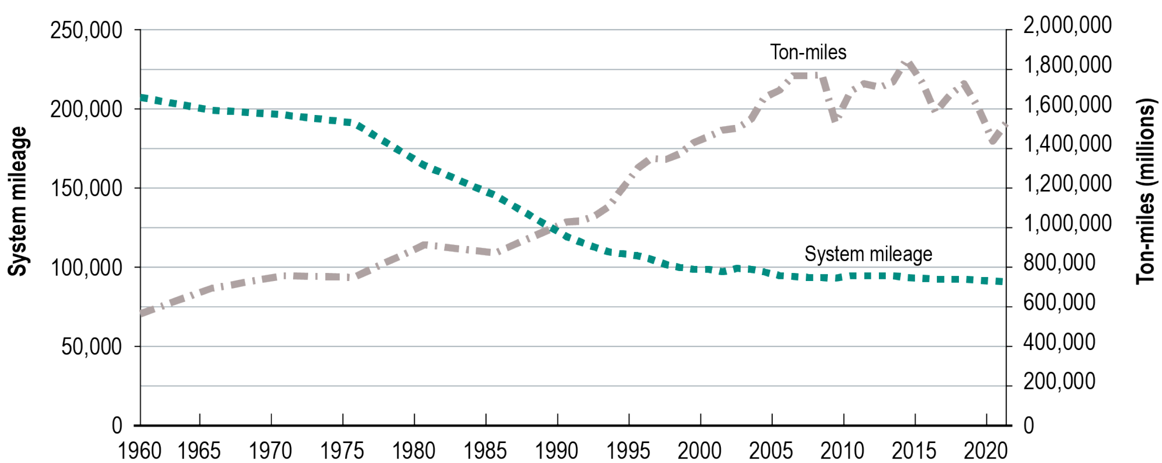
Track Inspection Improves Track Condition and Safety

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 2022 FRA inspectors or other railroad regulators reported 424 track safety standards violations, about half the number in 2021 and one-quarter of the number in

[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].

Figure 1-20 Class I Railroad System Mileage and Ton-Miles of Freight: 1960–2021



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 August 2023.

2018, and comparable to the numbers in the intervening years [USDOT FRA 2022].

Ports and Waterways

About 8,300 water transportation facilities existed in the United States in 2021 (Table 1-6). Dams and navigation locks are two of the principal infrastructure features of the U.S. inland waterway transportation system.[26] 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 2021, there were almost 44,800 U.S.-flagged maritime vessels operating on the waterways, an increase of 10.5 percent since 2010 (Table 1-6). Recreational boats have numbered about 12 million since 2010.

From 2010 to 2021, waterborne commerce (Table 1-6) increased by only 0.6 percent. Domestic tonnage decreased by 15 percent over that period and foreign tonnage increased by

[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 2018–2021

Item	2000	2010	2018	2019	2020	2021
Infrastructure						
Waterway facilities (including cargo handling docks)	9,309	8,060	8,237	8,250	8,334	8,276
Ports (handling over 250,000 tons)	197	178	181	185	192	208
Miles of navigable waterways	25,000	25,000	25,000	25,000	25,000	25,000
Lock chambers	276	239	239	237	237	237
Lock sites	230	193	193	192	192	192
U.S. flag vessels						
Total, commercial vessels	**41,354**	**40,512**	**43,170**	**43,752**	**44,501**	**44,755**
Barge/non-self-propelled vessels	35,008	31,906	33,266	33,600	34,168	34,363
Self-propelled vessels	10,410	10,775	9,904	10,152	10,333	10,392
Recreational boats, millions	12.8	12.4	11.9	11.9	11.8	12.0
Total, waterborne commerce (million tons)	**2,462**	**2,334**	**2,438**	**2,363**	**2,226**	**2,347**
Domestic	1,070	894	849	818	743	760
Foreign	1,392	1,441	1,589	1,545	1,483	1,587

NOTES: *Total, commercial 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 December 2023. **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 December 2023. **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 December 2023. *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 2023.

10 percent. 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, and metal products, as well as a variety of consumer goods and containerized products imported from around the world. By 2021 waterborne commerce had recovered to over 99 percent of the total in 2019. In 2022 low water conditions on the Mississippi River significantly reduced barge throughput, and these conditions reappeared in late summer and early fall in 2023 (refer to Chapter 3 Freight and Supply Chain).

Waterway Condition and Performance

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 281 million cubic yards in FY 2021. Seventy-four percent of this removal was done for navigational maintenance purposes [USACE 2023].

Time Delays at Navigation Locks Increase Three-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].

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 manatees, debris, ice, etc., through a single lock cycle. Commercial lockage's 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 Jul 29, 2021, available at https://www.iwr.usace.army.mil/ as of September 2023.

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 208 ports handled at least 250,000 short tons annually in 2021 (Table 1-6). The top 25 U.S. ports by tonnage handled 69 percent of the short tons in 2021 [USDOT BTS 2022d]. The average 2022 dwell time of container vessels at the top 25 U.S. container ports was 34.7 hours, up 2.7 hours from 32 hours in 2021. Average container vessel dwell times for individual ports are shown in the online *Port Profiles*, which is available at www.bts.gov/ports.

From 2019 to 2022, there has been a shift in the market share of twenty-foot equivalent units (TEUs) when comparing U.S. East Coast ports to U.S. West Coast Ports (Figure 1-21A and Figure 1-21B). The specific ports included were the Ports of Charleston, New York & New Jersey, Virginia, and Savannah for the East Coast. For the West Coast, the ports included were the Ports of Long Beach, Los Angeles, the Northwest Seaport Alliance (Seattle and Tacoma), and the Port of Oakland. Gulf Coast ports were not considered. For containerized imports (Figure 1-22A), 44 percent were shipped to East Coast ports in 2019 and that percentage increased to 48 percent in 2022. For containerized exports (Figure 1-22B), 48 percent were shipped from East Coast ports in 2019 and that percentage increased to 53 percent in 2022.

Record Low Water on the Mississippi and Ohio Rivers

The Mississippi River provides a vital link for freight movement in the United States. In 2022 and 2023 to date, that flow of freight has been hampered by low water levels on the Lower Mississippi River. Barges must carry less cargo to reduce their drafts and barge tows must be reduced in number and length. At times, some parts of the waterway system were not navigable by barges.

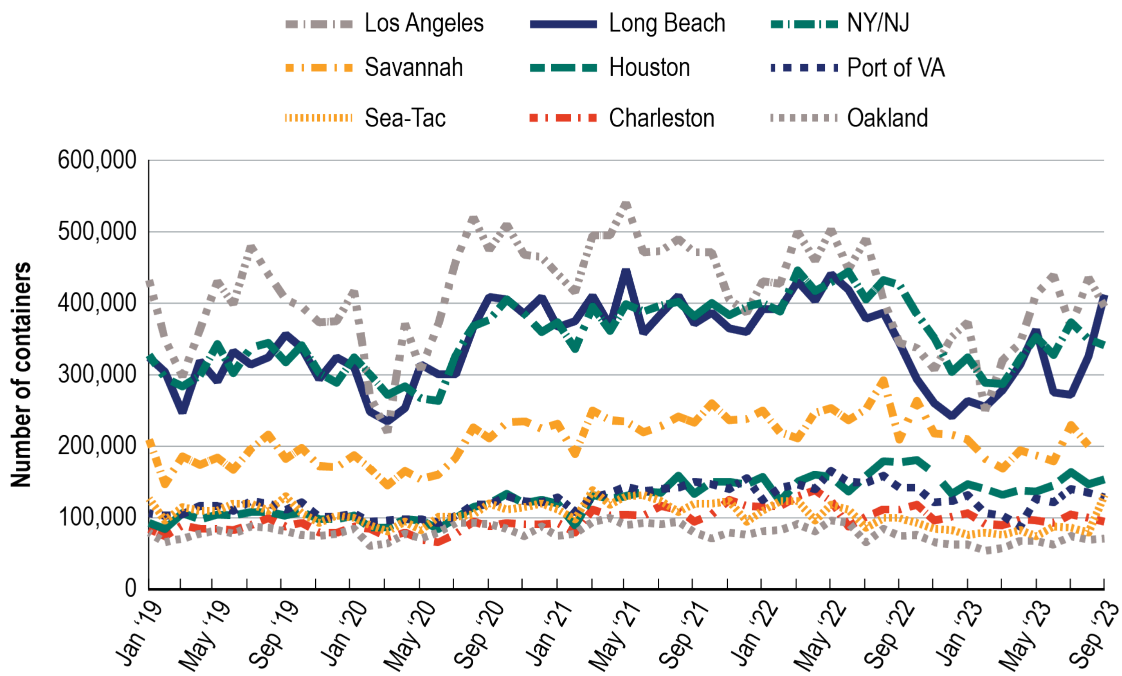
Many major barge commodities such as coal, chemicals, and petroleum move at similar volumes year-round. Grain and other farm products, however, are seasonal. In 2023, downbound (southbound) grain shipments from the Upper Mississippi through Lock and Dam 27 were even lower than the 2022 pattern, as shown in Figure 1-23.

Unfortunately, the low water has again coincided with the peak shipping season for U.S. corn and soybeans, our nation's largest export crops. The October 2023 downbound grain and agriculture product shipments on the Lower Mississippi below Lock and Dam 27 near Granite City, IL were predominately soybeans (69 percent) and corn (30 percent), leaving those major export commodities most vulnerable to the Lower Mississippi River disruption [USDOT BTS 2023f].

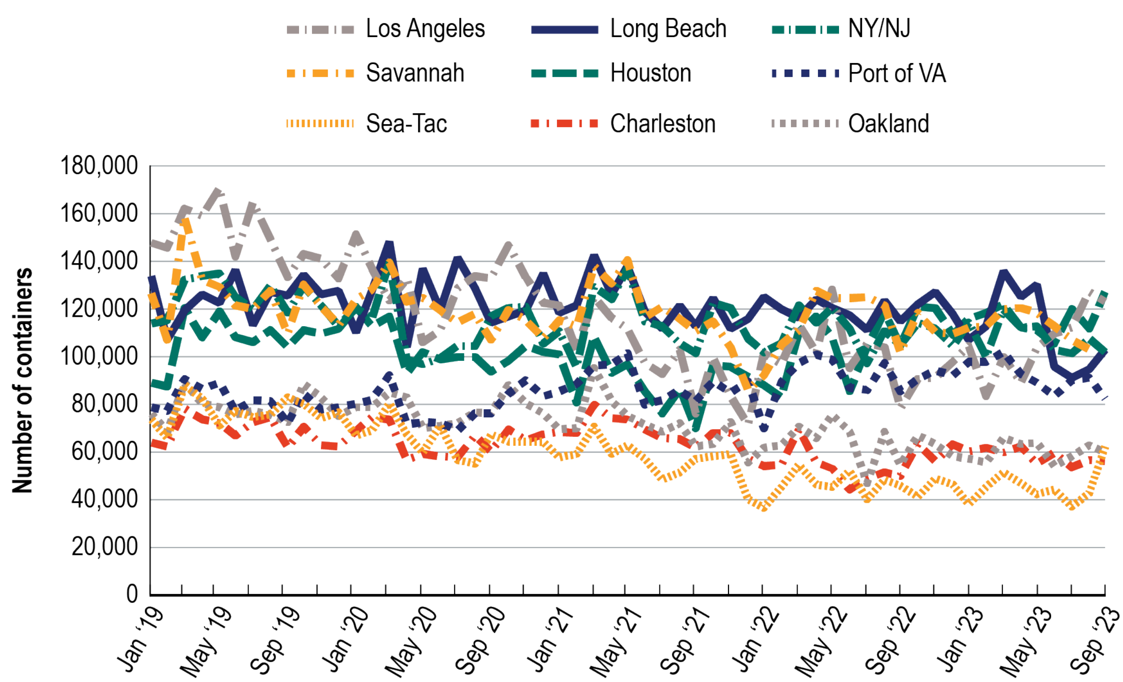
The implications are apparent in barge shipping rates. By early September 2022, barge rates were at record highs. Downbound grain rates on the Mississippi in October 2022 rose to more than double the 2021 peak and remained very high in early November of that year, as shown in Figure 1-24. However, the begin of winter 2023 saw very low barge rates, which have only just ticked up in October 2023. Low rates can be reflective of low demand—with interruptions in service and inability to move the same tonnage as cost effectively, shippers may be moving to other modes. More research would be necessary.

Figure 1-21 Loaded Containers at Select Ports:2019–2023

A. Import Containers



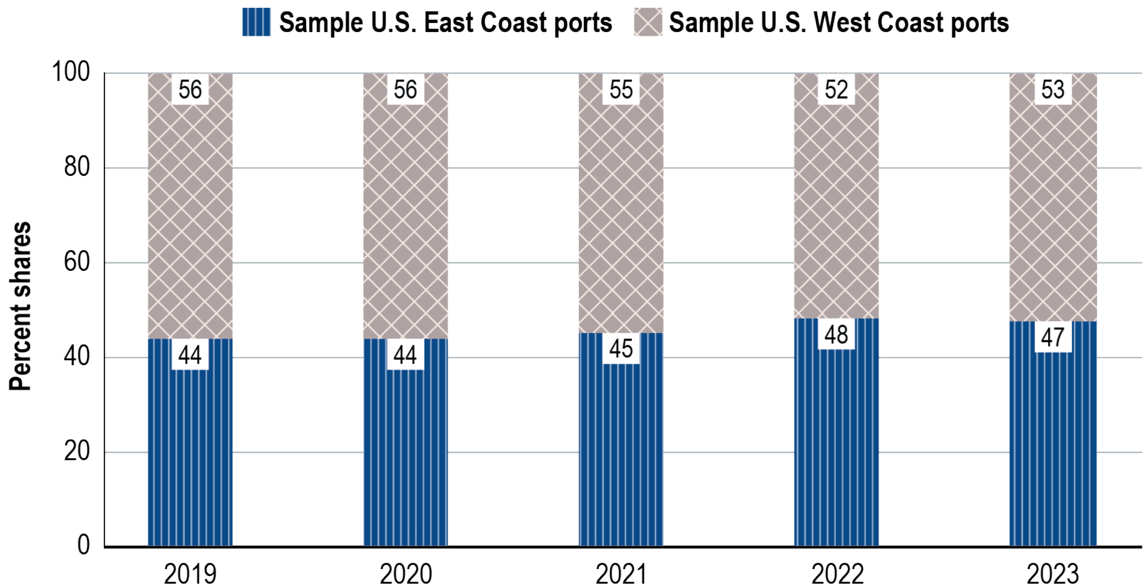
B. Export Containers



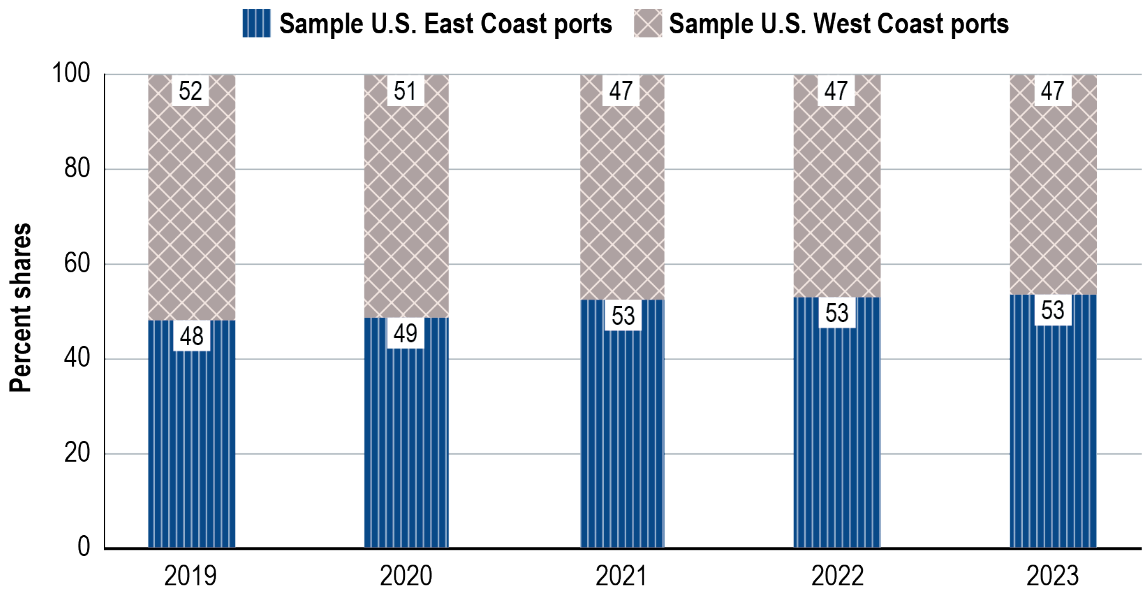
SOURCES: Reprinted from U.S. Department of Transportation, Bureau of Transportation Statistics, Supply Chain and Freight Indicators Dashboards, available at https://www.bts.gov/freight-indicators#loaded-import as of December 2023; U.S. Department of Transportation, Bureau of Transportation Statistics, Supply Chain and Freight Indicators Dashboards, available at https://www.bts.gov/freight-indicators#loaded-export as of December 2023.

Figure 1-22 Shares of TEUs by a Sample of East Coast and West Coast Ports: 2019–2023

A. Imported TEUs

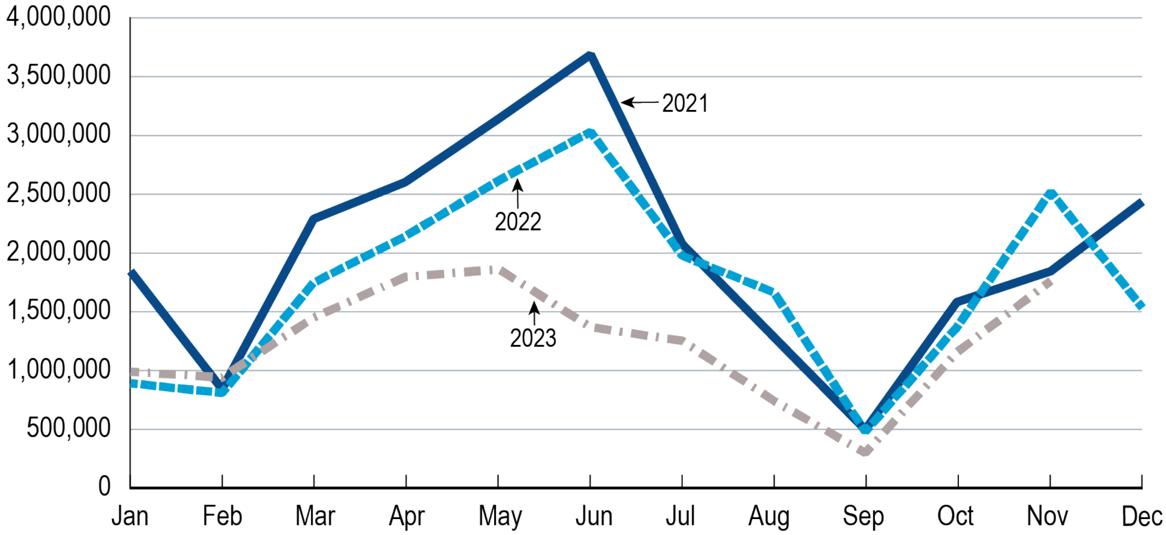


B. Exported TEUs



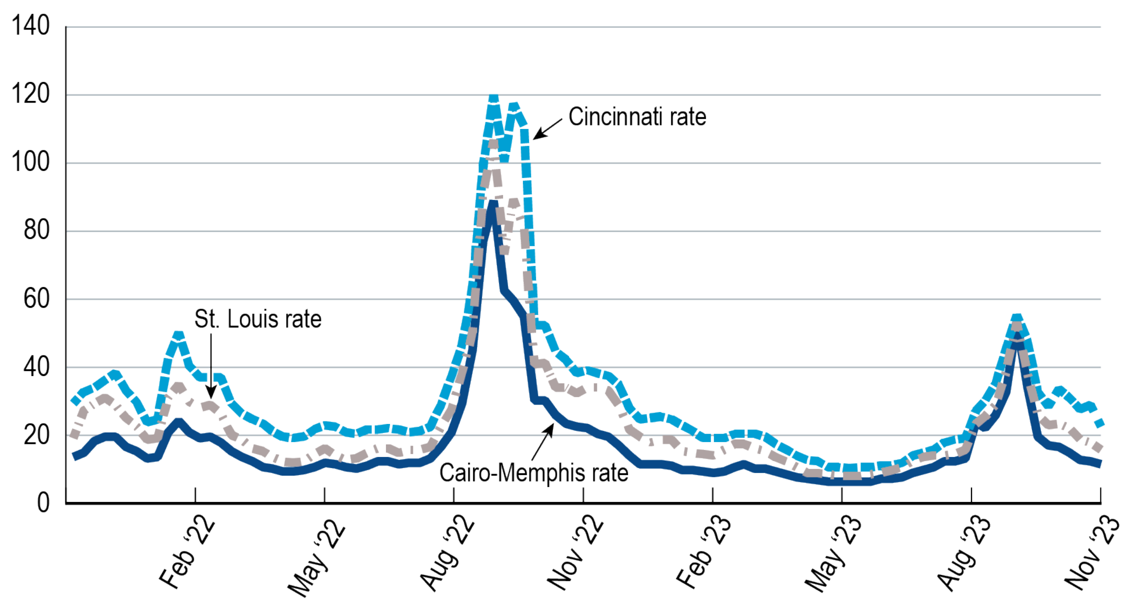
SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics analysis; based upon TEU volumes at the ports of Charleston, SC, http://scspa.com/about/statistics/; Long Beach, https://www.polb.com/; Los Angeles, https://www.portoflosangeles.org/; Northwest Seaport Alliance (Seattle/Tacoma), https://www.nwseaportalliance.com/; Oakland, https://www.oaklandseaport.com/; New York/New Jersey, https://www.panynj.gov/; Port of Virginia, http://www.portofvirginia.com/; and Savannah, https://gaports.com/; as of December 2023.

Figure 1-23 Monthly Downbound Barge Grain Tonnage at Mississippi Lock and Dam 27: 2021–2023



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, analysis based upon U.S. Department of Agriculture, Agricultural Market Service, Downbound Barge Grain Movements, available at *Downbound Barge Grain Movements*, http://www.usda.gov as of December 2023.

Figure 1-24 Weekly Downbound Grain Barge Rates: January 2022–November 2023



NOTE: 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.). Shown are St. Louis; Cincinnati, along the middle third of the Ohio River; and Cairo-Memphis from Cairo, IL, to Memphis, TN.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, analysis based upon Downbound Grain Barge Rates (12/01/23), Latest Supply Chain Indicators, available at http://www.bts.gov as of December 2023.

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 non-self-propelled fleets is notable (Figure 1-25), with just under 60 percent of the self-propelled fleet over 25 years of age, while 27 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.

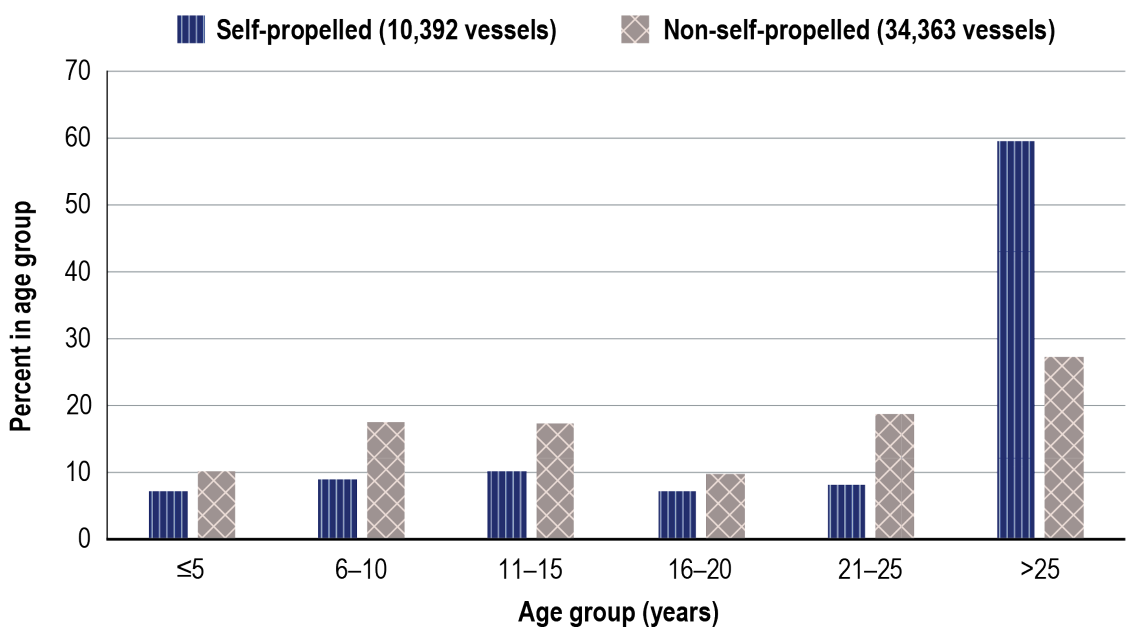
Ferries

Based on those ferry operations that responded to the biennial National Census of Ferry Operators (NCFO) in 2020 [USDOT BTS 2020], a reported total of 112.1 million passengers and 26.3 million vehicles were transported by ferry in 2019. 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) (Figure 1-26). 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

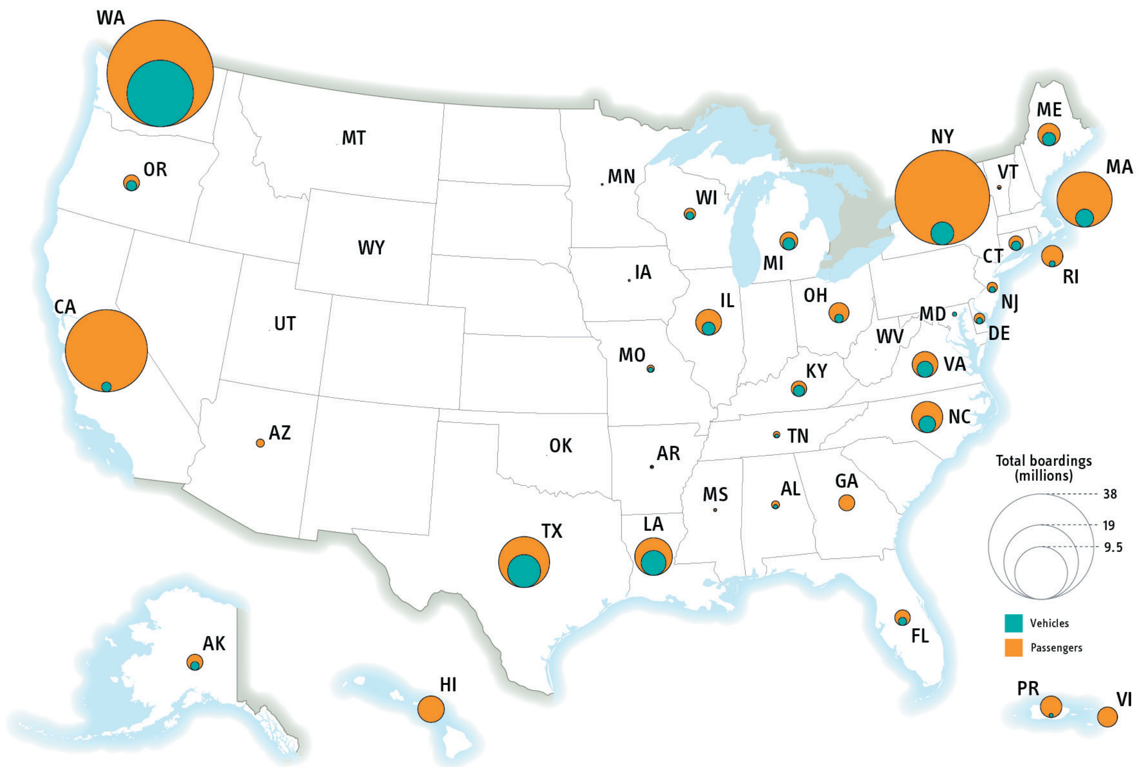
[28] Self-propelled vessels include dry cargo, tanker, and offshore supply vessels, ferries, and tugboats and towboats. Non-self-propelled vessels primarily include barges.

Figure 1-25 Number of U.S.-Flagged Vessels by Age Group and Propelled Type: 2021



SOURCE: U.S. Army Corps of Engineers. Waterborne Transportation Lines of the United States, Volumes 1 through 3 consolidated, Table 4, U.S. Flagged Vessels by Type and Age, table 4, available at https://www.iwr.usace.army.mil/About/Technical-Centers/WCSC-Waterborne-Commerce-Statistics-Center-2/WCSC-Vessel-Characteristics/ as of August 2023.

Figure 1-26 Ferry Passenger and Vehicle Boardings: 2019



NOTE: Boarding counts may be suppressed due to the data being considered proprietary by some ferry operators.

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 2023.

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

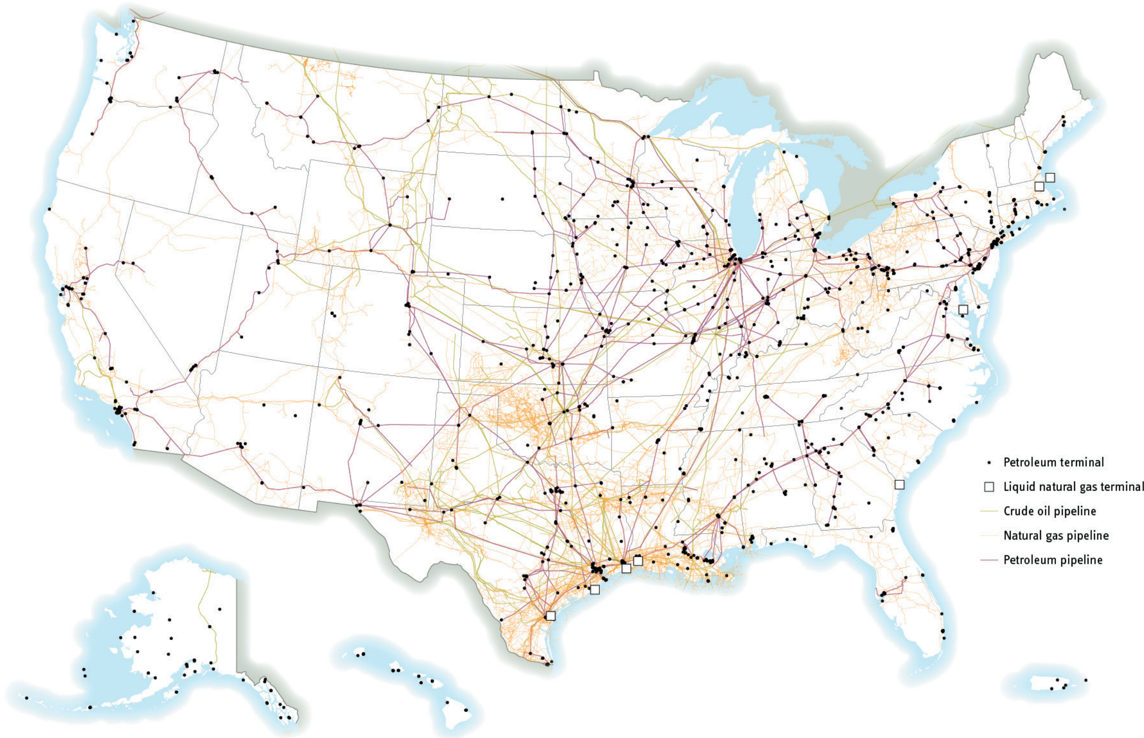
The U.S. natural gas terminal and pipeline system extends across the lower 48 states, with higher concentrations in Louisiana, Oklahoma, Texas, and the Appalachia region (Figure 1-27). In 2022 natural gas was transported via about 412,000 miles of gathering[29] and transmission[30] pipelines and over 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].

[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 1-27 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 November 2023.

Petroleum terminals and crude oil and petroleum pipelines form a system that transports crude and refined petroleum to markets across the country (Figure 1-27). 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 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 3.4 billion barrels in 2021 [USDOT BTS 2022b].

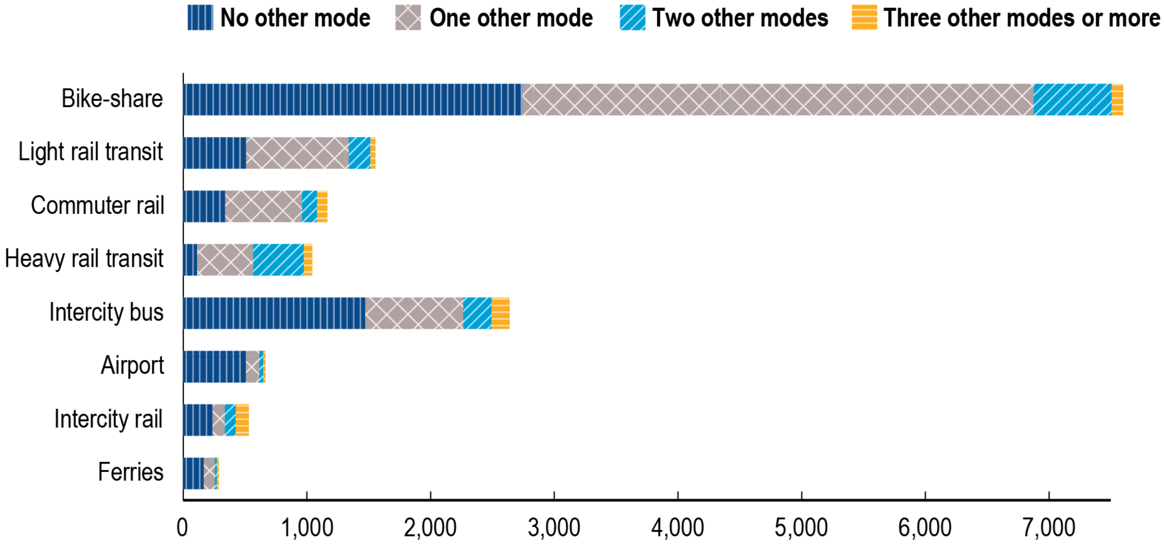
Passenger Intermodal Facilities

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

[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.

Figure 1-28 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 2023.

1,043 facilities), commuter rail (71 percent of 1,167 facilities), and light rail transit (67 percent of 1,554 facilities) (Figure 1-28). 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).

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, to assist drivers and help improve highway safety. These technologies are steps in the direction of fully autonomous vehicles. The 2022 TSAR (https://www.bts.gov/tsar) provides a detailed discussion of autonomous vehicle development.

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 2023]. Analysis of the Disengagement Report for 2022 shows that 24 companies doing autonomous vehicle testing in California operated their test vehicles for a total of 5,964,804 miles in autonomous mode and encountered 8,216 disengagements, resulting in a mean distance of about 726 miles between disengagements [HERGER 2023]. This is a remarkable improvement over the average of 14 miles experienced in 2018. The better performing AVs did markedly better than average

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

in 2022. The top five performing companies' vehicles all drove at least 19,000 miles between disengagements and the top performer almost 96,000 miles.

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 2021]. 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].

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 2023 there were 863,728 drones registered with the FAA, and 331,573 remote pilots have been certified. While 58.7 percent of the registered drones are for recreational use, the remaining 41.3 percent are dispatched for commercial tasks. Typical applications are for agriculture, forestry, mining, construction, and land management [USDOT FAA 2023].

System Resiliency

Eighteen Natural Disasters of a Billion Dollars or More Occurred in 2022

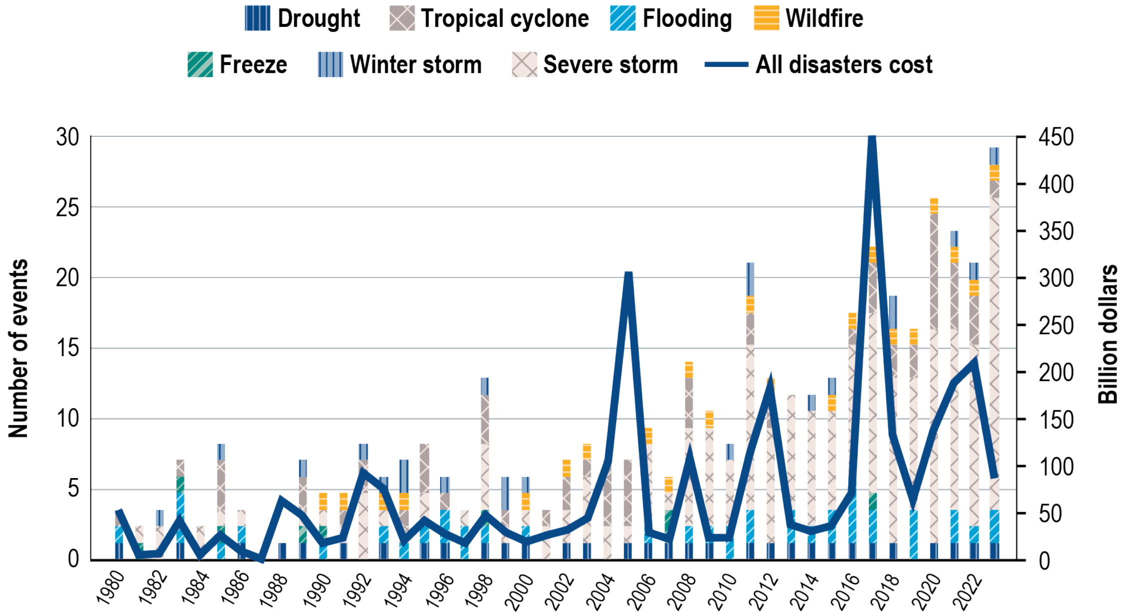
The U.S. Department of Commerce (USDOC), National Oceanic and Atmospheric Administration (NOAA) tracks weather and climate disasters, including hurricanes, tornadoes, floods, droughts, and wildfires where overall damages reached or exceeded $1 billion. In 2022 there were 18 weather and climate disaster events with losses exceeding $1 billion each across the United States. These events included 3 tropical cyclones, 10 severe weather or hail events, 2 tornado outbreaks, and 1 each related to drought, flooding, and wildfires [USDOC NOAA 2023a]. The 18 events cost the Nation a combined $165 billion in damages. In the first eight months of 2023 there 23 such events, with an aggregate cost approaching $74 billion. As shown in Figure 1-29, over the past two decades the number and severity of these disasters have been increasing at an accelerating rate, driven largely by the marked increase in the annual number of severe storms [USDOC NOAA 2023b]. Part of the physical recovery costs and overall economic impact were due to damage and disruption of the transportation system.

Hurricane Ian was the costliest disaster ($113 billion) in 2022. It made landfall in southwest Florida as a strong Category 4 hurricane on September 28, resulting in major flooding and damage [USDOC NOAA 2022]. 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.

While hurricanes brought disruption from too much water, drought has left the lower Mississippi River with too little water for normal

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

Figure 1-29 U.S. Billion-Dollar Disaster Events: 1980–2023



SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, U.S. Billion-Dollar Weather and Climate Disasters (2023). Available at https://www.ncei.noaa.gov/access/billions/ as of December 2023.

navigation in both 2022 and 2023. 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. Low water also restricts the loads each barge can carry, and the narrower channel restricts the number of barges in a single tow. These restrictions affect the ability to transport cereal grain and other bulk products by water from the Midwest to ports along the Gulf coast. As a result, downbound grain barge shipping rates on the Mississippi River increase drastically during these low water conditions. In the Fall of 2022 these rates were more than double the peak rate in 2021 [USDOT BTS 2022a]. Shipments through the Panama Canal have also been affected by reduced water depths, with resultant impacts on U.S. ports and international waterborne commerce. The section above on Waterway Condition and Performance, and also Chapter 3 Freight and Supply Chain, have detailed discussions of these drought issues and impacts.

Cybersecurity

Vulnerabilities Exist 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 previously

Cybersecurity plays an integral and growing role in our transportation system, from our sensors and controls that operate the system, to energy access powering vehicles and infrastructure, and the IT needed for day-to-day office operations of our organizations. Cyber incidents pose a variety of threats to transportation systems. Cyber vulnerabilities have been documented in multimodal operational systems, control centers, signaling and telecommunications networks, draw bridge operations, transit and rail operations, pipelines and other existing and emerging technologies.

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

Emerging Issues: Recovery from the COVID-19 Pandemic

The overriding issue affecting the U.S. transportation system is how traffic levels and the resulting system revenue and expenditures are recovering from the COVID-19 Pandemic that began in 2020. The recovery varies significantly by transportation mode, as summarized herein:

- **Highways:** Vehicle-miles traveled (VMT) in 2020 decreased 11 percent from 2019 to a level last seen in 2003. VMT rebounded in 2021 to nearly two-thirds of the pre-pandemic level. Reduced highway travel also meant reduced urban congestion levels, but the rebound in VMT has congestion indicators trending back up to their former high levels.
- **Public Transit:** The COVID-19 pandemic caused transit ridership to drop to 4.5 billion trips in 2020, a 45 percent reduction. While

Box 1-A Transportation Vulnerability and Resilience Data Program

The Transportation Vulnerability and Resilience Data Program (TVRDP) is a new BTS initiative to provide access to data and analyses tools necessary to measure the vulnerability of the transportation system to and the ability to recover from direct and indirect disruptions caused by natural, manufactured, and cyber events. TVRDP aims to address cyber resilience and vulnerability in the nation's multimodal transportation system and explore possible contours of a national cyber transportation statistics program designed to provide data and tools necessary to:

- Identify systemic cyber risk assessment, build cyber threat resilience, and enhance capabilities to recover from cyber attacks and prevent/reduce future cyber threat impacts for national multimodal transportation system.
- Identify the transportation system cyber requirements to perform cyber vulnerabilities and implement related resilience measures.
- Build cyber resilience and reduce systemic cyber risk to nations transportation system.
- Develop a gateway framework within TVRDP capable to provide various data collection, analysis, and response tools in one integrated system.

transit ridership is slowly increasing, it has yet to recover to pre-pandemic levels.

- **Aviation:** Total passenger enplanements at U.S. airports in 2020 were down 62 percent from 2019, to a level less than the total reported two decades earlier. Traffic rebounded in 2022 to about 89 percent of 2019's record-high enplanements and was on pace in 2023 to exceed that level. On the other hand, air freight increased 16.5 percent from 2019 to 2021.
- **Passenger Rail:** Amtrak suffered a 62 percent reduction in total ridership between 2019 and 2021, then recovered half the lost ridership during in FY 2022.
- **Freight Railroads:** In 2020 rail carloads were down 13 percent and total operating revenue dropped 11 percent, but U.S. rail intermodal was down only 2 percent. Rail traffic has since rebounded to near-normal levels.
- **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. By 2021 waterborne commerce had recovered to over 99 percent of the total in 2019.
- **Petroleum Pipelines:** Crude petroleum and products pipeline shipments were down 10 percent in the pandemic year of 2020 but rebounded in 2021 to 92 percent of the pre-pandemic levels.

A continuing issue has been finding sufficient resources to maintain highways and bridges in good condition. Presently about 10 percent of daily highway travel is on roads with a poor pavement condition rating, and the problem is most pronounced for principal highways that are not part of the National Highway System. About two-thirds of rough pavements are on roads owned by units of local government (counties, cities, and towns), which tend to have less maintenance funding available than do the states. Also, about 80 percent of deficient bridges are in rural areas.

A worrisome recent trend has been the occurrence of drought-induced low water levels on the Mississippi River and the Panama Canal in both 2022 and 2023, which have severely impacted waterborne freight shipments (refer to Chapter 3 Freight and Supply Chain for details).

Data Gaps

Needs for the Future

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

- 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.
- Dedicated infrastructure for bicycles and other forms of active transportation.

The Vehicle Inventory and Use Survey (VIUS), resumed in 2021 after a 2-decade absence, provides much needed data on the physical and operational characteristics of the Nation's population of trucks, pickups, vans, minivans, and SUVs, filling a longstanding data gap.

Expansion of the VIUS to automobiles and buses and a special VIUS targeted on the emerging population of electric vehicles will complete the picture.

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 homeowner 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). In addition, 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.

New Tools, Policies, and Approaches

Complete Streets is available through the Federal Highway Administration. The Smart Growth America National Complete Streets Coalition works to promote this new initiative. The FHWA site (https://highways.dot.gov/complete-streets) includes fundamental information and activities to advance Complete Streets.

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 2022 picture of passenger travel continues an uneven recovery from the 2019 peak and points to an uncertain future due to factors such as the enduring growth in working at home, changes in electronic communications, and population shifts. 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 curtailed their activities or shut down completely and households sheltered in place. Passenger travel rebounded somewhat in 2021 and into 2022, but the growth in work at home, labor force limits, and an increase in the retirement-age population contributed to substantial shifts in travel patterns

Highlights

- Dramatic changes affected passenger travel in the United States in 2020 and 2021 due to the sudden impact of COVID-19. Comparing pre-pandemic 2019 passenger travel levels with 2020–2022 levels reveal sharp losses with varying levels of recovery.
    - Highway travel was the first to recover, reaching 2019 levels by November of 2021 and staying around there in September 2022.
    - Air travel reached parity in early September of 2022 and long-distance rail a week later, both still with gaps.
    - Urban transit has not returned to pre-pandemic ridership, with levels about two-thirds 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. In 2022 it estimated that there were just below 31 million zero-worker households (23 percent of all households) housing about 46 million people—roughly 14 percent of the total U.S. population.
- Workforce, commuting behavior has changed significantly:
    - Working at home grew by 18.6 million workers in 2021, exceeded carpooling to become second to driving alone to access work. This phenomenon shifted back slightly in 2022, declining from 27.6 million in 2021 to 24.4 million in 2022—still about 15.4 million above 2019 levels. A significant pattern is that women now have greater shares working at home than men.
    - Driving alone to work, the most common way by far to commute, lost 14.5 million drivers in 2022 to levels not seen for decades. It recovered about 6 million drivers in 2022 but remained about 9 million below 2019.

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Highlights Continued

- Transit lost about 4 million of its 7.8 million riders, just about half of its ridership, and particularly commuter rail lost about two-thirds of its ridership in 2022. There has been overall recovery back to about 5 million riders, reaching almost two-thirds of 2019 levels. Long-distance commuter rail in 2022 is still at about half its 2019 level. Bus travel in 2022 is still down about 1.2 million and subway travel a million.
- Carpooling had lost only one percentage point in share in 2021 as some carpool members dropped out to work at home and has had a strange renaissance in 2022. it is almost at parity with 2019 but it continued to have major losses in two person pools but registered large gains above 2019 in 3-person pools and gains in 4–6 person pools, with only declines in large 7 or more person pools.

- 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.
- In 2022 domestic air travel reached 92 percent of 2019 levels while international air travel reached 77 percent—roughly 90 percent of 2019 overall. Significantly, both Hispanic and African American populations substantially exceeded 2019 air-travel levels, and Asians spent almost double the average spending of the total population in 2022.
- Amtrak also reached its peak year for passengers in 2019. By the corporation's 2022 fiscal year, Amtrak served 23 million passengers, an improvement of more than 12 million over fiscal year 2021.
- In 2021, despite declines, 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. In 2022 U.S. visitor arrivals reached 50.9 million, a 128 percent increase from 22.3 million in 2021, but still down 36 percent from 79.4 million in 2019.
- As in so many cases in the COVID-19 period, transportation spending registered a sharp drop by consumers from the pre-pandemic baseline year of 2019 to the COVID-19 year of 2020, followed by partial recovery in 2021 and 2022. 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 and reached close to parity with 2019 in 2022.
- On a per-vehicle or per-worker basis, transportation spending is similar for workers in different income quintiles, despite major differences in income.

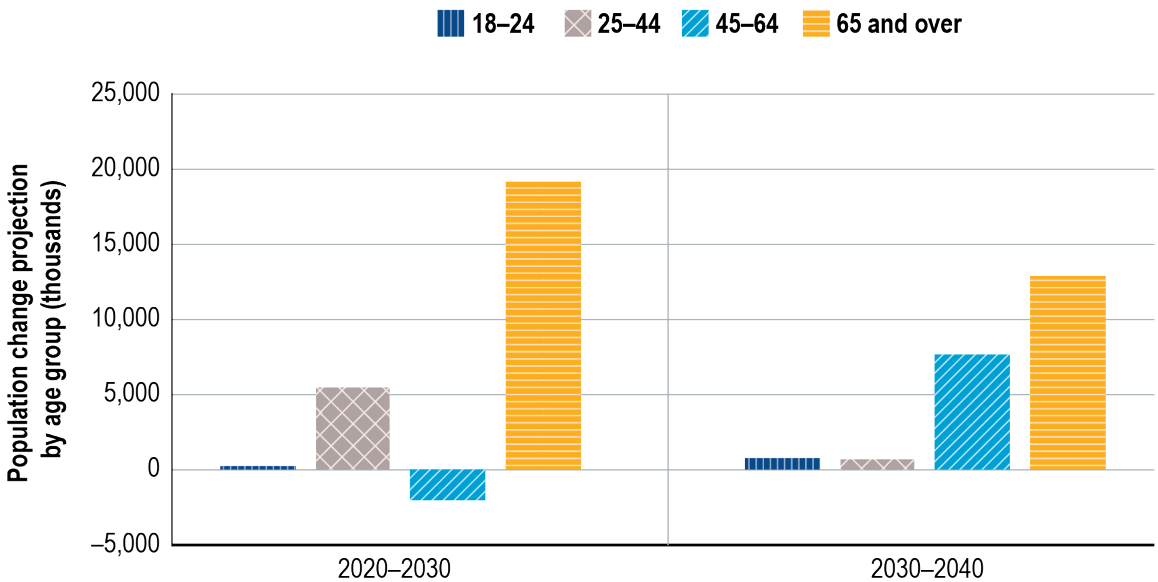
that will affect future passenger travel into the next decade.

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 to underserved communities that have been denied such treatment" [White House 2021]. Available statistics related to passenger travel provide a limited understanding of whether 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 U.S. population reached a third of a billion persons [USDOC CENSUS 2022]. As illustrated in Figure 2-1, the 2023 Census population projections updated from 2017 show that 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

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



SOURCE: U.S. Department of Commerce, Census Bureau, 2023 Projections, available at https://www.census.gov/data/tables/2023/demo/popproj/2017-summary-tables.html. Table 2 Projected age and sex composition of the population, as of November 2023.

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.

The Census Bureau's new projections estimate 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 as early as 2029 depending on immigration levels. 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.

The working-age population is the predominant generator of personal travel in our society, not just because of work trips but also because of the many 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 medical services, recreation, and family visits throughout the day. As a result, trip times and directions change.

Population changes and the consequences for travel are uneven 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). In 2022 the losses in the Northeast and Midwest declined but were still substantial. Declines in the West almost doubled from 145,000 in 2021 to 281,000 in 2022. All the gains therefore were in the South with increases rising from 658,000 to 705,000. One surprise, perhaps, is that the Midwest saw continuing reductions in migration losses throughout the period from about 208,000 in 2019–2020 to less than 100,000 in 2021–2022.

Population shifts from 2020 to 2021 indicated principal cities of metropolitan areas lost approximately 4.9 million persons, most of whom went to metro suburbs, while the remainder went to non-metro areas (Table 2-2). In 2021–2022, population losses in principal cities declined to about 4.7 million and suburbs gained about 4.9 million, but the gain was about 200,000 less than the previous year. A significant trend was that, instead of losses of about 200,000 in non-metropolitan areas in 2020–2021 the level of change was marginally positive, with about a million arrivals and departures, likely reflecting the effects of COVID-19 and work-at-home shifts.

Table 2-1 Net Domestic Migration by Region: 2019–2020, 2020–2021, and 2021–2022

Region	2019–2020	2020–2021	2021–2022	Numeric change, 2021–2022
Northeast	−315,166	−389,638	−325,193	64,445
Midwest	−207,685	−123,103	−98,293	24,810
South	503,502	657,682	704,711	47,029
West	19,349	−144,941	−281,225	−136,284

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

SOURCE: U.S. Census Bureau, S0702: Movers Between Regions, available at https://data.census.gov as of September 2023.

In 2021, the rural population experienced a natural population decrease (deaths exceeding births) in more than 73 percent of U.S. counties. This compares with 45.5 percent of all counties in 2019 and 55.5 percent in 2020.

The decline in natural population change reflects the overall birth rate in the 2010–2020 decade, which 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 2021]. The 2022 statistics indicate that the growth rate increased from a low in 2020–2021 to 0.4 in 2021–2022. All 50 states and the District of Columbia saw positive net international migration with an overall total of just above 1 million [USDOC Census 2022]. In combination, the low birth rate, high death rate, and in/out-migration, resulted in a population growth.

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. In the future, immigrant arrivals are projected to contribute more to population growth than natural population change. 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

Table 2-2 Population Shifts: 2020–2022 (Numbers in Thousands)

Outmigrants from	Domestic outmigrants	Domestic immigrants
Principal cities of metropolitan areas[1]	4,772	3,112
Balances of metropolitan areas[1]	3,293	4,935
Nonmetropolitan areas[1]	1,030	1,047

[1] Principal cities and balances are those within metropolitan areas. Metropolitan areas do not include Micropolitan Statistical Areas. Micropolitan Statistical Areas are included in non-metropolitan 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.

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, non-sampling error, and definitions are available at https://www.census.gov/programs-surveys/cps/technical-documentation/complete.html.

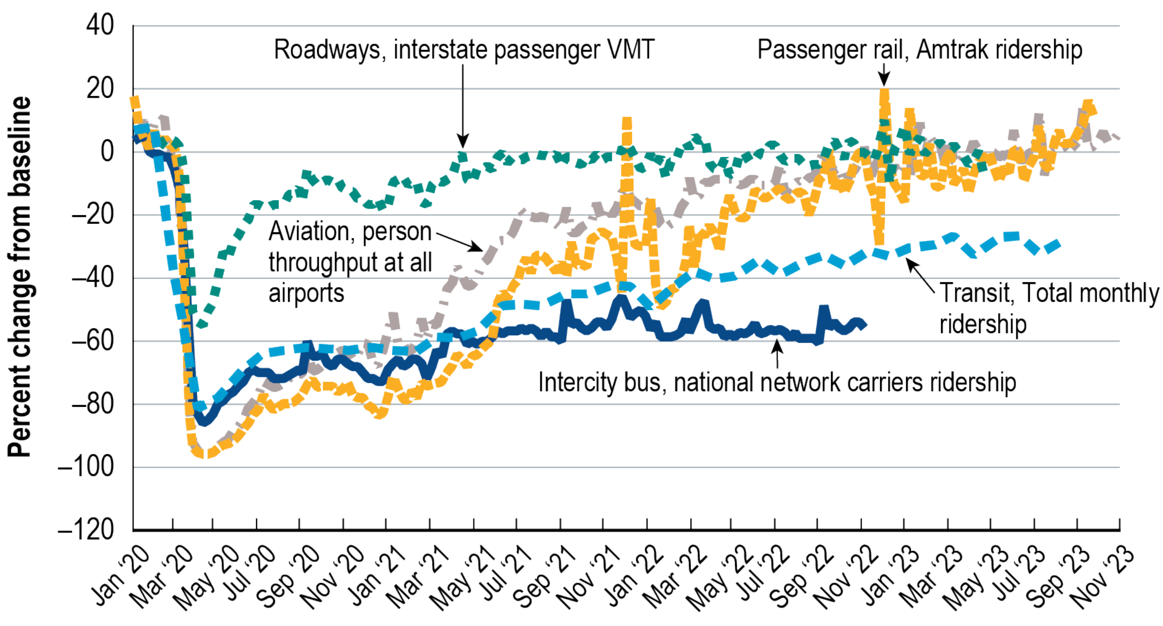
SOURCE: U.S. Census Bureau, Current Population Survey, 2022 Annual Social and Economic Supplement (CPS ASEC), Table A-3 available at https://www.census.gov/data/tables/time-series/demo/geographic-mobility/historic.html as of September 2023.

county. The percentages were similar in the 2020–2021 and 2021–2022 periods, suggesting that future growth for travel in most counties will be from visitation from outsiders or from people just passing through the county. The Census Bureau's 2023 main projection series has immigrant arrivals exceeding natural increase from 2023 onward. By 2038 natural change is expected to be net negative for the rest of the century.

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 via personal vehicles and commercial aviation. But other modes experienced a weaker recovery (especially transit and intercity bus). Even where passenger volumes are close to the 2019 "normal," the characteristics of these volumes have changed appreciably. Vehicle travel has shifted in terms of usage times and directions, and air travel has experienced an overall increase, although airlines report that most returning customers are primarily being driven by leisure, not business travelers who typically pay higher ticket prices [ING, Global aviation outlook]. The impacts of these pandemic-induced pattern shifts and substitutions of technological substitutes for face-to-face encounters go well beyond transportation, affecting downtown usage of offices and services, home arrangements and locations, and the use of technology and communications as substitutes for travel. Although the duration of these shifts

Figure 2-2 COVID-19 Passenger Impact: January 2020 to November 2023



KEY: VMT = vehicle-miles traveled.

NOTE: 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 2023 is uncertain, the slow return to pre-COVID 2019 levels of behavior suggests a substantial degree of permanency in these patterns.

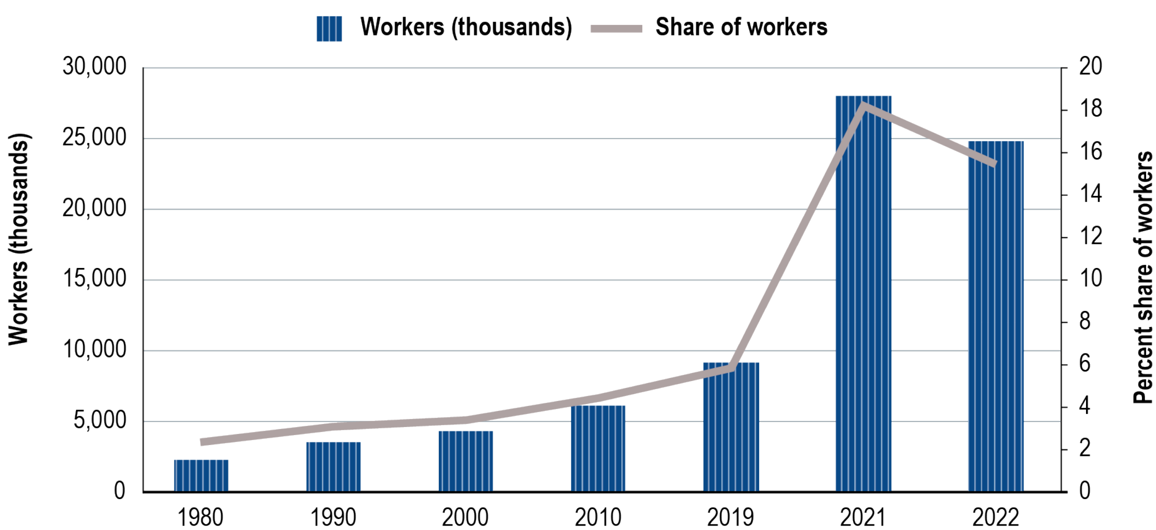
Changes in Local Commuting

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 commuting alone. In 2022 total work at home declined to about 24 million as its share slipped from 18 to just above 15 percent but still ranked second to driving alone, which gained 5 million, reaching 110 million. Driving alone was still short of the 2019 level of 119 million. (Table 2-3).

Table 2-3 provides a detailed mode choice tabulation for the pre-pandemic year 2019 and the second and third full pandemic years in 2021 and 2022, showing the values in numbers of commuters and the percentage modal share for each (given the COVID disruptions the American Community Survey (ACS) was not produced in 2020). The most immediate measure of change is in the final column, which shows the change in the number of commuters from 2019 to 2022. All the alternative modes decline substantially, drawn down by the switch of commuting to working at home.

The main finding here is that, after major losses in all commuting modes (outside of work at home) in 2021, some recovery can be observed in 2022. In 2021, working at home grew by 18.6 million, while driving alone lost 14.5 million drivers. Working at home has declined by 3.19 million in 2022, and driving alone has recovered somewhat but was still down about 9 million from the 2019 level. Carpooling lost one percentage point in share in 2021 and in 2022 recovered to slightly below 2019 levels. Of interest is that the two-person car-pools were still about a quarter million below the 2019 level, but larger carpools have gained and surpassed 2019 numbers, suggesting these

Figure 2-3 Long-Term Trend in Working at Home: 1980, 1990, 2000, 2010, 2019, 2021, and 2022



SOURCE: U.S. Department of Commerce, Census Bureau, Decennial Census 1980–2000 and 2010–2022 American Community Survey, Table S0801, available at https://data.census.gov/cedsci/ as of September 2023.

Table 2-3 Mode of Transportation to Work Change: 2019, 2021, and 2022

Mode of transportation	2019 (pre-pandemic) Count	2019 (pre-pandemic) Share (%)	2021 (1st pandemic year) Count	2021 (1st pandemic year) Share (%)	2022 (2nd pandemic year) Count	2022 (2nd pandemic year) Share (%)	Change from 2019 to 2022
TOTAL	**156,941,346**	**100.00**	**154,314,179**	**100.00**	**160,577,736**	**100.00**	**3,636,390**
Car, truck, or van	133,054,328	84.78	116,668,475	75.60	124,126,435	77.30	−8,927,893
Drove alone	119,153,349	75.92	104,650,121	67.82	110,245,368	68.66	−8,907,981
Carpooled	13,900,979	8.86	12,018,354	7.79	13,881,067	8.64	−19,912
In 2-person carpool	10,469,892	6.67	9,050,049	5.86	10,240,427	6.38	−229,465
In 3-person carpool	1,982,471	1.26	1,776,397	1.15	2,173,594	1.35	191,123
In 4-or-more-person carpool	765,777	0.49	683,451	0.44	835,092	0.52	69,315
Public transportation	7,778,444	4.96	3,793,329	2.46	5,013,135	3.12	−2,765,309
Bus	3,601,403	2.29	1,971,235	1.28	2,401,748	1.50	−1,199,655
Subway or elevated rail	2,935,633	1.87	1,400,185	0.91	1,952,645	1.22	−982,988
Long-distance train or commuter rail	921,391	0.59	294,566	0.19	466,508	0.29	−454,883
Light rail, streetcar, or trolley	242,776	0.15	82,915	0.05	129,309	0.08	−113,467
Ferryboat	77,241	0.05	44,428	0.03	62,925	0.04	−14,316
Taxicab	385,756	0.25	296,457	0.19	382,417	0.24	−3,339
Motorcycle	221,923	0.14	166,676	0.11	217,325	0.14	−4,598
Bicycle	805,722	0.51	616,153	0.40	731,272	0.46	−74,450
Walked	4,153,050	2.65	3,399,405	2.20	3,855,075	2.40	−297,975
Other means	1,571,323	1.00	1,805,586	1.17	1,870,345	1.16	299,022
Worked from home	8,970,800	5.72	27,568,098	17.86	24,381,732	15.18	15,410,932

NOTE: The survey was not conducted in 2020.

SOURCE: U.S. Department of Commerce, Census Bureau, 2019–2022 American Community Survey, Table B08301, available at https://data.census.gov/cedsci/ as of September 2023.

may be travelers shifting from transit or driving alone to pooling. At the same time, transit usage did recover somewhat. Transit lost about 4 million out of 7.8 million riders, totaling a shift of half of its ridership in 2021, regained about half that in 2022, but still fell 2.8 million passengers below 2019 ridership. Transit share of commuting in 2022 is just above 3 percent in contrast to almost 5 percent in 2019. The largest shift in share was long-distance commuter rail, which has recovered somewhat in 2022 but remains half the 2019 level. Bicycling remained below one-half percent in 2022. There is a continued small positive shift of about two-tenths of one percent in so-called Other Means of Transportation, which can include such things as e-scooters and personal boats but may include those who do not identify with the provided modes in the survey.

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 had a work trip under 20 minutes in 2021, dropping slightly to 41 percent in 2022. Adding those working at home to the group of workers with a commute under 20 minutes pushed the share under 20 minutes above 60 percent in 2021 and to just below 57 percent in 2022.

The data reported above are from the ACS, which from 1980 to 2020 had been the only source of such information as part of the decennial census surveys, but with the explosion in work at home activity, several statistical agencies undertook positive efforts to better understand the nature of the work at home phenomenon. Some valuable potential resources are the Continuing Population Survey (CPS), Annual Social and Economic Supplements, also a Census Bureau product. Given the way the question is framed different statistical numbers are generated. First, the newly minted term “telework” is employed along with the “work at home” term. The most significant change reflects the current recognition that we are now in a “hybrid” world where people spend a varying number of days working at home or in their usual workplace, given that, the CPS estimated that the total persons who worked at home in some capacity was about 27.5 million. Importantly, the detailed statistics obtained showed that about 11.5 million workers, 42 percent of workers, worked at home full time.

While the preference among transportation planners would be to obtain days-of-the-week information, the CPS’s powerful data set suggests that there are roughly equal levels of activity by 1 through 4 days a week. Experience in most major metropolitan areas indicates that the three mid-weekdays are predominant in travel. (Pew Research Center March 30, 2023, and subsequent studies).

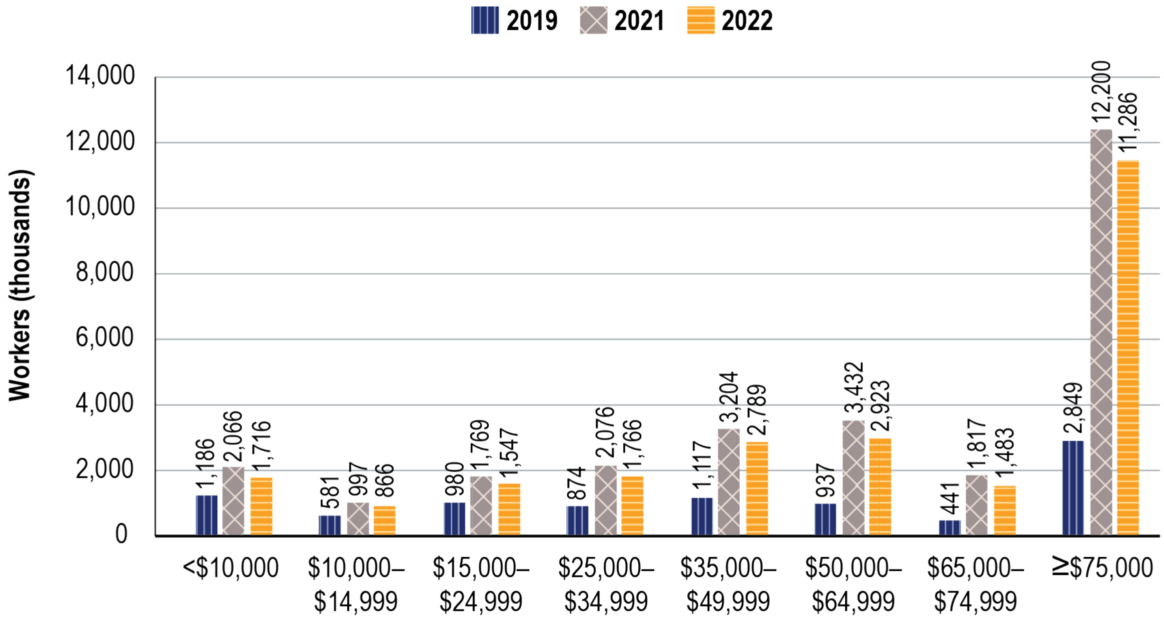
Working at home is one of the most dramatic changes in travel behavior since World War II. The dominant benefits are reduced commuting time and costs, reduced costs of office space for employers, and the broader availability of more effective electronic tools to support those who are able to perform their job without face-to-face relationships. While some people who work at home are in a lower income range, the main trend of office workers working from home, in the recent period has been among those in higher income brackets, which may have significant implications for travel patterns. (Figure 2-4).

ACS data support the recognition that the dominant factor in determining work at home tendencies is education and the nature of the work, with 75 percent of those working at home having at least a bachelor’s degree. Repercussions from the shift to working at home go beyond travel demand characteristics such as travel volumes and temporal and spatial distributions into broader influences on viability of certain businesses that serve commuters, office space needs, and home arrangements as well as a likely change in the times, directions, and modal choices of trips.

As Table 2-4 indicates, the percentage of those who work at home increased across the board into mid-year 2023, from 17.9 percent in October 2022 to 19.5 percent in August 2023. Most significant is that women are substantially more engaged in working at home at 21.6 percent in contrast to 17.7 percent for men, generating a national average of 19.5 percent.

As noted elsewhere, much of this measure among groups is correlated strongly to education level and the nature of the work. This is borne out in that Hispanics, with the lowest education levels of any group, had the lowest work at home rate just around 10 percent, African Americans at 15.4 percent were mid-way in education and working at home between the national average and the Hispanic rate, and notably Asians with the highest education levels working at the highest level at home at 31.2 percent, more than 10 percentage points above the national average.

Figure 2-4 Workers Working at Home by Income: 2019, 2021, and 2022



SOURCE: U.S. Department of Commerce, Census Bureau, 2019–2022 American Community Survey, Table B08119, available at https://data.census.gov/cedsci/ as of September 2023.

Table 2-4 Percentage of Work-at-Home Patterns by Gender, Race, and Ethnicity: October 2022 to August 2023

Month	Total	Men	Women	White	Black	Asian	Hispanic
Oct 22	17.9	16.5	19.4	17.6	13.8	29.8	9.0
Nov 22	18.5	17.2	20.1	18.4	14.2	29.8	9.5
Dec 22	19.0	17.8	20.3	18.8	14.6	30.9	10.2
Jan 23	19.4	18.2	20.8	19.2	14.4	32.0	11.1
Feb 23	20.0	18.7	21.3	19.7	16.3	31.4	11.3
Mar 23	19.5	17.9	21.4	19.1	16.1	32.2	11.2
Apr 23	18.5	16.7	20.6	18.2	14.9	30.0	9.9
May 23	18.9	17.3	20.8	18.9	14.5	28.7	9.9
Jun 23	19.0	17.2	21.0	18.8	14.7	30.4	9.5
Jul 23	19.9	17.8	22.5	19.7	15.9	30.7	10.2
Aug 23	19.5	17.7	21.6	19.3	15.4	31.2	9.9

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *The Economics Daily*, One out of five workers teleworked in August 2023. Data are from the CPS and are not seasonally adjusted. Available at https://www.bls.gov/cps/telework.htm#data as of September 2023.

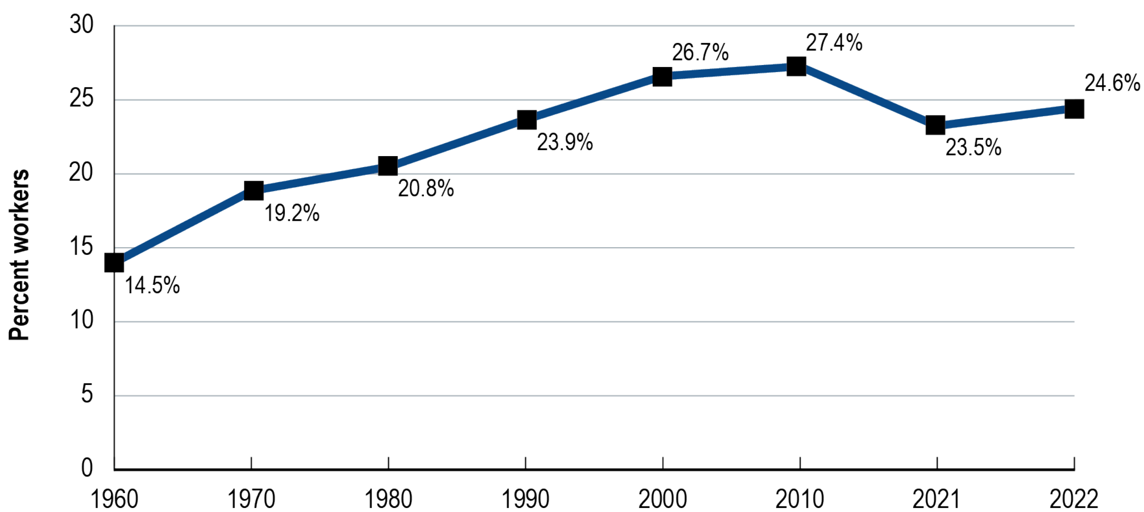
Figure 2-5 supports the observation that the growth in working at home is among longer distance commuters. The trend in an increasing share of workers leaving their home county to work reversed after six decades of growth in 2020–2021, falling to levels seen last in the 1990s, before climbing a single percentage point to 24.6 percent in 2022.

Changes in Intercity and International Travel

In 2019 the United States was on the verge of a major expansion in long-distance travel and tourism. (The World Tourism Organization of the United Nations defines tourism as typically involving an overnight stay but a stay less than a year's duration [UNWTO 2022]). 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 in its FY 2019, carrying a record 32.5 million passengers. 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.

Amtrak continued its recovery, rising to almost 23 million passengers in its FY 2022, an increase of almost double the FY 2021 level. However, it still was about 70 percent of its 2019 level. The recovery continued. Compared to Q3 of 2022, Amtrak saw its ridership increase by 18 percent in Q3 of 2023. Table 2-5 presents the air travel passenger trend for both domestic and international services for 2019 through 2022. By 2022 domestic travel was 92.5 percent of the 2019 level, and international travel was just

Figure 2-5 Percentage of Workers Leaving Their Home County to Work: 1960, 1970, 1980, 1990, 2000, 2010, 2021, and 2022



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 2023. U.S Department of Commerce, Census Bureau, 2010–2022 American Community Survey, Table B08007 and Table B08203, available at https://data.census.gov/cedsci as of September 2023.

Table 2-5 U.S. Air Travel Passenger Trends in the COVID-19 Period: 2019–2022

Year	Domestic	International	Total
2019 (pre-pandemic)	811,545,260	241,435,921	1,052,981,181
2020 (1st pandemic year)	335,607,840	63,047,151	398,654,991
2021 (2nd pandemic year)	605,935,323	94,624,181	700,559,504
2022 (3rd pandemic year)	750,535,394	186,751,556	937,286,950
2022 share of 2019	92.5%	77.4%	89.0%

SOURCE: Bureau of Transportation Statistics T-100 Market data.

at 77 percent of the 2019 volume. [BTS T-100 Market data].

The U.S. Travel Association (USTA) estimates that U.S. travel made a partial recovery in 2021, with domestic leisure travel spending exceeding the 2019 base year, but domestic business travel lagged badly at less than half of 2019 spending. The leisure spending trend in 2022 substantially exceeded 2019 spending, while domestic business travel still lagged 2019. The international inbound spending trend was still below 2019 spending. The USTA indicates that business travel and international travel are not expected to return to pre-pandemic levels until 2027 and 2025, respectively. [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 312 million recreation visits in 2022, up about 5 percent from 2021 after a 25.3 percent surge from 2020 levels when park facilities were closed for at least part of the year due to COVID-19 concerns [USNPS 2022]. The NPS indicates that visits are effectively back to pre-pandemic levels and only 6 percent below the all-time high year.

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 global cruise passengers. This level dramatically declined to 4.8 million in 2021 and had a significant recovery to 20.4 million in 2022 but was still below the pre-pandemic peak in 2019[CLIA 2023]. 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. The Cruise Line International Association's baseline forecast of 2023 expects passenger volumes to reach and exceed 2019 levels by the end of 2023 [CLIA 2023]. The North American cruise market is by far the world's largest with 3 of the top ten cruise ports in the world located in Florida.

International Travel

Major components of international travel to the United States are the land border crossings, many of which facilitate local trips made daily. This is distinguished from tourism stays that involve longer distances and usually overnight stays. The typically large number of pedestrians crossing into the United States from Mexico dropped substantially in 2020 but made a limited increase in 2021 with further gains in 2022 reaching 36 million contrasted to the nearly 50 million in 2019.

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. In October 2022, Canadian government removed the COVID-19 border and travel restrictions to the U.S. while the U.S. opened land border with Mexico on November 2021. Both recovered to the traditional range of 1.8 to 1.9 passengers per vehicle in 2022 (Table 2-6).

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 2-7). In effect, Canada had shut down foreign travel. This represents a decrease of about 87.8 percent from 2019 as international travel declined 75.8 percent from 2019 to 2020 but rose by 15.0 percent in 2021 and in 2022 rose substantially but still had reached only about 70 percent of 2019 levels.

Mexican travel to the United States was not as negative, jumping to four times as many visitors as Canada in 2021, ranking first in international visits to the United States that year but well below the historical trend. In 2022 Mexico had reached visitor levels of 70 percent of 2019 visits, similar to Canada. The top 10 international visitors to the United States from 2019 to 2022 by country of origin are ranked in Table 2-7. The changes from 2021 are substantial. Canada regained first place over Mexico. 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 and over 70 percent of the 2022 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 2022 the European countries regained their major positions in

Table 2-6 U.S. Border Land-Passenger Gateways Entering the U.S: 2019–2022

	Land Passengers						
Country by Year	Total	Personal vehicle passengers	Pedestrians	Bus passengers	Train passengers	Personal vehicles	Buses
2019							
Total	241,926	188,067	49,699	3,866	294	99,818	228
Mexico	188,229	136,890	49,176	2,153	10	73,085	152
Canada	53,697	51,177	523	1,713	285	26,733	77
2020							
Total	116,911	90,647	25,046	1,153	64	56,833	99
Mexico	106,589	80,591	24,999	992	7	50,605	90
Canada	10,322	10,056	48	161	57	6,229	10
2021							
Total	132,374	102,952	27,972	1,385	65	62,979	100
Mexico	125,864	96,562	27,935	1,350	17	58,548	96
Canada	6,510	6,389	37	35	47	4,431	4
2022							
Total	193,800	155,366	36,071	2,314	49	87,510	110
Mexico	166,184	128,472	35,887	1,822	3	73,245	86
Canada	27,617	26,894	184	492	46	14,265	25

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 2023.

Table 2-7 Top 10 International Visitors to the United States: 2019–2022 (Millions)

	2019		2020		2021		2022	
Rank	**Country**	**Arrivals**	**Country**	**Arrivals**	**Country**	**Arrivals**	**Country**	**Arrivals**
1	Canada	20.72	Mexico	6.81	Mexico	10.40	Canada	14.60
2	Mexico	18.33	Canada	4.81	Canada	2.53	Mexico	12.90
3	United Kingdom	4.78	United Kingdom	0.73	Colombia	1.06	United Kingdom	3.50
4	Japan	3.75	Japan	0.70	United Kingdom	0.46	Germany	1.50
5	China	2.83	South Korea	0.44	India	0.43	France	1.30
6	South Korea	2.30	Brazil	0.42	Ecuador	0.41	India	1.30
7	Brazil	2.10	China	0.38	Dominican Republic	0.41	Brazil	1.20
8	Germany	2.06	India	0.34	Peru	0.40	Columbia	0.90
9	France	1.84	France	0.30	Argentina	0.30	S. Korea	0.90
10	India	1.47	Germany	0.29	Guatemala	0.28	Spain	0.80
	All countries	**79.44**	**All countries**	**19.21**	**All countries**	**22.10**	**All countries**	**51.80**

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 2023.

visitations, whereas one of the main Asian nations, Korea, dropped from fifth to ninth. China dropped out of the top 10 list.

In comparison, there were 4 Asian countries among the top 10 international visitors to the United States in 2019–2022.

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 2023].

Completing the picture of U.S. world tourism, the United Nations' World Tourism Organization (UNWTO) put 2022 levels of international travel down almost 34 percent from 2019. UNWTO 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]. The NTTO indicated for 2022 that the United States had 5.5 percent of world travel with U.S. tourism receipts, or spendings in the U.S. by foreign visitors, at 164.5 billion in 2022, first in the world and an 11 percent share of all the travel spending by visitors in the world. In 2022 the United States reached third in world arrivals [UNWTO 2022]. Despite those losses, the United States still led the world in tourism receipts but compared to most other major tourism destinations had regained income at a slower rate compared to 2019 levels at about two-thirds of the 2019 level.

The NTTO identified the trends in both arrivals of international visitors and outbound travel by U.S. citizens (Table 2-8). The values indicate only slight increases in 2021 from the substantial declines registered in 2020. In 2021 arrivals rebounded by 15.0 percent, from about 19.2 million in 2020 to 22.1 million and rose to

Table 2-8 International Inbound and Outbound Travel: 2019–2022 (Millions)

	Passengers				Percent change from 2019		
Inbound/outbound	2019	2020	2021	2022	2020	2021	2022
Arrivals	79.44	19.21	22.10	50.90	−75.8%	−72.2%	−35.9%
Outbound	99.27	33.16	49.10	80.70	−66.6%	−50.5%	−18.7%

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 2023.

almost 51 million visitors in 2022 but remained 36 percent below 2019 levels. Similarly, departures by U.S. citizens in 2022 rose by 66 percent to 81 million departures but still down 19 percent from the 2019 level of 99 million.

Equity Aspects of Local and Long-Distance Travel

National statistics on the equity aspects of travel by socioeconomic groups are limited at this time. It is therefore particularly worth highlighting the latest BTS data on the access of rural populations to intercity transportation services. The new data measures the rural population at the county level in terms of the population's access within either:

- 75 miles of a major intercity airport with scheduled service.
- 25 miles of any other airport with scheduled service, intercity bus stops or intercity rail stations.

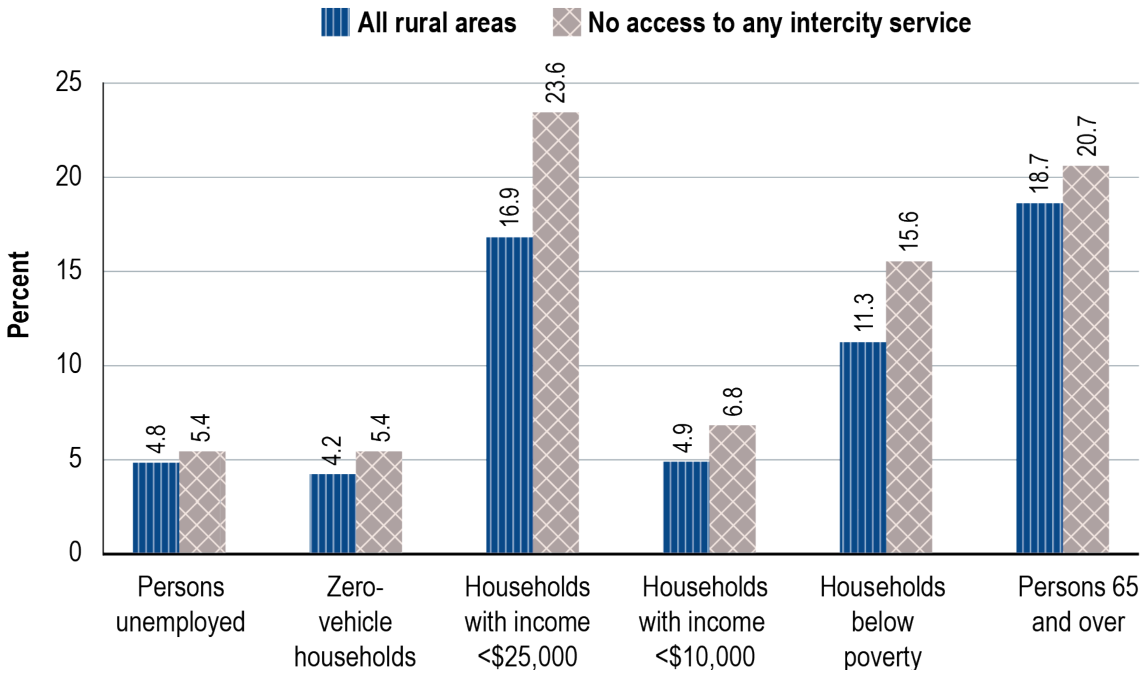
The BTS study shows that the percent of the nation's population with intercity access rose from 87 percent in 2006 to 89 percent in 2018 and then fell to 85 percent in 2021. This is attributable to the increase and then decline of scheduled intercity bus services. That decline caused the share of the rural population with no access to rise to 15 percent in 2021. This can be a function of changes in service delivery or shifts in the rural population locations. The percentage of the rural population without access to air or rail services was effectively unchanged, leaving intercity bus services as the key driving factor for the overall decline in the rural access (refer to Figure 2-6 [USDOT BTS 2023]).

The remainder of this section relies on more traditional data sources. The ACS, which provides data on vehicle availability and commuting behavior by racial, ethnic, and income groups, and data from the Consumer Expenditure Survey reports transportation spending by consumers in those groups. The American Time Use Survey addresses time use in work, leisure, etc. The Census and Bureau of Labor Statistics (BLS) data can 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, pushing the limits of statistical reliability. Other surveys conducted at the federal level often provide extensive information on racial and ethnic groups but with limited or no transportation linkages.

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 2-7 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 at least one percentage point per decade) and

Figure 2-6 Demographic of Rural Population and Characteristics of Rural Areas: 2021



NOTE: All rural areas include areas with and without access.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Access to Intercity Transportation database, available at https://data.bts.gov/stories/s/Rural-Access-to-Intercity-Transportation/gr9y-9gjq/.

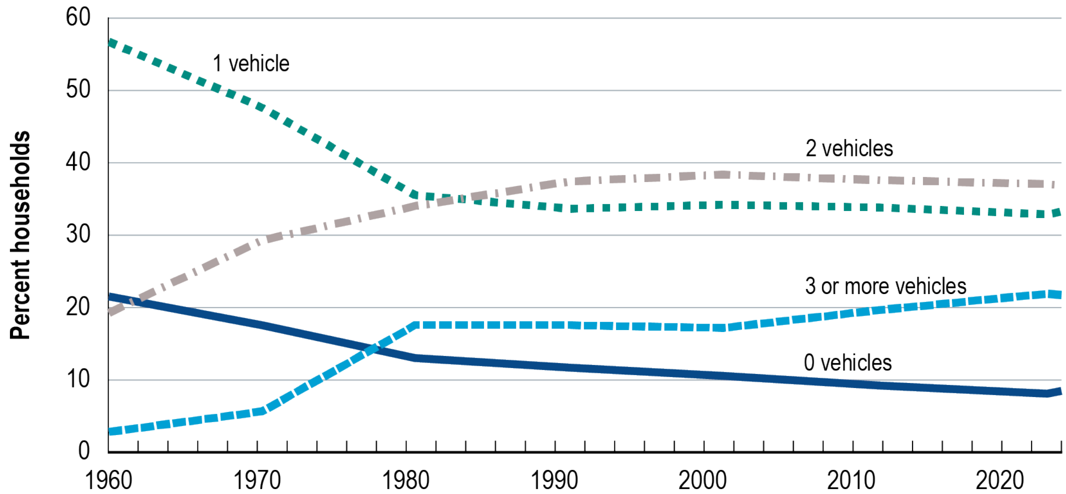
considerable growth in three or more vehicle households.

More than half of the households with no vehicle are also households with no workers (Figure 2-8). 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. Overall, the availability of vehicles to workers has diminished slightly in all worker levels in 2022 compared to 2021. For example, 3 or more households without a vehicle rose from 2.5 percent in 2021 to 2.9 percent in 2022.

Figure 2-9 documents vehicle availability trends for the two largest racial and ethnic groups. Vehicle availability has been increasing among the major minority households, with Hispanics closing on the national average. However, 2022 witnessed some relatively minor changes with the national average for zero-vehicle households rising to 8.3 percent from 8.0 percent, with African American units showing a slight increase and Hispanic units a slight decrease.

Commuting by the largest racial and ethnic groups is illustrated in Table 2-9 and Table 2-10. Percentages of African Americans and Hispanics who drive alone closely matched the total population in 2021. In 2022, the African American population and the total population registered 0.3 percent increases in driving alone, whereas the Hispanic population remained effectively unchanged. While Hispanics typically have a higher share of carpooling, they saw a significant increase above the pre-COVID levels. There were small increases in transit usage above 2021 but still dramatically below 2019 pre-COVID patterns. Both African Americans and Hispanics continue to have a higher percentage of transit use to work while still not approaching

Figure 2-7 Share of Households by Vehicles Available: 1960–2022



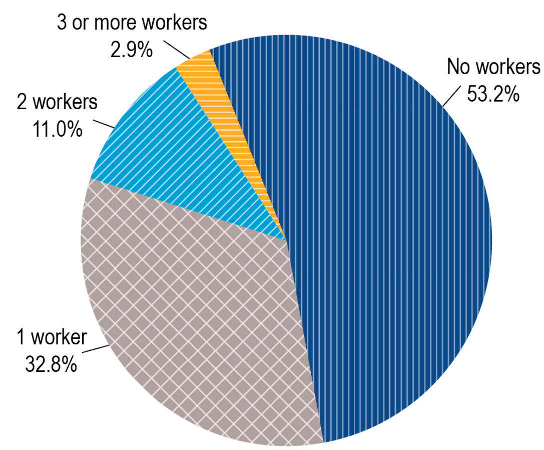
No. of vehicles owned	1960	1970	1980	1990	2000	2010	2021	2022
0 vehicles	21.5%	17.5%	12.9%	11.5%	10.3%	9.1%	8.0%	8.3%
1 vehicle	57.0%	47.7%	35.5%	33.7%	34.2%	33.8%	32.9%	33.2%
2 vehicles	19.1%	29.3%	34.0%	37.4%	38.4%	37.6%	37.1%	36.9%
3 or more vehicles	2.5%	5.5%	17.5%	17.4%	17.1%	19.5%	21.9%	21.6%

SOURCE: U.S. Department of Commerce, Census Bureau, Decennial Census 1960–2000 and 2010–2022 American Community Survey, Table DP04, available at https://data.census.gov/cedsci/ as of September 2023.

2019 levels. A lower percentage of Hispanics or African Americans work at home than the overall population. In work at home, there were strong shifts in 2022 back away from the 2021 peaks. The overall national share of work at home was down from 17.9 percent in 2021 to 15.2 percent in 2022. The sharpest reduction was among Asians, down from 27.5 to 21.8 percent.

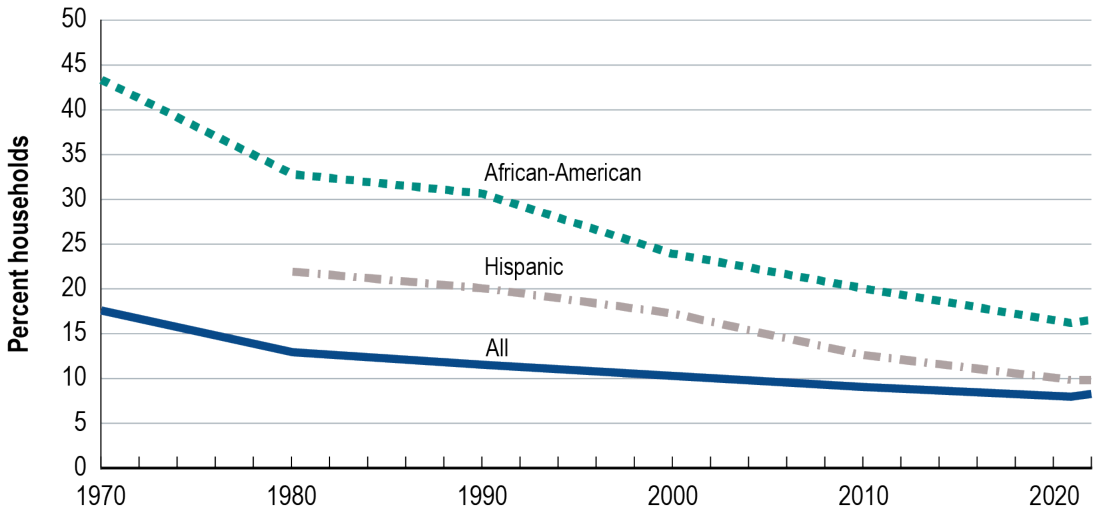
Asian-Americans exhibit some exceptional characteristics. They have the lowest drive-alone share, despite their high incomes, and had a transit use share second to African Americans. Their walk to work share was greater than all other groups and they have a substantially higher percentage of working at home than other minorities and exceed the general population at 21.8 percent.

Figure 2-8 Workers in Households Without Vehicles by Number of Workers: 2022



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 2-9 Long-Term Trend in Zero-Vehicle Households: 1970, 1980, 1990, 2000, 2010, 2021, and 2022



Type of household	1970	1980	1990	2000	2010	2021	2022
All	17.5%	12.9	11.5	10.3	9.1	8.0	8.3%
African-American	43.1%	32.6	30.5	23.8	20.0	16.1	16.4%
Hispanic	NA	21.8	20.0	17.2	12.6	9.9	9.8%

KEY: NA = not applicable.

SOURCE: U.S. Department of Commerce, Census Bureau, Decennial Census 1970–2000 and 2010–2022 American Community Survey, Table S0201, available at https://data.census.gov/cedsci/ as of September 2023.

Table 2-9 Comparisons of Major Racial and Ethnic Groups Using Traditional Major Modes: 2000, 2010, 2019, 2021, and 2022

Major mode and group	2000 (%)	2010 (%)	2019 (%)	2021 (%)	2022 (%)
Drove alone					
Hispanic	60.6	67.8	71.6	66.8	66.7
African-American	67.0	72.0	72.9	66.5	67.2
Total population	75.7	76.5	75.9	67.8	68.7
Carpool					
Hispanic	22.7	16.0	13.2	12.9	13.8
African-American	16.0	10.0	8.9	7.9	8.7
Total population	12.2	9.7	8.9	7.8	8.6
Transit					
Hispanic	8.6	7.8	6.3	3.9	4.5
African-American	12.0	10.9	9.6	5.7	6.3
Total population	4.6	4.9	4.9	2.5	3.1

SOURCE: U.S. Department of Commerce, Census Bureau, Decennial Census 2000 and 2010–2022 American Community Survey, Table S0802, available at https://data.census.gov/cedsci/ as of September 2023.

Commuting data reveal gender differences that may reflect varying aspects of labor force participation more than equity aspects of transportation. The differences in mode choice are small and shrinking (Table 2-11), with only relatively small changes over time. There was a significant strengthening on all sides in carpooling, rising from 7.8 percent in 2021 to 8.6 percent in 2022—trending toward pre-COVID levels. Notably, women gained in the larger carpools, traditionally a function of the job categories characteristic of men. A small loss was in bicycling where female shares declined further. As expected, Working at Home declined somewhat leaving the extreme levels of 2021 from about 18 percent to just above 15 percent. Most significantly, women have a substantially greater share than men.

With the significant declines in drivers in 2020 and 2021 and the slow movement back toward the 2019 "normal," travel times changed as

Table 2-10 Non-Motorized Commuting: 2022

Commute	All	Black or African-American	Hispanic or Latino	Asian alone
Walked	2.4%	2.2%	2.4%	3.3%
Other non-motorized means	2.0%	2.6%	2.5%	2.2%
Worked from home	15.2%	12.9%	10.1%	21.8%
Mean travel time to work (minutes)	26.4	27.2	27.7	27.1

SOURCE: U.S. Department of Commerce, Census Bureau, 2022 American Community Survey, Table S0201, available at https://data.census.gov/cedsci/ as of September 2023.

Table 2-11 Means of Transportation to Work by Gender: 2021 and 2022

	All		Male		Female		F/M Ratio	
Tansportation	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Workers 16 years and over	154,314,179	160,577,736	81,813,405	85,362,714	72,500,774	75,215,022	88.6%	88.1%
Car, truck, or van	75.6%	77.3%	76.9%	78.5%	74.1%	75.9%	96.4%	96.7%
Drove alone	67.8%	68.7%	69.4%	70.2%	66.0%	66.9%	95.1%	95.3%
Carpooled	7.8%	8.6%	7.5%	8.3%	8.1%	9.0%	108.0%	108.4%
In 2-person carpool	5.9%	6.4%	5.7%	6.1%	6.1%	6.7%	107.0%	109.8%
In 3-person carpool	1.2%	1.4%	1.1%	1.3%	1.2%	1.4%	109.1%	107.7%
In 4-person carpool	0.8%	0.9%	0.8%	0.9%	0.7%	0.9%	87.5%	100.0%
Public transportation (excluding taxicab)	1.06%	3.1%	106.0%	2.9%	106.0%	3.3%	100.0%	113.8%
Walked	2.5%	2.4%	2.3%	2.4%	2.6%	2.4%	113.0%	100.0%
Bicycle	0.4%	0.5%	2.2%	0.6%	2.2%	0.3%	100.0%	50.0%
Taxicab, motorcycle, other means	1.5%	1.5%	0.5%	1.6%	0.3%	1.4%	60.0%	87.5%
Worked from home	17.9%	15.2%	16.4%	13.9%	19.5%	16.7%	118.9%	120.1%

SOURCES: U.S. Department of Commerce, Census Bureau, 2021 American Community Survey, Table S0801, available at https://data.census.gov/cedsci/ as of September 2022. U.S. Department of Commerce, Census Bureau, 2022 American Community Survey, Table S0801, available at https://data.census.gov/cedsci/ as of September 2023.

expected—strong gains from 2019 to 2021 in those reaching work in under 20 minutes and strong declines in work trips over 60 minutes. 2022 saw the trends slide back toward the 2019 "normal." The over 60 minutes traveler's category in 2019 was reduced by about 2 percentage points in 2021 and regained half of that in 2022. A similar pattern is visible in the under 20 minutes category (Table 2-12).

There was effectively no change in start times over the three observation periods or between men and women. This broad characterization of the start times is determined more by the nature of work in occupations and industries, rather than any potential preferences people might have.

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, such as construction sites or working in factories and refineries. 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, likely reflecting the probable desire to work at home among long-distance commuters having an effect on travel time.

Table 2-12 Travel Time to Work by Gender: 2019, 2021, and 2022

Travel time	All	Male	Female
Travel time to work (minutes)			
2022	26.4	28.0	24.5
2021	25.6	27.3	23.7
2019	27.6	29.1	25.8
Overall travel time			
2022			
Under 20 minutes	41.3%	38.6%	44.7%
Over 60 minutes	8.5%	10.1%	6,7%
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			
2022			
Before 7 AM	32.3%	38.1%	25.6%
After 7 AM	67.6%	61.8%	74.3%
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%

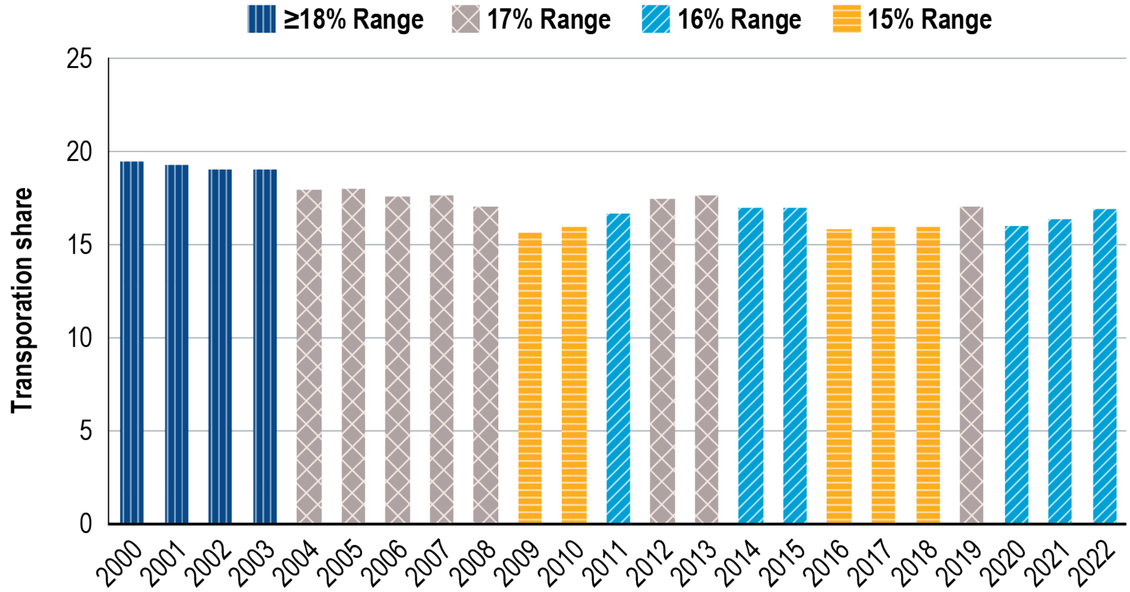
SOURCE: U.S Department of Commerce, Census Bureau, 2019–2022 American Community Survey, Table S0801, available at https:// data.census.gov/cedsci as of September 2023.

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 prerequisite to understanding racial and ethnic differences in consumer spending.

Figure 2-10 presents the broadest view of transportation spending expressed as the transportation share of consumer spending in this century. Early in this century the transportation share of consumer spending was in the 18–19 percent range. The share declined to the 17 percent range in 2022, slightly surpassing 2019 in spending level (Table 2-13). Changes in other spending choices, such as housing, can affect the transportation share. It is important to recognize that transportation spending does not include travel spending paid for by an employer or by any source outside the household, which clearly also dropped appreciably in the 2020–2022 COVID-19 period.

Figure 2-10 Transportation Share of Consumer Spending: 2000–2022 (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 October 2023.

Table 2-13 Selected COVID-19 Related Trends in Overall Spending (Spending per Consumer Unit): 2019–2022

					Percent change	
Expenditure type	**2019**	**2020**	**2021**	**2022**	**2021–2022**	**2019–2022**
Average annual expenditures	**$63,063**	**$61,332**	**$66,928**	**$72,967**	**9.02%**	**15.70%**
Food	$8,169	$7,310	$8,289	$9,343	12.72%	14.37%
Food at home	$4,643	$4,935	$5,259	$5,703	8.44%	22.83%
Food away from	$3,526	$2,375	$3,030	$3,639	20.10%	3.20%
Housing	$20,679	$21,417	$22,624	$24,298	7.40%	17.50%
Apparel	$1,883	$1,434	$1,754	$1,945	10.89%	3.29%
Transportation	$10,742	$9,826	$10,961	$12,295	12.17%	14.46%
Vehicle purchases	$4,394	$4,523	$4,828	$4,496	−6.88%	2.32%
Gasoline other fuels	$2,094	$1,568	$2,148	$3,120	45.25%	49.00%
Purchased transportation	$781	$263	$452	$845	86.95%	8.19%
Healthcare	$5,193	$5,177	$5,452	$5,850	7.30%	12.65%
Entertainment	$3,090	$2,909	$3,568	$3,458	−3.08%	11.91%
Education	$1,443	$1,271	$1,226	$1,335	8.89%	−7.48%

NOTES: All values are in current dollars and 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.

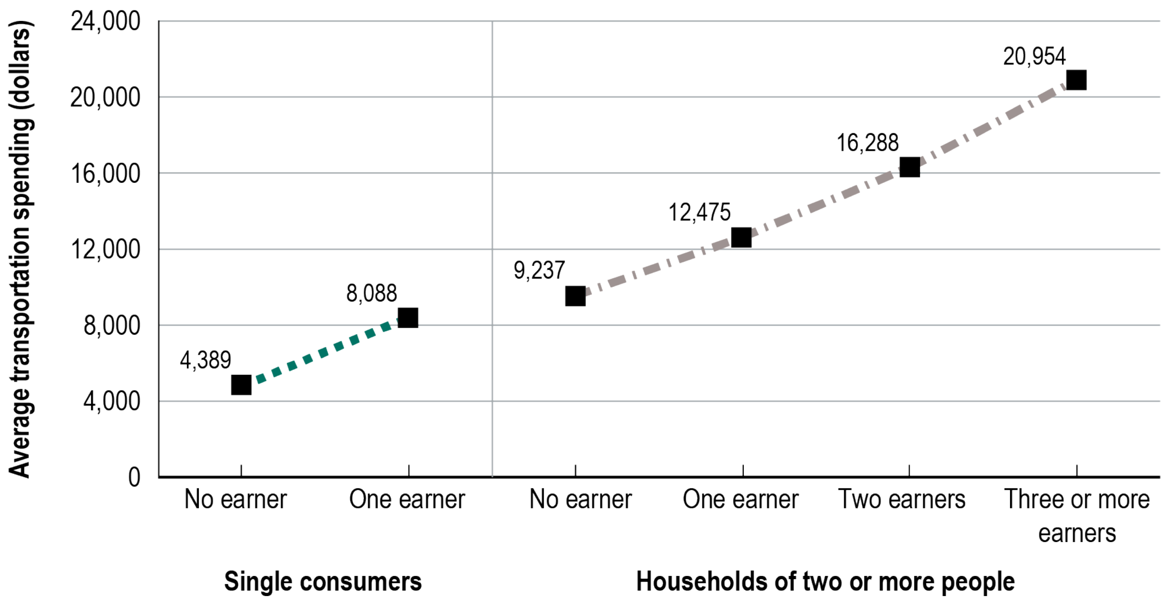
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Surveys, available at https://www.bls.gov/cex/tables/top-line-means.htm as of September 2023.

Table 2-13 provides recent details of all consumer transportation spending from the pre-COVID base year of 2019 into the subsequent COVID-19 years. The drop in transportation expenditures from 2019 to 2020 is heavily affected by a decline in purchased transportation and in fuel purchases which is in turn due to the reduction in VMT. 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. 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, a partial recovery in 2021, and then further recovery in 2022. Transportation's total increase from 2019 to 2022 was less than the overall trend in total expenditures, and a large part of the increase was the product of major increases in fuel expenditures as travel activity recovered and fuel prices jumped. Purchased transportation, mostly airline travel, also saw a major surge to levels exceeding 2019 levels. Also, changes in consumer expenditure areas outside of transportation, such as trips to restaurants, can affect transportation's spending share.

Transportation spending is strongly affected by the number of workers in a household, as shown in Figure 2-11. The Consumer Expenditure Survey (CEX) statistics for 2022 identified a key social change that affects travel. It estimated that there were just below 31 million zero-worker households (23 percent of all households) housing about 46 million people—roughly 14 percent of the total U.S. population. This reflects the long-term increasing numbers of baby boom retirees, leading to lower average transportation spending due to changed travel patterns of retirees [USDOL BLS CEX 2022].

While spending increases with number of workers in the household, Table 2-14 shows that spending on a per-vehicle or per-worker basis in 2022 is more constant across different income

Figure 2-11 Transportation Spending by Earners: 2022



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 2023.

Table 2-14 Transportation Spending Per Person, Per Worker, Per Vehicle by Income: 2022

Transportation spending type	All consumer units	Lowest 20 percent	Second 20 percent	Third 20 percent	Fourth 20 percent	Highest 20 percent
TOTAL transportation spending	**$12,295.00**	**$4,928.00**	**$8,156.00**	**$10,749.00**	**$14,719.00**	**$22,926.00**
Per person	5,122.92	3,080.00	3,883.81	4,478.75	5,075.52	7,164.38
Per worker	9,457.69	12,320.00	9,062.22	8,268.46	8,177.22	10,917.14
Gasoline, other fuels, and motor oil	**3,120.00**	**1,553.00**	**2,360.00**	**3,166.00**	**3,919.00**	**4,601.00**
Per Vehicle	1,642.11	1,553.00	1,573.33	1,666.32	1,703.91	1,769.62
Public and other transportation (all purchased transportation)	**845.00**	**262.00**	**429.00**	**544.00**	**845.00**	**2,145.00**
Per person	352.08	163.75	204.29	226.67	291.38	670.31
Per worker	650.00	655.00	476.67	418.46	469.44	1,021.43
Intracity mass transit fares	**57.09**	**48.62**	**42.29**	**60.03**	**54.43**	**80.11**
Per person	23.79	30.39	20.14	25.01	18.77	25.03
Per worker	43.92	121.55	46.99	46.18	30.24	38.15
Taxi fares and limousine services*	**66.36**	**38.44**	**48.15**	**56.72**	**66.34**	**122.18**
Per person	27.65	24.03	22.93	23.63	22.88	38.18
Per worker	51.05	96.10	53.50	43.63	36.86	58.18

* Diary item.

NOTES: Consumer units (CUs) consist of persons who are related by blood, marriage, or adoption. However, CUs may also consist of individuals living with others but are financially independent, or persons living together and making joint financial decisions. 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 2023.

quintiles. (Note: the lowest quintile, with large numbers of retirees, tends to have larger values than expected when expressed on a per-worker basis). Total transportation spending per person rises with income but stabilizes when evaluated on a per-worker basis. In 2022, the increase in the third and fourth quintile is generated by more auto travel and increased fuel price and fuel consumption and the resumption of increases in purchased travel for air travel and cruises etc.

Spending on vehicle fuel (when analyzed on a per-vehicle basis) is similar among workers of different incomes but rises slightly with income. The overall effect of all purchased transportation (i.e., transportation one buys a ticket to use) on a worker basis is also relatively stable, except for extreme growth among the two highest income categories. The effects by income 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. There were only slight increases in the lower two quintiles but bigger jumps in the middle to highest quintiles, perhaps due to some recovery in commuter rail expenditures. But on a per-worker basis, transit spending is greatest among the lowest income group, again perhaps perturbed by retirees in the group.

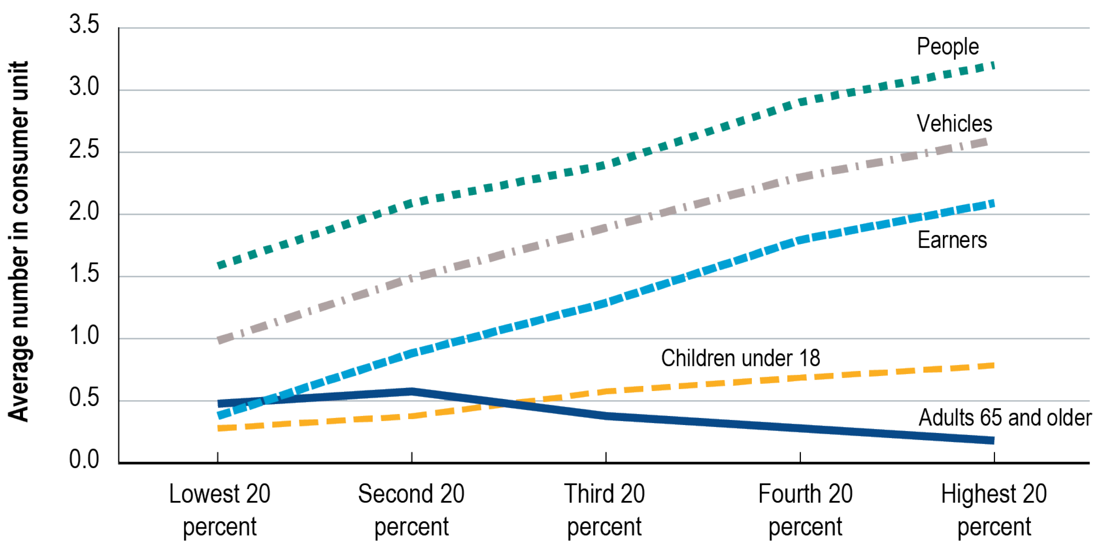
Overall consumer unit (as defined in note 1 of Table 2-14) demographic patterns tend to remain relatively stable over time, for example, the variations between the 2021 and 2022 data are in the range of one-tenth for any characteristic and in many cases are identical (Figure 2-12). The most apparent observation that supports the outcomes of other tables is the close pattern relationship between population, earners, and vehicles. The general sense of auto ownership over past decades 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. Such an increase in the total number of vehicles within a household certainly contributed to the increase in the household's transportation spending.

An alternative profile statistic identifies the share of households with no vehicles versus at least one. At the national level, 89 percent of units are reported to 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 according to the Consumer Expenditure Survey.

Consumer Spending on Transportation by Racial and Ethnic Categories

Differences among racial and ethnic groups in spending on transportation are shown in Table 2-15. The standout is perhaps that of Asians with the highest levels of spending (and highest incomes) of all groups. Asian incomes are associated with the highest levels of

Figure 2-12 Demographic Patterns by Income Quintile: 2022



Measure	Lowest 20%	Second 20%	Third 20%	Fourth 20%	Highest 20%
People	1.6	2.1	2.4	2.9	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	0.9	1.3	1.8	2.1
Vehicles	1.0	1.5	1.9	2.3	2.6

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 2023.

Table 2-15 Annual Expenditures per Consumer Unit for Major Economic and Transportation Categories: 2022

			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)	**$72,967.36**	**$64,330.15**	**$74,442.62**	**$77,368.84**	**$57,646.48**	**$87,950.00**
Food	9,342.73	9,301.54	9,348.98	9,726.39	7,190.96	11,507.00
Housing	24,298.34	22,964.14	24,527.20	25,115.62	21,149.54	29,560.00
Apparel	1,944.63	2,197.43	1,899.92	1,830.57	2,295.89	2,337.00
Transportation	12,294.91	12,585.91	12,245.40	12,609.46	10,153.49	15,299.00
Health care	5,850.49	3,964.10	6,173.04	6,571.80	3,882.83	5,643.00
Entertainment	3,458.21	2,329.38	3,651.64	3,965.52	1,851.32	2,599.00
Education	1,335.43	894.80	1,410.67	1,544.99	638.99	2,880.00
Transportation expenditures	**$12,294.90**	**$12,585.92**	**$12,245.39**	**$12,609.46**	**$10,153.49**	**$15,298.00**
Vehicle purchases, new/used	4,495.92	4,374.18	4,516.68	4,729.31	3,294.89	7,175.00
Gasoline, other fuels, and motor oil	3,119.74	3,662.68	3,027.15	3,105.97	2,574.26	2,771.00
Vehicle finance charges	294.58	342.30	286.45	286.29	287.36	239.00
Maintenance and repairs	1,160.15	1,148.45	1,162.26	1,187.31	1,018.34	1,011.00
Vehicle rental, leases, licenses, and other charges	787.26	607.04	817.99	836.54	711.41	916.00
Vehicle insurance	1,592.23	1,780.60	1,560.11	1,540.66	1,671.88	1,550.00
Public and other transportation	845.02	670.67	874.75	923.38	595.35	1,636.00
Vehicles owned	1.9	1.7	1.9	2	1.4	1.6
Transportation expenditures per vehicle (selected items)						
Fuel expenditures per vehicle	$1,641.97	$2,154.52	$1,593.24	$1,552.99	$1,838.76	$1,731.88
Maintenance and repairs per vehicle	$610.61	$675.56	$611.72	$593.66	$727.39	$505.50
Insurance per vehicle	$838.02	$1,047.41	$821.11	$770.33	$1,194.20	$775.00

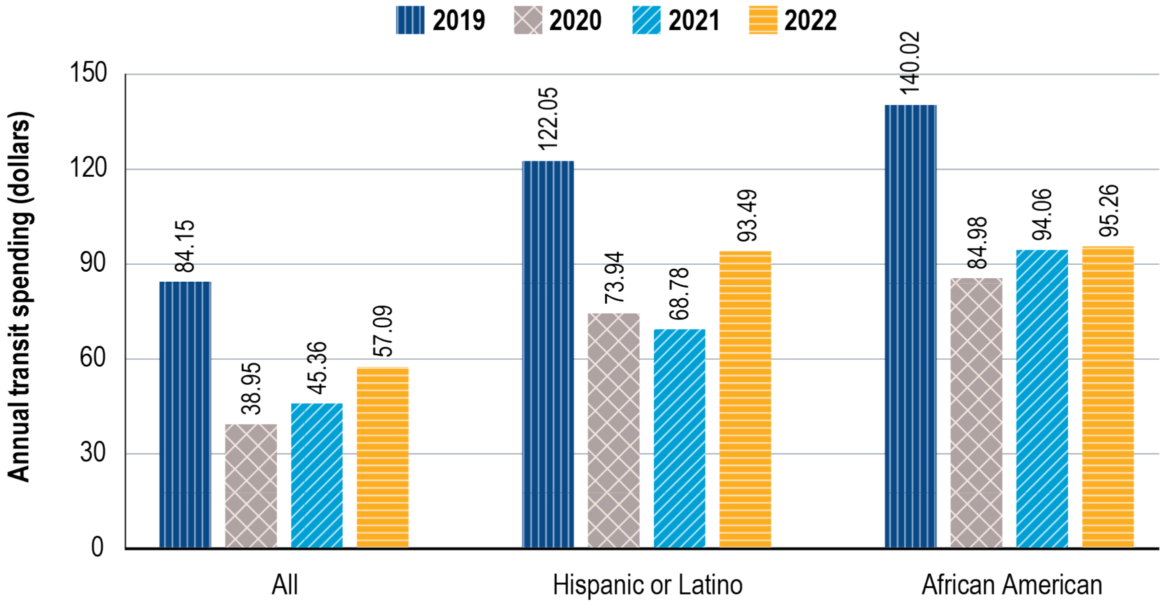
NOTE: Consumer units (CUs) consist of persons who are related by blood, marriage, or adoption. However, CUs may also consist of individuals living with others but are financially independent, or persons living together and making joint financial decisions.

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 2023.

education among all groups. Also, theirs is the highest level of spending on education, more than double the closest other racial and ethnic categories in spending (Table 2-15). Asians comprise only 5 percent of the population, thus sampling statistics tend to be less available on their characteristics. Both Asian and Hispanic incomes benefit from large numbers of workers in the unit as noted in the table.

Annual transit spending has not yet recovered from the pandemic period (Figure 2-13). Overall, the data indicate that the general population and the African American population were both spending about 68 percent of the 2019 base year in 2022. Hispanics, however, spent more on transit than the general population, at 76 percent in their recovery. Not presented in the table but the Consumer Expenditure Survey data show that living in center cities and large

Figure 2-13 Annual Transit Spending in the COVID-19 Period: 2019–2022



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, available at www.bls.gov/cex/tables.htm as of September 2023.

metropolitan areas shifts the share of spending going to housing and transportation with overall shares for both at about 50 percent of spending, but with a greater share of that 50 percent going to housing versus transportation. These data indicate a high share of housing plus transportation costs among Hispanics. This may reflect their highest transportation share due to their highest number of workers per unit and their resulting work travel needs along with their largest family size.

Rural populations tend to have similar, but slightly lower total spending shares of housing and transportation than their urban counterparts, but with greater transportation costs and lower housing costs even though their home ownership levels are substantially higher than metropolitan residents (83 percent home ownership vs. 61 percent urban). There tends to be few Hispanics and African Americans in rural areas, roughly 4 and 5 percent of rural population, respectively, so the low-income groups there tend to be White, non-Hispanics (Table 2-16) [USDOL BLS CEX 2022]. Overall attributes are as below.

Table 2-17 shows racial and ethnic differences in spending on public and other purchased transportation (e.g., air, taxi, train) [USDOL BLS CEX 2022]. 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:

- African American bus usage was relatively small in 2019—averaging just under $9 a year per consumer unit and dropped almost to zero in 2020; bus usage returned to about $2.50 in 2021. African American reporting for 2022

Table 2-16 Housing and Transportation Spending Shares for Urban and Rural Households: 2022

Category	Urban	Rural
Number of households (000's)	108,534	25,556
Share of households	80.9%	19.1%
Share of aggregate spending	81.5%	18.5%
People per household	2.4	2.5
Children under 18	0.6	0.6
Adults over 65	0.4	0.6
Earners	1.3	1.3
Vehicles	1.7	2.4
Vehicles per household	1.7	2.4
Zero-vehicle household	12%	6%
At least one vehicle	88%	94%
Homeownership	61%	83%
Hispanics	17%	4%
African-Americans	15%	5%
Total annual household spending	73,490	70,750
Total transportation spending	12,078	13,217
Transportation spending share	16.4%	18.7%

SOURCE: U.S. Department of Commerce, Census Bureau, 2019–2022 American Community Survey, Table B08119, available at https://data.census.gov/cedsci/ as of September 2023.

was unable to provide measures for intercity bus, train, and cruise travel.

- Hispanic usage followed a similar pattern; $14 in 2019, $4 in 2020, and recovering somewhat to $5 in 2021. Hispanic reporting for 2022 was unable to report intercity bus and cruise travel. it did display intercity train fares as at $10.78 in 2022, in contrast to $19.24 in 2019.
- African American airline fares were somewhat more positive at $275 in 2019, dropping to $79 in 2020, and then rising to $237 in 2021, reaching an above 2019 level of $368 in 2022.
- Hispanic air usage was similar, with $338 in 2019, dropping to $151 in 2020, and returning somewhat to $258 in 2021. Again, as among African Americans, it reached a high of $442 in 2022, more than $100 above the 2019 level.

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, almost doubling to $845 in 2022. It is notable that the usage of local transportation, cabs, and transit at traveler destinations were heavily affected by the decline of intercity public modes and personal vehicle travel among minority groups and the general population.

Emerging Issues: Covid Impacts on Passenger Travel

As noted in the Introduction, the 2022 trend picture of passenger travel continues an uneven recovery from the 2019 peak and points to an uncertain future due to factors such as the enduring growth in working at home, changes in electronic communications, declining population growth and locational shifts. 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 curtailed their activities or shut down completely and households sheltered in place. Passenger travel rebounded somewhat in 2021 and into 2022, but the growth in work at home, labor force limits, and an increase in the retirement-age population contributed to substantial shifts in travel patterns that will affect future passenger travel into the next decade.

The central transportation issue is the loss of the workplace as one of the main nodes, in addition to home, that define travel patterns, including the location, direction, and the time of travel, generating the largest change in travel behavior since World War II. The key question might be when we will ever get back to 2019 levels of travel, if ever. Current indications are that at this time on the order of 28 million people work at home at least part of the time. The 2022 ACS

Table 2-17 Average Annual Household Expenditures on Intercity Transportation (Dollars): 2019–2022

Transportation purchased	All Consumer Units	Hispanic or Latino	Black or African-American	Asian
2019 public and other transportation	780.55	609.20	534.20	NA
Airline fares	513.14	337.80	274.69	NA
Intercity bus fares	15.28	14.29	8.86	NA
Local trans. on out-of-town trips	20.33	12.38	11.00	NA
Taxi fares and limousine services on trips	11.94	7.27	6.46	NA
Intercity train fares	30.24	19.24	18.26	NA
Ship fares	56.39	37.91	43.09	NA
2020 public and other transportation	263.46	264.63	199.11	NA
Airline fares	159.89	150.80	69.70	NA
Intercity bus fares	2.23	4.23	0.38	NA
Local trans. on out-of-town trips	6.89	4.21	3.55	NA
Taxi fares and limousine services on trips	4.05	2.48	2.08	NA
Intercity train fares	7.96	4.89	2.75	NA
Ship fares	11.24	9.63	1.65	NA
2021 public and other transportation	451.54	411.54	393.33	NA
Airline fares	321.99	257.83	236.74	NA
Intercity bus fares	4.18	4.94	2.57	NA
Local trans. on out-of-town trips	14.21	8.82	9.47	NA
Taxi fares and limousine services on trips	8.35	5.18	5.56	NA
Intercity train fares	11.20	6.92	8.45	NA
Ship fares	19.51	10.14	10.17	NA
2022 public and other transportation	845.02	670.67	621.87	1636.29
Airline fares	606.41	442.03	368.32	1178.11
Intercity bus fares	9.25	NA	NA	12.32
Local trans. on out-of-town trips	24.81	15.61	21.27	41.41
Taxi fares and limousine services on trips	14.57	9.17	12.49	24.32
Intercity train fares	24.24	10.78	NA	34.30
Ship fares	37.64	NA	NA	NA

NOTE: NA = Data are not available.

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.

showed a decline in 8 million workers driving to work alone with parallel declines in other modal alternatives from 2019 based on the gain of over 15 million people shifting to work at home in the same 2019–2022 time period. Intercity/international travel restoration is being keyed on 2025 and beyond. A key issue is the substitution of technological options for long distance business travel. Any forecasts of travel developed in 2019 or earlier are effectively worthless today, and at a minimum must be restudied and re-justified to guide investment. Freight also is impacted in terms of the types and locations of deliveries.

But the central questions go well beyond transportation. They raise questions of the economic viability of offices, the size and location of homes, population redistributions, unclear impacts on economic productivity and the extension of corporate culture among new workers. The effects of COVID may disappear but not the new patterns or technologies that were instigated by it. The effectiveness of working at home, the new communications technologies are only at the beginning of their impacts.

This chapter has also provided the 2022 picture of passenger travel which indicates the closing of some gaps in travel by racial and ethnic groups. A key issue will be expanding the analysis of the accessibility of locations to employment, social services and daily needs to better serve different population groups both metropolitan and rural.

Data Gaps

This chapter provides perspective on the events that unfolded in passenger transportation during the COVID-19 years and an assessment of their implications within existing data constraints. A fuller treatment should be made but will best occur in the future when the implications have stabilized somewhat, the assessment is less speculative and statistical capabilities are better. Long-term monitoring is critical. When will be back to 2019, if ever, and what variants in behavior are now part of our new passenger travel world?

It is often the case that when 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 in 2021 was 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 can indicate socio-economic characteristics associated with the observed travel behavior. Much is known about travel volumes, but little is known about the traveler's characteristics or the purposes of the travel. Inferential tools need to be improved to permit these missing characteristics, to be related to field measurements 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 by the USDOT in 1995. Consequently, we do not know how much travel on local transportation infrastructure is by people traveling through an area or visiting from a distant place. Such travel has different characteristics and requires different transportation management strategies to accommodate effectively and will be a significant part of future local travel.

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 even more limited. Anecdotal evidence suggests that the bus industry carries substantial numbers of travelers, but little is known about their numbers and characteristics. Ridership counts are consistently collected only for buses operated by or for publicly supported transit systems. Although local and intercity 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 broader 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 relatively 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 difficult to establish, and linking it to the socioeconomic characteristics of the same neighborhood. A particular concern is in rural areas where there are significant weaknesses in transportation facilities and services among the Native American nations. Data challenges are even greater for understanding the special mobility needs of disabled residents within their 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. Special studies are required.

A major statistical challenge is to develop more sound measures of working-at-home populations. Several agencies sought to address this during the pandemic but used varying definitions. The ACS 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 work week. The transportation profession now 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. As a result of work at home changes, we have lost major parts of one of the main nodes determining travel, the workplace, both the directions and temporal structure of many trip patterns have reformed.

A change in labeling geographic areas of 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 something labeled “principal cities” that masks important population changes and combines statistics on population characteristics and commuting flows between a city center and its constituent neighborhoods with flows between spatially separated city centers. (The Washington metro area has 7 separately designated principal cities in addition to Washington, DC, itself. At present transportation flows between these disparate locations are treated as one internal area.) 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 services availability. Work towards developing these measures needs to be underway on many levels.

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CHAPTER 3
Freight and Supply Chain

Introduction

Freight transportation provides essential links among economic units from production to consumption, serving all sectors of the economy and supplying consumers with goods. This chapter begins by examining U.S. production, commonly referred to as gross output, and international trade as key drivers of transportation demand. The characteristics of the U.S. freight transportation system and the movement of goods are explored. The chapter concludes by identifying essential data sources which, when made available, can greatly assist in planning and performance monitoring endeavors.

Highlights

- The total 2022 value of U.S. foreign trade reached about $5.31 trillion, a 15.8 percent increase from 2021. This growth exceeded 2022 trade-specific inflation, signifying a recovery from the effects of COVID-19 and a resurgence in trade activity.
- Trade between the United States and Canada in 2022 amounted to nearly $793 billion, reflecting growth from the $666 billion reported for 2021, equivalent to a 19 percent increase (value not adjusted for inflation).
- In 2022, the U.S. freight transportation system moved nearly 20 billion tons of goods valued at approximately $19.0 trillion.
- Trucking maintained its status as the dominant mode of freight transportation by both weight and value in 2022, moving 12.6 billion tons of cargo valued at over $13.6 trillion. This represented 64.5 percent of the total freight weight and 72.5 percent of the total value.
- U.S. east coast ports handled 106.7 billion tons versus 97.2 billion tons for U.S. west coast ports.
- U.S. east coast ports have shown continuous growth of Asian imports over the past 10 years, approaching a near-even split in 2021. U.S. east coast ports' Asian imports ultimately surpassed U.S. west coast ports in 2022, importing 70.2 billion metric tons compared to 63.2 billion imported metric tons for the U.S. west coast ports.
- Pipelines dominated U.S.-Canada trade in 2022, carrying about 44.8 percent of total freight weight. Carrying 58.4 percent of freight weight, vessel transport is the dominant mode in U.S.-Mexico trade. Trucks are the second mode of choice for U.S.-Mexico trade, carrying nearly 32 percent of freight weight.
- In 2019, 2020, and 2021, the average vessel dwell times for the top 25 U.S. container ports were 28.1 hours, 28.2 hours, and 32.1 hours, respectively. The average vessel dwell time continued to increase in the first half of 2022, reaching 35.5 hours, altogether showing a gradual increase due to COVID-19-related demand.

Much of the data presented herein is derived from the Freight Analysis Framework (Box 3-A), a data source that provides a comprehensive perspective of freight movement across states and major metropolitan areas, categorized by commodity groups and transportation modes. The Freight Analysis Framework serves as a valuable resource for understanding the intricate web of freight transportation in the United States, facilitating informed decision-making and strategic planning.

Factors That Affect Freight Transportation Demand

Freight transportation demand hinges significantly on domestic production and international trade. Table 3-1 shows the output of domestic industries that create demand for freight movement. The manufacturing industry continued its leading role as the sector most dependent on the U.S. freight system, representing about 39 percent of total gross output of the eight industries most dependent on the U.S. freight system. The utilities, wholesale trade, and retail trade sectors had their highest outputs during the 2017–2022 period, while agriculture/forestry/fishing/hunting and construction sectors experienced their lowest outputs during the same period. Manufacturing experienced its highest output since COVID-19 year 2020 but has not yet reached its pre-COVID-19 output levels.

Figure 3-1 highlights the international trade that creates additional demand for freight movement. The total 2022 value of U.S. trade reached about $5.31 trillion, a 15.8 percent growth from 2021. The 2022 Import Price Index increased 8.5 percent and the Export Price Index increased 13.0 percent from the previous year; the increases signify a recovery from the effects of COVID-19 and a resurgence in trade activity.[1]

In the same year, Canada maintained its position as the top U.S. trading partner, a status it had attained the previous year (Figure 3-1). Trade between the United States and Canada in 2022 amounted to nearly $793 billion, reflecting an impressive growth over the $666 billion in trade from 2021—a 19 percent increase. Mexico and China also retained in 2022 their second and third positions, respectively, from the previous year. China's trade growth from 2021 to 2022

[1] U.S. Bureau of Labor Statistics, Import Price Index (End Use): All Commodities and Export Price Index (End Use): All Commodities as of December 2023. The U.S. Import and Export Price Indexes (MXP) measure changes in the price of goods and services traded between the United States and its top five trading partners (Canada, Mexico, China, Japan, and Germany).

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 (2018–2022), and forecast year estimates through 2050. Data may be accessed through the FAF Data Tabulation Tool.

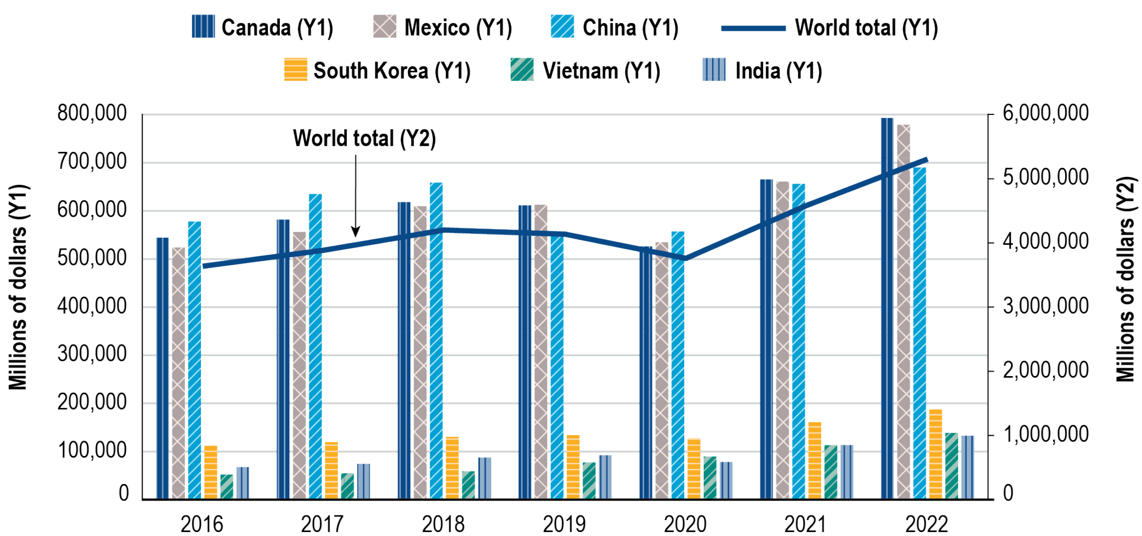
Table 3-1 Gross Output of Freight System-Dependent Industry Sectors: 2017–2022 (Billions of 2017 Chained Dollars)

Industry sector	2017	2018	2019	2020	2021	2022
Total of sectors highly dependent on transportation and warehousing	**13,768.1**	**14,181.9**	**14,165.9**	**13,446.8**	**14,177.3**	**14,231.4**
Sectors highly dependent on transportation and warehousing						
Agriculture, forestry, fishing, and hunting	448.9	447.2	440.1	454.5	454.8	434.8
Mining	462.8	536.2	568.2	471.8	501.7	531.9
Utilities	474.1	496.4	492.9	481.5	492.5	507.1
Construction	1,578.0	1,601.3	1,614.9	1,643.6	1,669.3	1,564.3
Manufacturing	5,676.6	5,786.4	5,724.7	5,335.3	5,498.2	5,541.9
Wholesale trade	2,053.9	2,115.5	2,089.1	1,986.7	2,203.5	2,198.7
Retail trade	1,846.9	1,914.6	1,932.0	1,931.2	2,089.5	2,092.2
Transportation and warehousing	1,226.9	1,284.3	1,304.0	1,142.2	1,267.8	1,360.5

NOTES: Chain dollars adjust 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 2017 chain dollars)*, available at: https://apps.bea.gov/iTable/?reqid=150&step=2 as of November 2023.

Figure 3-1 U.S. Trade Growth with Selected 6 of Top-10 Trading Partners: 2016–2022 (Current Dollars)



NOTES: Not-Seasonally Adjusted (NSA) trade data refers to raw or unadjusted economic data that has not undergone the process of removing seasonal variations. It reflects the actual values observed for a given time period without any adjustments for regular, recurring patterns associated with specific seasons, months, or quarters. NSA data includes the effects of seasonality, making it subject to fluctuations influenced by factors such as holidays, weather patterns, and other calendar-related events. NSA data are not inflation adjusted.

SOURCE: Bureau of Census, U.S. Department of Commerce, "U.S. International Trade in Goods and Services: 2022", available at https://www.census.gov/foreign-trade/Press-Release/ft900/final_2022.pdf as of August 2023.

was more modest, with an increase of about 5.2 percent. Notably, Vietnam, South Korea, Mexico, India, and Canada all exhibited robust growth rates during this period, ranging from a low of 16.6 percent (South Korea) to a high of 23 percent (Vietnam).

U.S. trade with Mexico and China in 2022 amounted to $779 billion and $690 billion, respectively. Mexico's trade experienced significant growth during the 2016–2022 period, surpassing China in trade value in 2019, mainly due to trade tensions in 2018. Although China held the title of the United States' leading trade partner in 2020, primarily due to the surge in pandemic-related consumer purchases, Canada and Mexico reclaimed their historic positions of trade dominance in 2021, securing the top two trading partner positions, while China dropped to third in the list of top 10 trade partners.

Evolving Trends in Total Freight Movement

In 2022, the U.S. freight transportation system moved nearly 20 billion tons of goods valued at approximately $19.0 trillion (in 2017 dollars) (Table 3-2). This extensive transportation system relied on capital assets totaling $8 trillion, encompassing critical infrastructure elements such as ports, highways, rail systems, airports, and pipelines. In 2022, the industry saw an increase in asset value of $143.3 billion from 2021.[2]

Data from 2022 reveals notable shifts when compared to the pre-COVID-19 year 2019. There was an overall reduction in both weight and value, with a decrease of 321 million tons and $184 billion between 2019 and 2022. The "Air, air and truck" category was the only exception, though with modest weight and value gains from 2019 to 2022. Similarly, the "Multiple modes and mail" sector exhibited marginal growth in terms of value.

Trucking maintained its status as the dominant mode of freight transportation in both weight and value in 2022, moving 12.6 billion tons of cargo valued at over $13.6 trillion. This represented 64.5 percent of the total freight weight and 72.5 percent of the total value. Notably, trucking's freight volume was approximately 8.1 times higher than that of rail, the third-ranked mode. Pipelines played an important role, transporting 3.9 billion tons in 2022, or roughly 19.9 percent of the total freight tons transported, demonstrating the importance of energy-related flows to the entirety of U.S. freight movements.

Distance of Freight Movement and Modes of Transportation Used

In the realm of freight transportation, a considerable proportion of both value and weight is attributed to relatively short distances. In 2022, for instance, freight moved by all modes covering distances less than 100 miles accounted for approximately 30 percent of the total freight value and 36 percent of the total freight weight (Figure 3-2A and Figure 3-2C). This translates to a substantial $5.6 trillion in value and 7.1 billion tons in weight. As shipment distances extend up to 249 miles, these proportions escalate significantly, reaching 56 percent of the total value and 74 percent of the total weight, increasing value and weight to $10.5 trillion and 14.6 billion tons.

When it comes to modal preferences across various distances, the landscape varies considerably. Trucks emerged as the dominant mode, carrying the most goods in terms of value for distances less than 2,000 miles (Figure 3-2B) within the United States. Figure 3-2D and Figure 3-2F illustrate that trucking also carried

[2] Bureau of Transportation Statistics, Freight Transportation and the Economy – Freight-related fixed assets, available at https://data.bts.gov/stories/s/Freight-Transportation-the-Economy/6ix2-c8dn as of September 2023.

Table 3-2 Freight Weight and Noninflation Adjusted Value by Mode: 2019 and 2022

	Weight							
	2019				2022			
Millions of tons	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]
TOTAL	**19,932**	**17,825**	**1,139**	**968**	**19,611**	**17,414**	**1,208**	**989**
Truck	12,852	11,941	468	443	12,641	11,747	448	446
Rail	1,599	1,160	267	172	1,567	1,081	319	167
Water	821	657	113	51	784	626	118	40
Air, air and truck	7	2	3	2	8	2	4	2
Multiple modes and mail	653	538	63	52	624	514	57	53
Pipeline	3,905	3,437	221	247	3,901	3,364	258	280
Other and unknown	96	89	5	2	86	80	5	2

	Value							
	2019				2022			
Billions of 2017 dollars	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]
TOTAL	**18,945**	**15,126**	**1,575**	**2,243**	**18,761**	**14,838**	**1,522**	**2,401**
Truck	13,809	11,294	985	1,530	13,611	11,032	933	1,646
Rail	584	226	138	220	563	215	133	214
Water	268	182	47	39	253	174	44	36
Air, air and truck	611	150	237	223	655	154	242	259
Multiple modes and mail	2,582	2,343	78	161	2,596	2,361	65	170
Pipeline	1,061	929	73	59	1,058	901	89	68
Other and unknown	30	2	17	11	26	2	16	8

[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 5.5.1, July 2023.

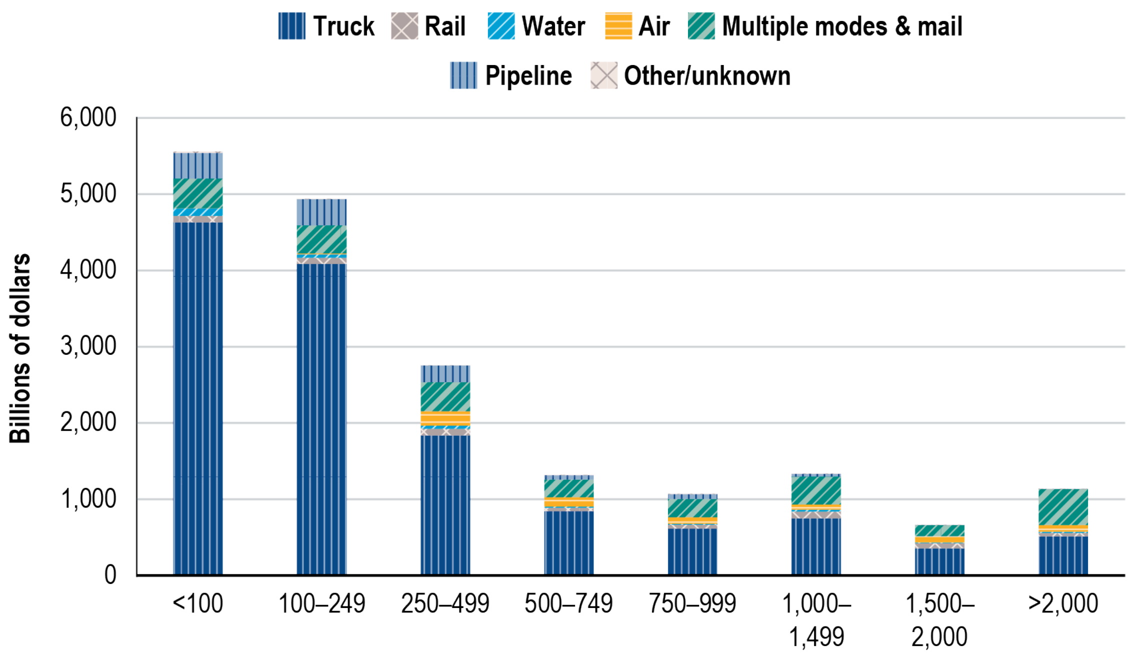
the greatest share of tons and ton-miles of goods for distances under 250 miles. Trucking remains widely used across other distances in 2022, even for distances exceeding 2,000 miles. Rail, on the other hand, takes the lead in both tonnage and ton-miles for goods shipped over distances ranging from 1,000 to 2,000 miles, particularly for heavy commodities. Notably, air and multiple modes collectively accounted for nearly half of the value of all shipments covering distances exceeding 2,000 miles.

Top 10 Commodities

Table 3-3 and Figure 3-3 and Figure 3-4 present the top 10 domestic commodities for the year 2022, categorized both by weight and mode, as well as by value and mode. Collectively, these top 10 commodities account for nearly 13.3 million tons, a substantial 67.2 percent share of all domestic commodities by weight, as shown in Table 3-3. Notably, these commodities fall primarily within the bulk freight category, with a clear absence of manufactured goods. They

Figure 3-2 Domestic Shipment Value and Weight by Mode and Distance Bands: 2022

A. Total Value by Distance Band (Billions of 2017 Dollars): 2022



B. Mode Share of Value by Distance Band: 2022

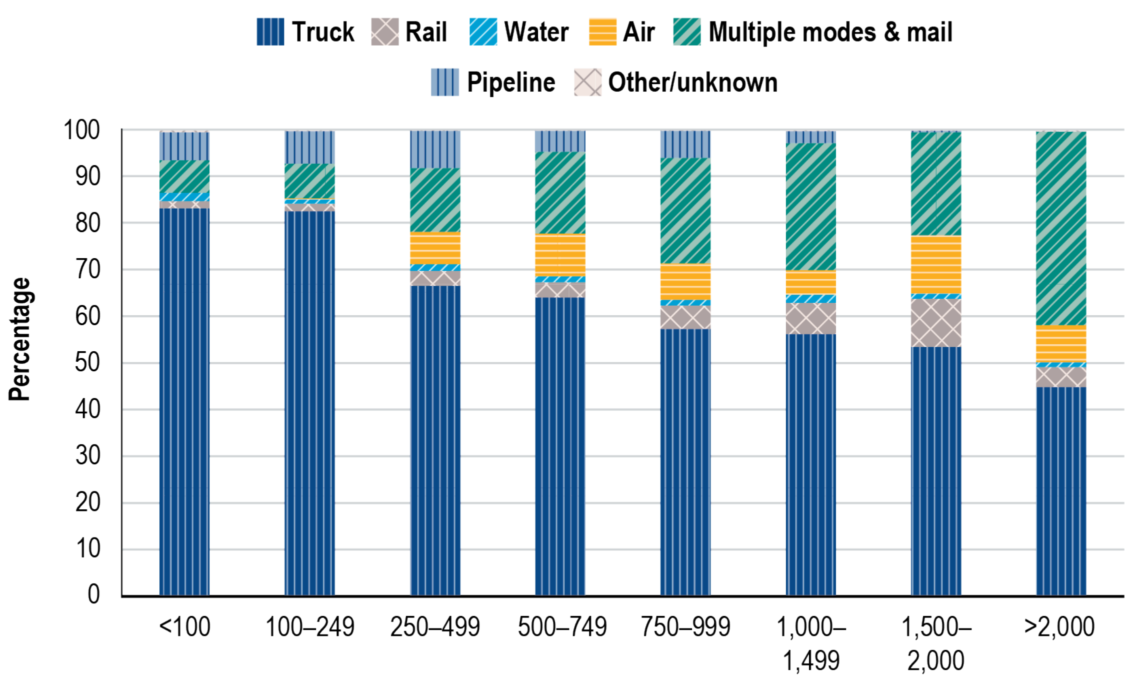
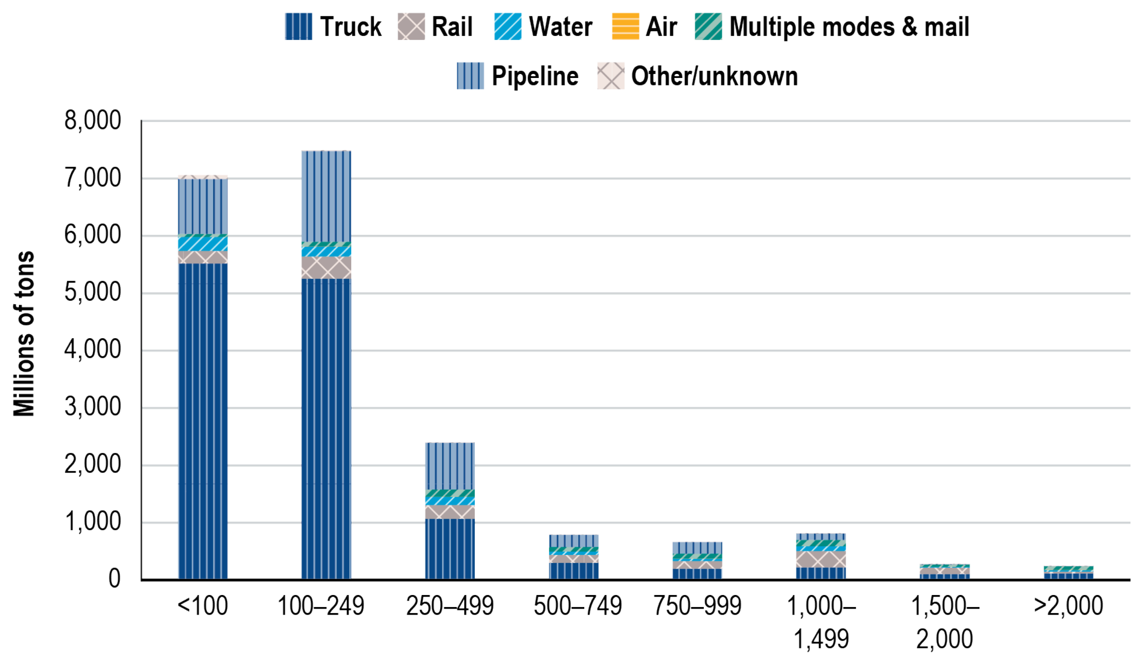


FIGURE 3-2 Continued

C. Total Tonnage by Distance Band: 2022



D. Mode Share of Tonnage by Distance Band: 2022

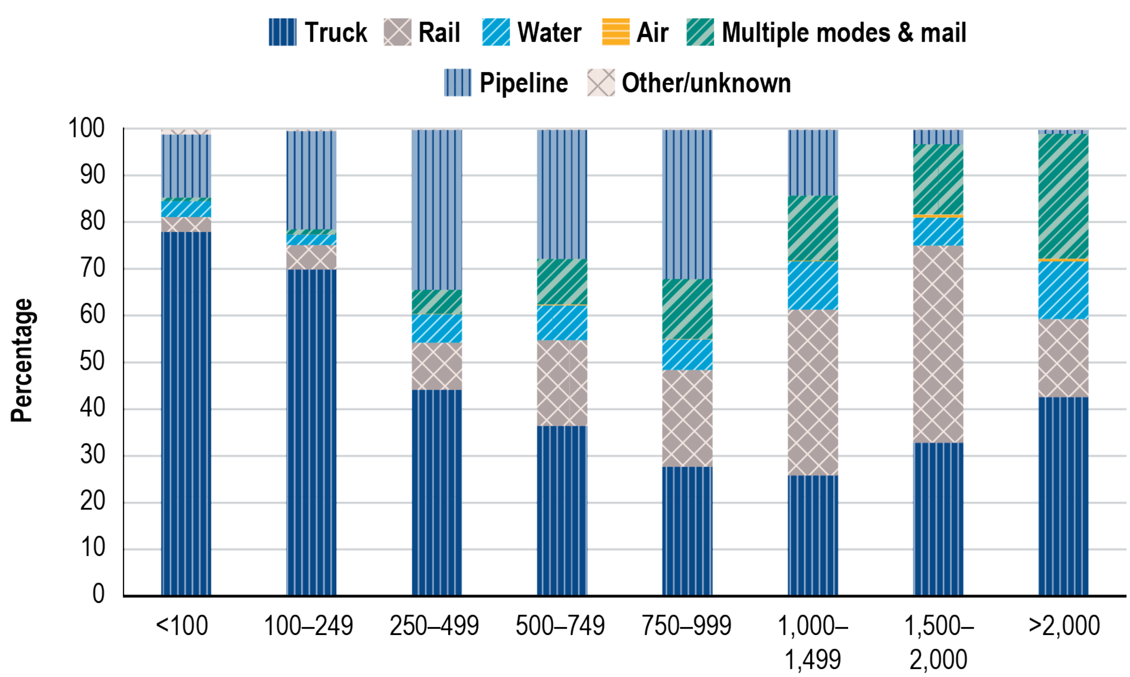
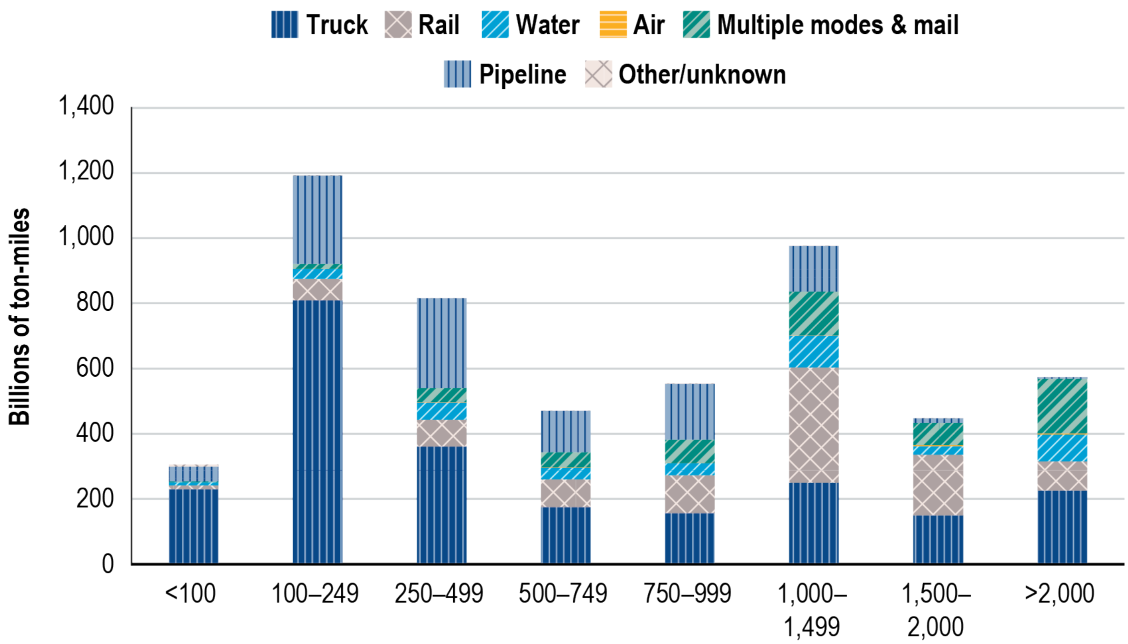
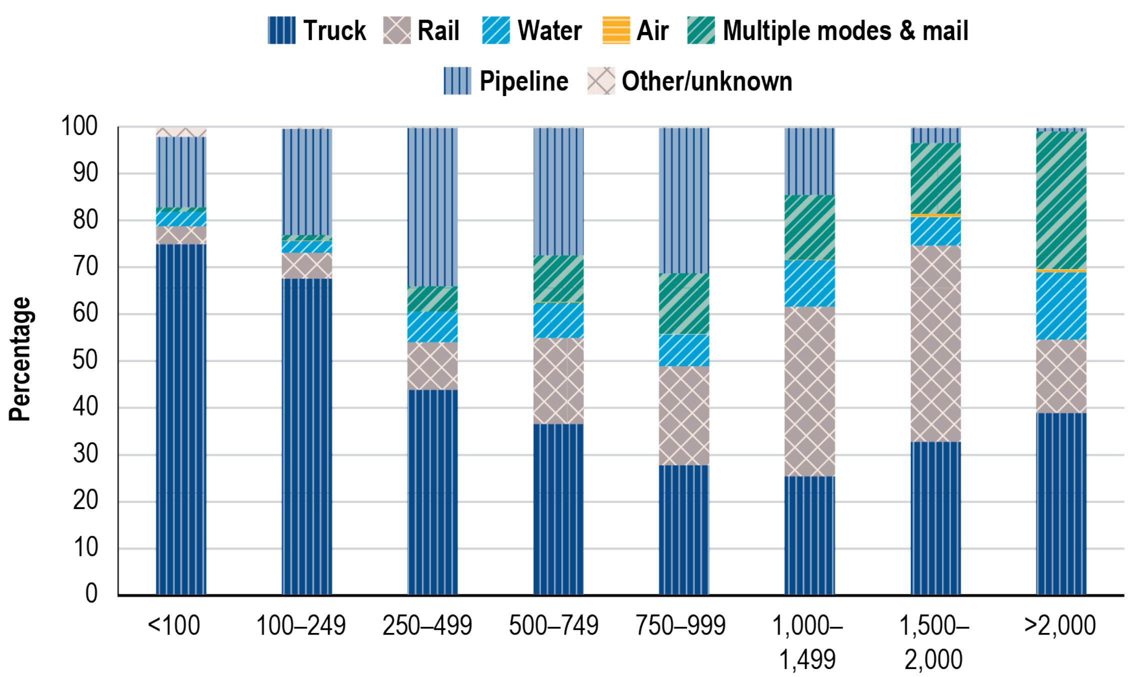


FIGURE 3-2 Continued

E. Total Ton-Miles by Distance Band: 2022



F. Mode Share of Ton-Miles by Distance Band: 2022



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

rely on multiple modes of transportation, with only nominal instances of air transport. Bulk commodities shipped by air usually consist of higher value specialty products transported in breakbulk form, such as sacks and barrels on pallets.

The standout commodity within this list is "Natural gas and fossil products," representing the largest volume at 23.2 percent of the total top 10 commodity volumes.[3] Pipelines play a crucial role, transporting 2.39 billion tons of coal and petroleum products, accounting for a substantial 77.6 percent of the approximately 3.1 billion tons for this commodity. Gravel, gasoline, nonmetallic mineral products, and cereal grains, ranking second to fourth by weight, are primarily transported by trucks. In fact, the tons moved by trucks for these top 10 commodities alone represent 39.3 percent of the total weight of all commodities.

Shifting focus to the economic value, the top 10 commodities by value altogether account for 61 percent of the total value of all commodities. This list prominently features manufactured goods, marking a significant contrast to the bulk commodities highlighted in the top 10 by weight list (as detailed in Table 3-3). Trucks are pivotal in transporting these high-value commodities, accounting for $8.13 trillion worth of freight, representing 71 percent of the approximately $11.4 trillion total value of the top 10 freight commodities. This also constitutes 43.2 percent of the total value of all commodities. In contrast, the second-ranked category by value, "Multiple modes and mail," carries 15.7 percent of the total value of the top 10 commodities (as depicted in Figure 3-2A and Figure 3-2B).

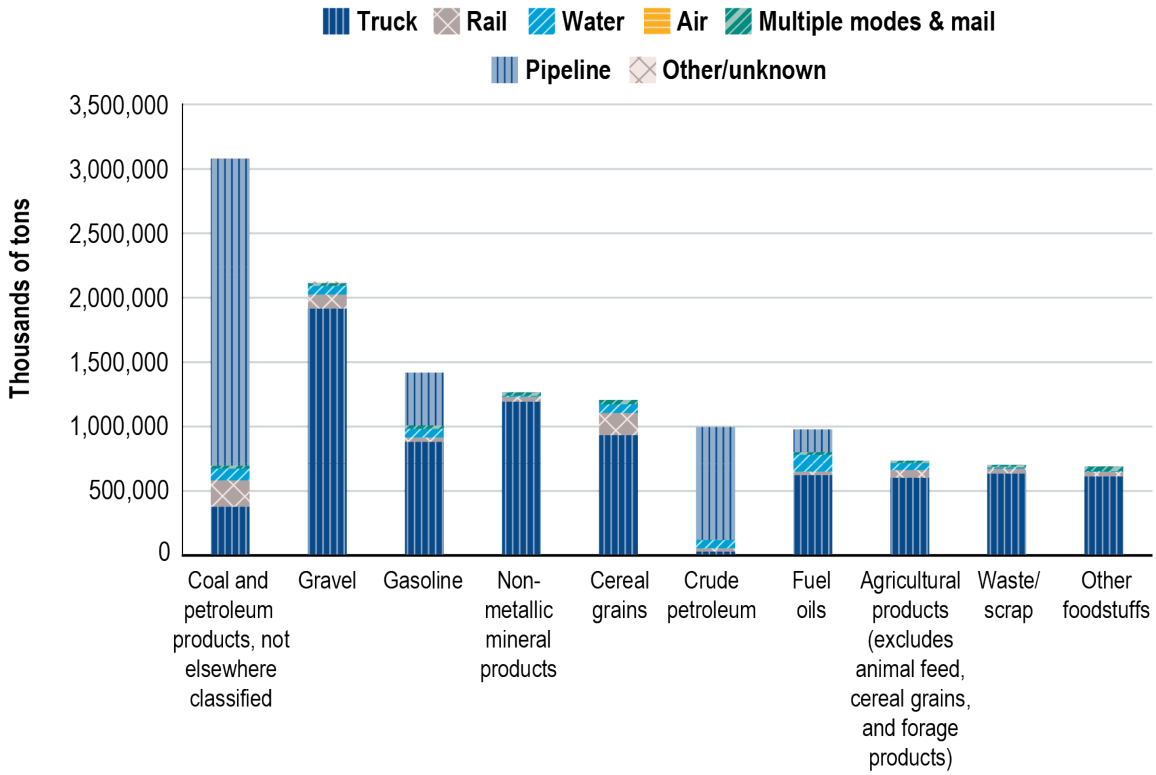
[3] Note the description of Standard Classification of Transported Goods (SCTG) 19 was changed from "Coal, n.e.c. (not elsewhere classified)" to "Natural gas and fossil products" in the FAF 5.5 release to be more consistent with the commodities in this category.

Table 3-3 Top 10 Commodities by Weight and Value: 2022

Commodities by weight	Thousands of tons	Commodities by value	Billions of 2017 dollars
Coal and petroleum products, not elsewhere classified	3,079,613	Electronics	1,906,463
Gravel	2,122,077	Motorized vehicles	1,535,728
Gasoline	1,413,907	Mixed Freight	1,511,774
Non-metallic mineral products	1,261,901	Pharmaceuticals	1,412,866
Cereal grains	1,202,542	Machinery	1,212,237
Crude petroleum	1,094,889	Miscellaneous manufactured products	851,417
Fuel oils	973,066	Plastics/rubber	789,608
Agricultural products (excludes animal feed, cereal grains, and forage products)	727,759	Gasoline	757,659
Waste/scrap	696,821	Coal and petroleum products, not elsewhere classified	734,099
Other foodstuffs	684,677	Other foodstuffs	731,852
TOTAL, Top 10	**13,257,251**	**TOTAL, Top 10**	**11,443,703**
TOTAL of all commodities	**19,715,704**	**TOTAL of all commodities**	**18,799,297**
Top 10 share of TOTAL	**67.2%**	**Top 10 share of TOTAL**	**60.9%**

SOURCE: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.5.1, August 2023.

Figure 3-3 Tonnage of Top 10 Domestic Commodities by Mode: 2022



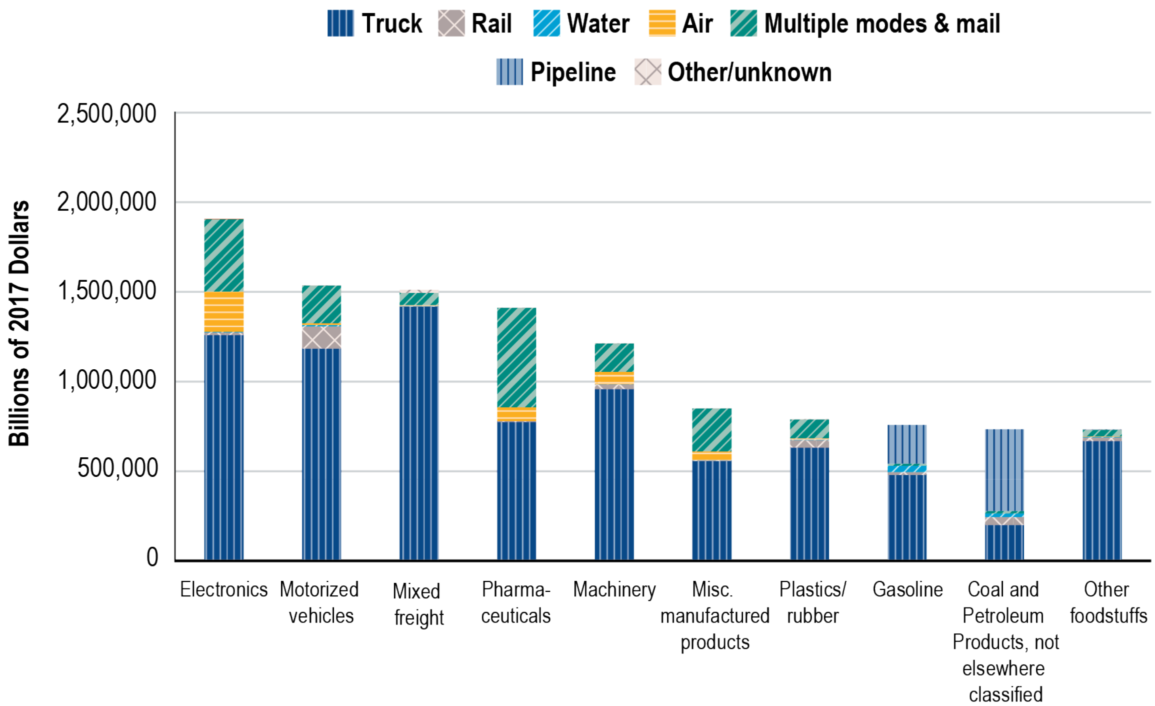
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.5.1, August 2023

International Freight

The nominal value of international freight, the sum of import and export values shown above in Table 3-2, is estimated at $3,923 billion in 2022. This is an increase of $362 billion from 2021. Though international freight holds a relatively small share of total U.S. freight value of $18.95 trillion in 2022, the 20.1 percent share underestimates the true importance of international freight. International freight is handled in the Nation's maritime ports, land borders, and airports, so there is a high concentration of logistics activities in these areas. This is especially true for the coexistence of the maritime ports of Los Angeles and Long Beach in the same metropolitan area.

Table 3-4 delineates U.S. international freight by geography and mode. Vessels played a significant role in transporting goods between the United States and Asia, with a total value of $1,219,767 million in 2022, reflecting an increase of $174,000 million compared to 2021. In this landscape, vessel transport claimed a substantial 60.5 percent market share in 2022, a 2.2 percent growth from the previous year. On the other hand, air transport lost market share for U.S.-Asian routes, declining from 37.5 percent in 2021 to 35.2 percent in 2022. The value of air transport, with a relatively modest $37,000 million increase from the previous year, amounted to $708,985 million in 2022. Similar dollar amounts were transported by vessel and air (44.8 vs. 48.6 percent) between the United States and Europe.

Figure 3-4 Value of Top 10 Domestic Commodities by Mode: 2022



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 5.5.1, August 2023.

Table 3-4 Value of U.S.-International Freight Flows by Geography and Transportation Mode: 2022 (Millions of 2017 Dollars)

	Mode						
Geography	Truck	Rail	Pipeline	Air	Vessel	Other	TOTAL
Canada	411,976	118,839	134,430	37,461	43,462	44,967	791,133
Mexico	535,951	91,391	14,728	20,385	95,372	15,684	773,512
Asia	NA	NA	NA	708,985	1,219,767	86,481	2,015,233
Europe	NA	NA	NA	591,094	545,162	80,000	1,216,256
Other	NA	NA	NA	105,220	377,848	20,988	504,056

KEY: NA = not applicable.

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

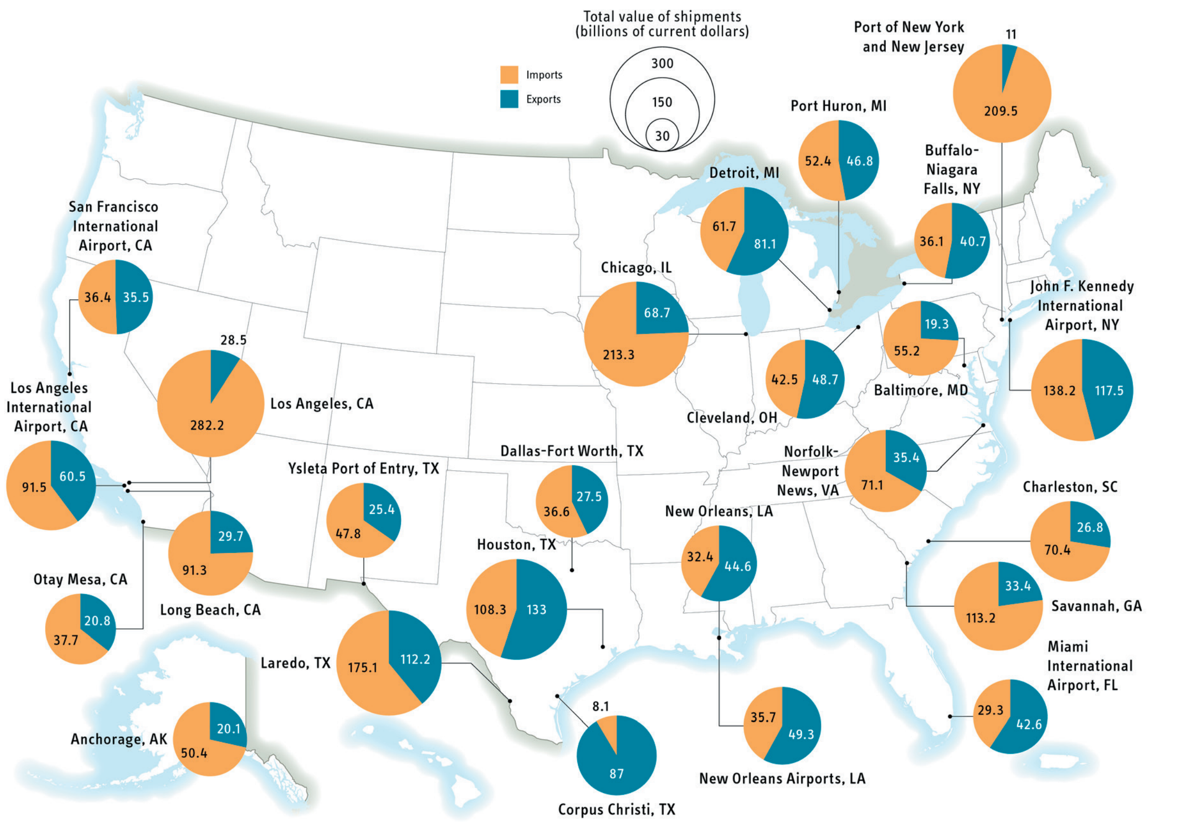
SOURCES: Truck, Rail, and Pipeline: U.S. Department of Transportation, Bureau of Transportation Statistics, TransBorder Freight Data, available at www.bts.gov/transborder; **Air, Vessel, and Other:** U.S. Department of Commerce, Census Bureau, *USA Trade Online*, https://usatrade.census.gov/ as of August 2023.

Figure 3-5 reveals the significance of the Nation's top 25 gateways for the year 2022, where 17 of them handled more imports than exports. The top gateway position was held by Los Angeles, CA, which handled values of $282.2 billion and $28.5 billion in freight exports and imports. Los Angeles's imports exceeded second-ranked gateway Laredo, TX, by $107.1 billion while trailing the same gateway in exports of $83.7 billion.

On the land border front, Laredo, TX, took the top spot as the number one land gateway, with international freight valued at $287.3 billion, which also aligns with the overall high trade volumes between the United States and Mexico. Though ranked as the number 5th gateway, Houston, TX, served as the United States' primary export gateway, boasting an export value of $133.0 billion, followed by John F. Kennedy International Airport with an export value of $117.5 billion.

The leading maritime gateway was the Port of Los Angeles, which saw export and import freight throughput valued at $310.7 billion. Remarkably, the Port of Los Angeles also clinched the title of the foremost import gateway, handling imports valued at $282.2 billion, surpassing the Houston gateway by approximately $173.8 billion.

Figure 3-5 Top 25 U.S. International Freight Gateways by Freight Value: 2022



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 Dec. 6, 2023. **Land:** U.S. Department of Transportation, Bureau of Transportation Statistics, North American Transborder Freight Data, available at https://www.bts.gov/transborder as of December 2023. **Water:** U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, USA Trade Online, available at https://usatrade.census.gov as of December 2023.

U.S. North American Freight

Canada and Mexico, our neighbors to the north and south, play a pivotal role in U.S. trade as the top two U.S. trade partners in 2022 (Figure 3-1). Trade with these nations relies on an array of transportation modes, including trucking, pipelines, and rail (Figure 3-6). In 2022, the total freight flow between the United States and Canada amounted to $792.7 billion, marking a 19.3 percent increase from the $664.2 billion recorded in 2021. On the southern border, the U.S.-Mexico freight flow reached $779.3 billion in 2022, reflecting a substantial 17.9 percent surge from the $661.2 billion reported in 2021.

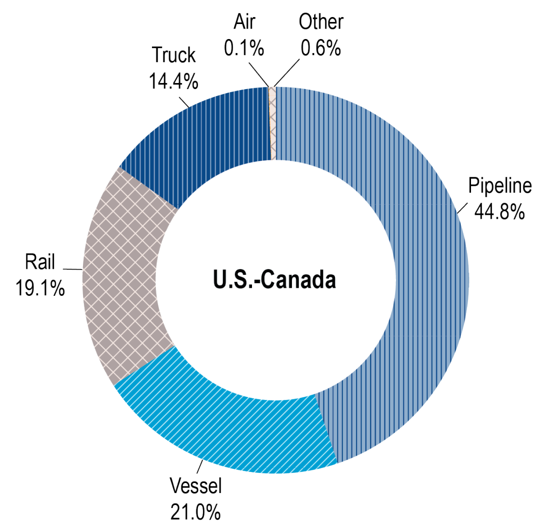
U.S.-Canada trade includes the substantial use of pipelines for transporting crude oil, natural gas, and refined petroleum products. In 2022, pipelines carried 44.8 percent of the total freight weight. This dominance far surpassed other modes, with vessels and rail capturing 21.0 percent and 19.1 percent, respectively (Figure 3-6). Trucking emerged as the fourth most influential mode in U.S.-Canada trade, commanding a 14.1 percent share of the overall freight weight.

In stark contrast, in U.S.-Mexican trade in 2022, vessels held a commanding position, accounting for 58.4 percent of trade, followed by trucking with a 32 percent share of the total freight weight. Rail transportation came next in line, capturing a 9 percent market share. Meanwhile, air freight played a relatively minor role in both U.S.-Canada and U.S.-Mexico trade flows, constituting a mere 1 percent share of the overall freight weight.

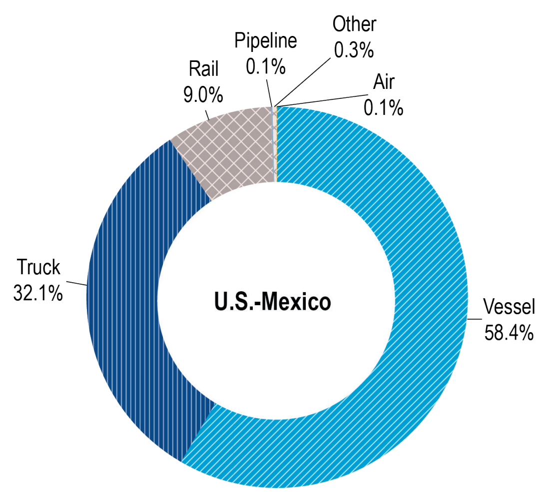
Inbound trucks and trains crossing the Texas border in 2022 moved about 47.7 million and 16.4 million tons, respectively. Ten states—Texas, Illinois, Michigan, California, New Jersey, Ohio, Florida, Georgia, Tennessee, North Carolina—accounted for 91.6 percent of all

Figure 3-6 Modal Shares of U.S. Trade with Canada and Mexico: 2022

A. Modal Shares in U.S.-Canada Trade in Short Tons, 2022; Total Short Tons = 442.3 Million



B. Modal Shares in U.S.-Mexico Trade in Short Tons, 2022; Total Short Tons = 400.3 Million



NOTE: *Other* includes imports into free trade zones, mail, and unknown.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Freight Data, available at https://www.bts.gov/transborder as of September 2023.

freight moved. In 2022, about 22.8 million and 17.2 million tons were moved on inbound trucks and trains, respectively, across the Michigan border. In addition to Michigan, this freight was destined to six other states—Minnesota, Ohio, Indiana, Illinois, Texas, and California and accounted for 78.8 percent of all freight moved [FAF, USDOT BTS and FHWA 2022].

Shifts in Containerized Freight

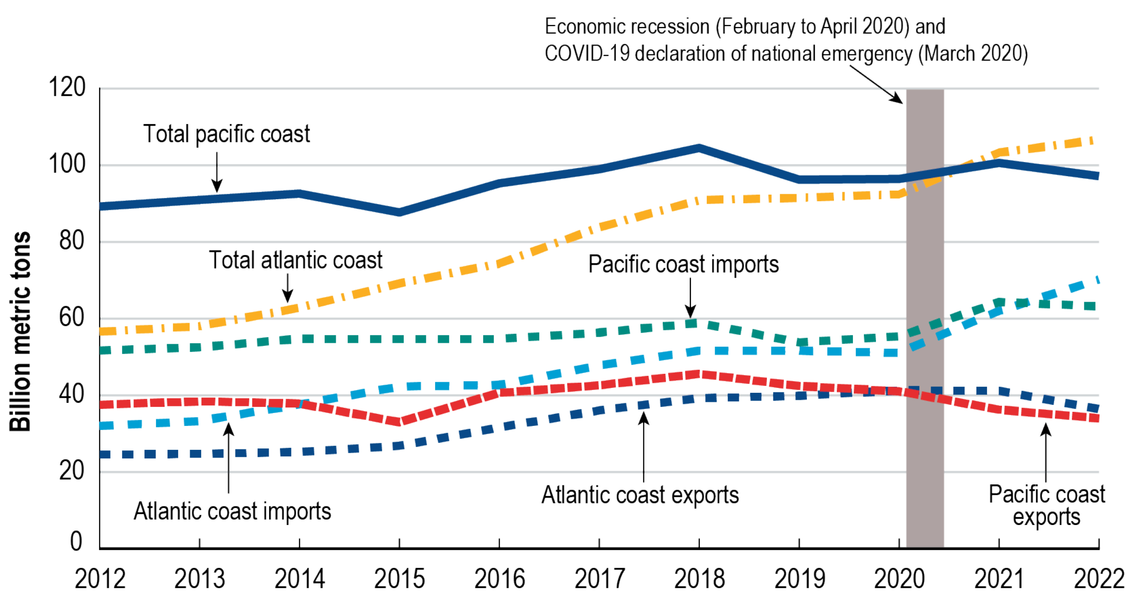
The U.S. west coast to U.S. east coast supply chain shift of Middle Eastern and Asian countries[4] containerized imports and exports observed in 2021 became even more pronounced in 2022, as carriers continued to take advantage of improved capabilities of the Suez Canal and U.S. east coast ports, leading to greater connectivity to liner shipping networks of U.S. east coast ports, as discussed herein.

As Figure 3-7 shows, U.S. west coast ports 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 imports and growth in exports over the past 10 years, ultimately surpassing U.S. west coast ports in 2022. U.S. east coast ports imported 70.2 billion metric tons in 2022 compared to 63.2 billion imported metric tons for the U.S. west coast ports the same year.

Export volumes also show a decline in market share for U.S. west coast ports in 2022, with U.S. east coast ports and U.S. west coast ports handling 36.5 and 34.0 billion tons, respectively. Notably, both coasts show a decline in export volumes since COVID-19 year 2020.

[4] The U.S. Census Bureau combines Middle Eastern and Asian countries as Asia; the following countries are included in 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.

Figure 3-7 U.S. East Coast and West Coast Asian Containerized Freight Volumes: 2012–2022



SOURCE: U.S. Department of Commerce, Census Bureau, Economic Indicators Division, available at http://usatrade.census.gov as of November 2023.

The overall U.S. east coast ports' share of container volumes was even more pronounced in 2022. U.S. east coast ports container volume surpassed that of U.S. west coast ports for the first time in 2021 after showing 10 years of continuous growth since 2012. In 2021, U.S. east coast ports and U.S. west coast ports handled 103.3 billion tons and 100.6 billion tons, respectively. The gap favoring U.S. east coast ports widened in 2022, with U.S. east coast ports handling 106.7 billion tons versus 97.2 billion tons for U.S. west coast ports.

Figure 3-7 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. Further, average annual growth rates for the two-year period following COVID-19 year 2020 show dramatic differences, with U.S. Atlantic coast ports averaging growth rates of 7.5 percent versus 0.5 percent for U.S. west coast ports for the same two-year period.

The Liner Shipping Connectivity Index (LSCI), developed by the United Nations Conference on Trade and Development (UNCTAD) in 2004, serves as an important metric for evaluating the extent of connectivity between countries, ports, and the global shipping network. Ports that achieve high LSCI scores enjoy a notable advantage, as they can provide a wider array of shipping options to shippers in comparison to ports with lower network connectivity.

Figure 3-8 presents the U.S. ports having the top 20 LSCI scores, reflecting data for the years 2021 and 2022. These scores are calculated as averages derived from quarterly reports in each respective year. The success of U.S. east coast ports in securing a larger share of the Asian market can be attributed, at least in part, to their ability to establish more robust connections with global shipping networks from expanded capacity and capability to handle larger vessels

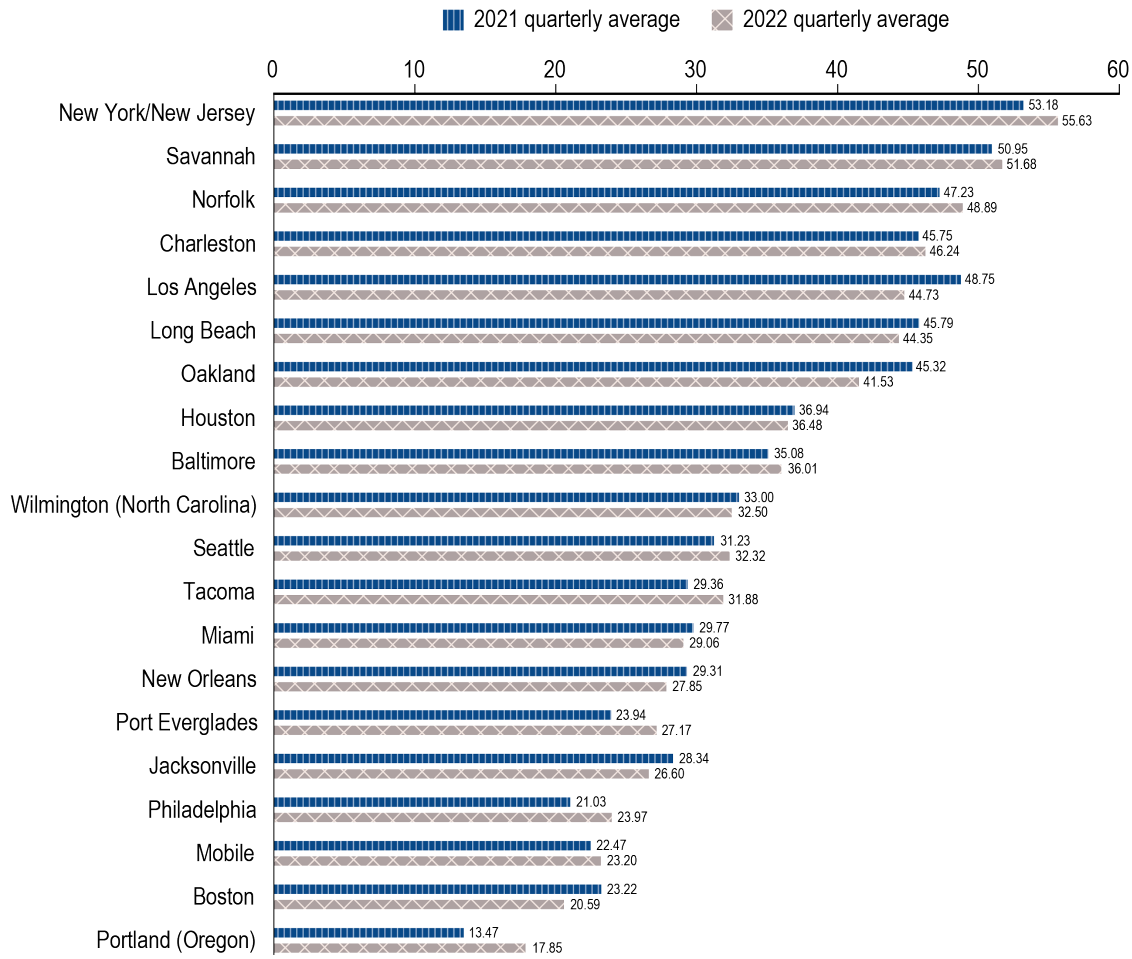
In 2022, several U.S. east coast ports—New York/New Jersey, Savannah, Norfolk, and Charleston—secured the top four positions in terms of connectivity. Remarkably, six other U.S. east coast ports also made it to the top-20 list. Meanwhile, on the U.S. west coast, ports such as Los Angeles, Long Beach, and Oakland, ranked fifth, sixth, and seventh, respectively, were joined by three other U.S. west coast ports in the top 20.

The prevalence of U.S. east coast ports in the top 20 can be attributed to supply chain shifts from the U.S. west coast to the U.S. east coast. These east coast ports have significantly expanded their capacity and capabilities in recent years to meet the growing demands of shipping lines. Additionally, the inclusion of four U.S. gulf coast ports (Houston, New Orleans, Mobile, and Tampa) in the top 20 reflects their noteworthy port improvements. These improvements have been rewarded with the presence of neo-Panamax vessels transiting the Panama Canal, as shipping lines seek alternative intermodal connections compared to west coast options.

Overall, 11 of the top 20 connected ports have improved their scores from 2021 to 2022, with 7 of these improvements occurring among U.S. east coast ports. However, U.S. west coast ports, including Los Angeles, Long Beach, and Oakland, experienced declines in their scores during this period. Los Angeles recorded the most significant decline (4.02) among the top 20 connected ports and lost its 2021 place as the third highest LSCI port. On a positive note, ports like Portland (OR), Tacoma, and Seattle

[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 3-8 U.S. Top 20 Container Port Liner Shipping Connectivity Index: 2021 and 2022



SOURCE: 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 September 2023.

demonstrated higher scores in 2022 compared to their 2021 ratings, likely attributable to freight diversions from Los Angeles, Long Beach, and Oakland.

Freight Transportation Performance

The Nation's freight transportation network is a complex system with numerous nodes and links, each capable of becoming a bottleneck that can impact overall freight transportation performance. The COVID-19 pandemic brought heightened attention to these supply chain bottlenecks. An effective way to gauge supply chain performance is by examining the movement of marine containers as they traverse various links (such as ships, roads, rail, and barges) and nodes (including marine terminals, customs, border posts, free zones, and distribution centers). These links and nodes are also important within port areas, where container ships navigate between the port's entrance buoy to berths and containers are loaded, discharged, stored, and processed through gate facilities. The supply chain disruptions experienced recently have placed substantial stress on many of these nodes and links throughout the network, some of which are monitored by the Bureau of Transportation Statistics with the use of various freight performance indicators.

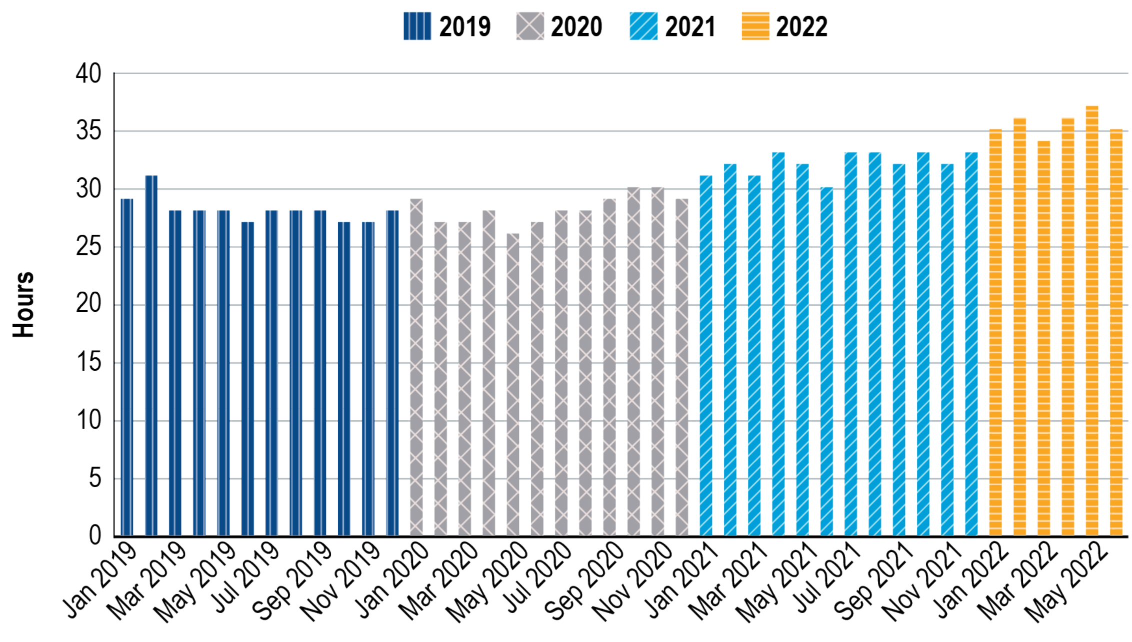
Container Port Performance

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 to measure the time the vessel spends at the berth, referred to as container-vessel dwell time.

Figure 3-9 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-19-related demand [USDOT BTS 2022b]. The impact of COVID-19-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 3-10 illustrates the impact larger vessels have had at the United States' largest container

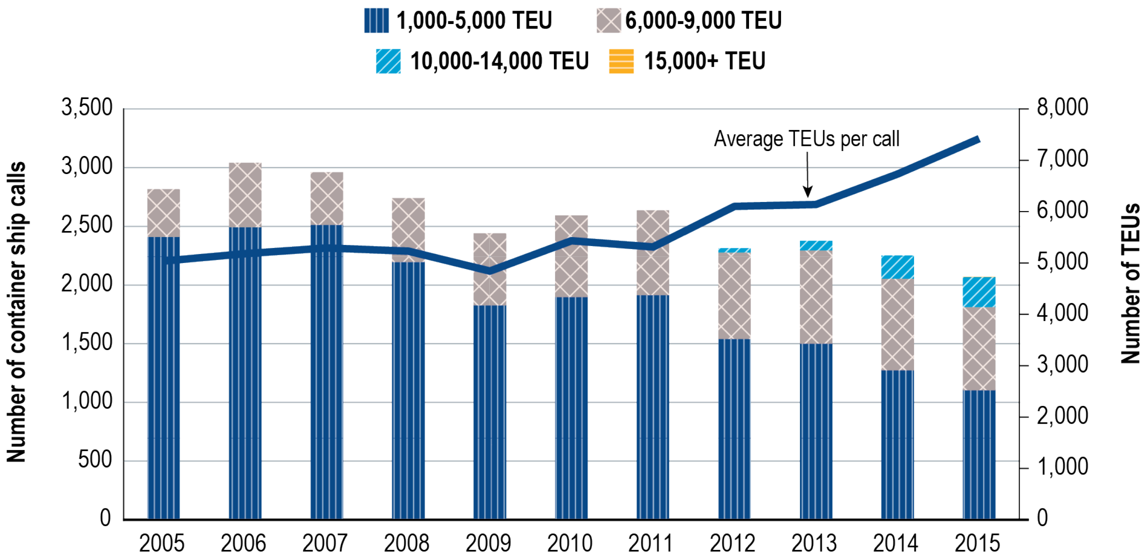
Figure 3-9 Average Container Vessel Dwell Time for Top 25 U.S. Container Ports: 2019–June 2022



NOTE: 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.

SOURCE: 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 October or November 2023.

Figure 3-10 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.

SOURCES: 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 as of October or November 2023.

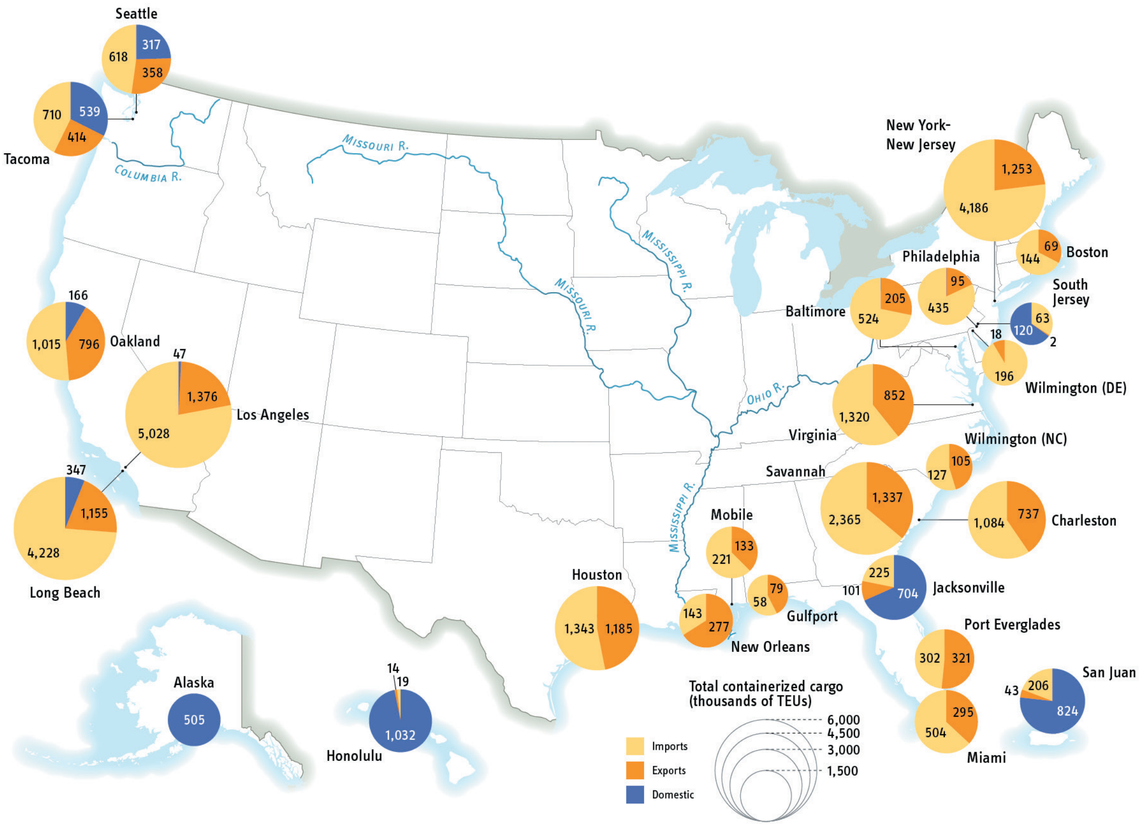
port complex in San Pedro Bay, which includes the ports of Los Angeles and Long Beach.

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 TEU, increased from an average of 5,039 TEU per call in 2005 to 7,420 TEU 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.

Figure 3-11 identifies the top 25 U.S. 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 3-5 presents the World Bank's global rankings of these ports for each port's overall rank by vessel size category.

The World Bank conducts an annual assessment of global container port performance, using indicators that include vessel waiting time (the duration a vessel remains anchored), the time it takes for a vessel to transit from the entrance buoy to the berth, and the vessel's berth time [WBG 2022]. These rankings are indicative of how efficiently these ports manage vessels of various sizes and different call sizes, acknowledging that larger vessels, as measured in TEU capacity, will spend more time at berth. The 2022 assessment draws from vessel AIS data and carrier operational timestamps, covering 350 container ports worldwide, a slight reduction from the 370 ports evaluated in 2021.

Figure 3-11 U.S. Top 25 Container Ports Based on Twenty-Foot Equivalent Units (TEUs): 2020



SOURCE: U.S. Army Corps of Engineers, Navigation Data Center, personal communication, special tabulation, November 12, 2020, and November 2, 2021, as of October or November 2023.

Table 3-5 presents the 2021 and 2022 World Bank container port rankings for the top 10 container volume ports in the United States. Notably, 6 of these top 10 ports improved their overall rankings from 2021. However, in 2022, 8 out of the top10 ports found themselves ranked in the bottom third among the 350 ports evaluated by the World Bank for 2022. These lower rankings reflect the congestion challenges these ports faced as they adapted to shifting demand patterns. As previously mentioned, 11 of the top-20 U.S. ports in terms of the Liner Shipping Connectivity Index improved their connectivity compared to the previous year. This shift of liner carriers to ports with improved connectivity placed some stress on these ports' capacity to handle the increased liner calls. Consequently, this is reflected in longer vessel turnaround times, as evident from the World Bank's rankings.

Despite dropping 26 positions in its World Bank ranking compared to 2021, Virginia emerged as the highest performing U.S. port in 2022. It also secured the top position in each of the five vessel size categories. In contrast, Charleston experienced the most significant drop in overall ranking among the top 10 U.S. ports, falling 211 places from 2021 to 2022. The data also highlight that ports faced greater challenges when serving vessels in the 1,500–5,000 TEU capacity category. For this category, ports averaged a ranking of approximately 248, compared to an average ranking of 176 in the next highest vessel size category. The best average ranking, 79, was accorded to ports in the >13,500 TEU category. These rankings underscore that not all vessel size categories receive the same level of service, emphasizing the ongoing challenges port operators encounter in efficiently allocating berths and equipment, particularly with multiple vessel calls involving vessels of varying capacities.

Rail and Truck Performance

Figure 3-12 presents the average rail terminal dwell times for the seven major railroads from January 2, 2021, to September 2, 2023. Dwell time refers to the average time in hours a freight car spends within terminal boundaries of the 10 largest terminals for each of the railroads. The measurement of dwell time begins with the train's arrival, customer release, or interchange receipt and ends with the train's departure, a customer receives the car from the railroad, or the freight car is transferred to another railway. Notably, Norfolk Southern (NS), Burlington Northern and Santa Fe Railway (BNSF), and Chessie System and Seaboard Coast Line Railroad (CSX) experienced their highest dwell times the week of December 31, 2022, with dwell times of 35.2, 37.5, and 31.2 hours, respectively. Meanwhile, Kansas City Southern Railway Company (KCS) (32.10 hours), Union Pacific (UP) (29.7 hours), and Canadian National Railway (CN) (23.31 hours) all recorded peak dwell times the week of February 20, 2020. Canadian Pacific (CP) (26.7 hours) reached its highest dwell time the week of March 4, 2023, and UP experienced peak dwell times the week of February 26, 2022.

Table 3-6 presents the average system-wide annual dwell times by railroad and geographic category for the years 2020 to 2022. While all railroads, except for CN and KCS, saw some increases in dwell times from 2020 to 2022, the most significant rise occurred among the Eastern railroads. Specifically, CSX and NS reported average dwell time increases of 4.94 and 7.33 hours, respectively. This stands

Table 3-5 World Bank Container Port Performance Index Rankings of Top 10 U.S. Container Ports: 2022

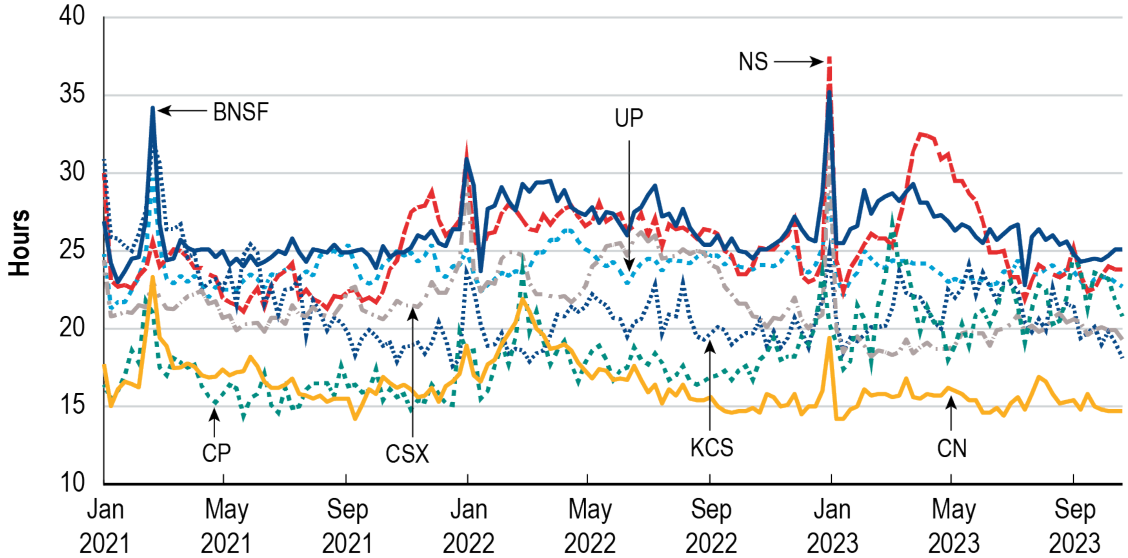
Port	Overall rank 2021	Overall rank 2022	2022 Rank by vessel size ranges				
			<1,500 TEU	1,501–5,000 TEU	5,001–8,500 TEU	8,501–13,500 TEU	>13,500 TEU
Los Angeles	370	337	95	283	195	171	96
Long Beach	348	328	242	329	204	160	103
NY/NJ	251	309	204	279	164	156	72
Savannah	367	350	258	326	217	178	105
Houston	119	338	189	240	185	177	0
Virginia	23	49	64	63	73	64	55
Oakland	359	345	216	280	189	172	102
Charleston	130	341	150	274	193	167	100
Tacoma	345	327	0	190	184	163	85
Seattle	336	293	0	214	160	153	69

KEY: TEU = twenty-foot equivalent unit.

NOTE: The higher the number for the ranking, the poorer the performance

SOURCE: World Bank, Container Port Performance Index 2022, available at https://openknowledge.worldbank.org/entities/publication/6a51b12c-77cd-4236-be5b-13e468fe0cca as of September 2023.

Figure 3-12 Average Rail Terminal Dwell Time in Hours: January 2, 2021–September 2, 2023



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight Indicators, available at https://www.bts.gov/freight-indicatorsas of September 2023.

in contrast to the Western and Central railroads, where dwell time increases ranged from 0.38 to 2.93 hours.

The shift of Asian container trade to U.S. east coast ports, which increased container volumes, has spurred greater demand for rail freight movements among the Eastern railroads. This has led to increased pressures on intermodal rail operations, resulting in extended dwell times at Eastern railroad terminals. The data indicate that the average dwell time for 9 out of 10 major CSX terminals increased from 2021 to 2022, and 7 out of NS's 10 major terminals also experienced increased dwell times [BTS Freight Indicators 2023]. Among the 18 major Eastern railroad terminals reporting 2022 data, only one showed a dwell time decrease that year. Notably, CSX's Louisville terminal witnessed the most significant increase in dwell time among the 70 major terminals of the 7 railroads, rising from 24.3 hours in 2021 to 37.0 hours in 2022.

As previously noted, the growing share of Asian cargo flowing through east coast ports has increased congestion in these ports, as evidenced by vessel dwell times. This not only leads to more time spent by vessels in port, but also requires a larger number of trucks to

Table 3-6 Average Railroad System-Wide Annual Dwell Time Hours: 2020–2022

	Average dwell times (hours)		
Railroad system	**2020**	**2021**	**2022**
Western railroads			
BNSF	26.62	25.32	27
UP	22.87	23.8	24.3
Central railroads			
CP	15.27	16.5	18.2
CN	17.07	16.7	16.8
KCS	20.31	22.5	20.2
Eastern railroads			
CSX	18.26	21.6	23.2
NS	18.77	23.9	26.1

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight Indicators, available at https://www.bts.gov/freight-indicators as of September 2023.

deliver the increased volume of containers along the U.S. east coast and to inland destinations, including the Midwest. As explained in TSAR 2022, this shift is primarily attributed to the expanded capabilities of the Suez Canal and several east coast ports to accommodate larger vessels.

Table 3-7 displays the average truck speeds in the Port of Los Angeles/Long Beach (PLA) and the Port of New York/New Jersey (PNY) for the years 2019–2022. Truck speed refers to the average speed of trucks on the National Highway System within 5 miles of the port. The data indicate that average truck speeds generally increased each year during this period. Notably, PNY trucks tended to travel at lower average speeds than PLA trucks, indicating greater traffic congestion at PNY. Interestingly, both ports saw their highest truck speeds during the second quarter of each year from 2019–2022, suggesting seasonal variability of cargo volumes handled at the ports. However, PLA's average truck speed remained consistently higher than PNY's average truck speed for the same quarter, with PLA's average truck speeds also increasing for each quarter from 2019–2022. The truck speed data indicate higher congestion at PNY.

Emerging Issues: Disruptions to Supply Chains from Drought

Weather can affect supply by disrupting production of material to be moved, especially in agriculture, as well as disrupting operation of the transportation system. Waterborne commerce is particularly affected by droughts in addition to disruptions from extreme weather events as noted in Chapter 1 State of The System.

The Mississippi River system traditionally serves as a critical artery for transporting goods across the 12 states bordering the Upper Mississippi River system and Louisiana. In 2020 and 2021, the transportation of freight by water saw incremental gains in market share, rising from 56 to 57 percent (as illustrated in Figure 3-13).

Table 3-7 Average Truck Speed in the Port of Los Angeles/Long Beach (PLA) and the Port of New York/New Jersey (PNY): 2019–2022

Port	Average speed by quarter				Average annual speed
	1st	2nd	3rd	4th	
Port of NY/NJ					
2019	18.14	17.80	17.86	17.76	17.89
2020	18.59	20.31	19.42	19.17	19.37
2021	19.99	19.96	19.74	19.33	19.75
2022	19.90	19.33	19.60	19.00	19.46
2019–2022 average speed by quarter	19.15	19.35	19.16	18.81	NA
Port of LA/LB					
2019	19.45	19.63	19.39	19.12	19.40
2020	19.61	20.43	19.88	20.07	20.00
2021	20.87	20.65	20.28	20.38	20.55
2022	20.59	20.73	21.03	20.87	20.81
2019–2022 average speed by quarter	20.36	20.60	20.40	20.44	NA

KEY: NA = not applicable.

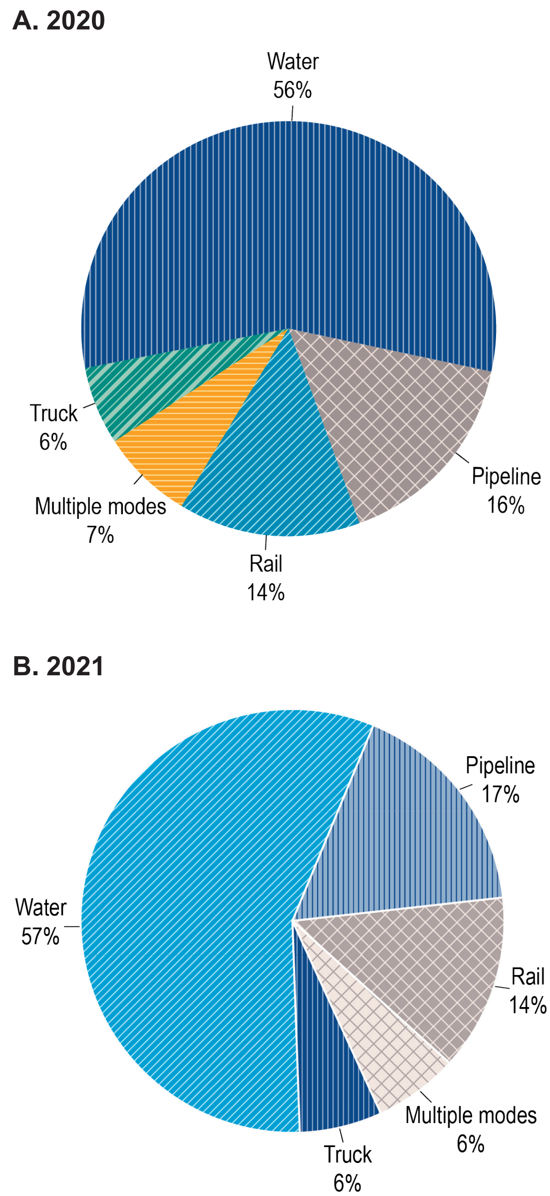
SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight Indicators, available at https://www.bts.gov/freight-indicators as of September 2023.

During the same period, market shares in trucking remained relatively stable, while pipeline transport increased by approximately 1 percent. Conversely, rail and multiple modes of transportation experienced declines. These statistics underline the significance of Louisiana as a key hub for facilitating the movement of goods, with nine states contributing to 86.4 percent of inbound shipments to Louisiana and 13.6 percent of outbound shipments from the state.

In 2022, the flow of barges along the Mississippi River was hampered by reduced water levels caused by what is termed a "flash drought." This unusual weather phenomenon, which had previously occurred mainly over the Missouri and Ohio tributaries, now centered itself over the Central United States, affecting the Mississippi River. The flash drought led to increased soil absorption of water and heightened water evaporation, consequently diminishing water levels along the Mississippi River, particularly between Cairo, Illinois and Memphis, Tennessee. As reported in TSAR 2022, these lower river draft conditions prevented barge fleets from operating at full capacity, resulting in a significant surge in barge freight rates. Prices skyrocketed from approximately $11–$12 per ton during the summer of 2022 to over $71 per ton in October 2022.[6] This sudden cost increase prompted some modal shifts, with businesses turning to rail and trucking options.

Low water levels became a recurring issue in 2023. While grain shippers and barge operators adapted by reducing barge capacity to prevent barges from becoming stranded, this practice of light-loading caused a further tightening of the barge supply, ultimately leading to even higher freight rates. As of the time of drafting this report, grain barge spot rates have surged by 42 percent compared to the same period in 2022

Figure 3-13 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 as of December 2022.

[6] InsideLogistics, "Record low water levels on the Mississippi River in 2022 show how climate change is altering large rivers", December 19, 2022, available at https://www.insidelogistics.ca/features/record-low-water-levels-on-the-mississippi-river-in-2022-show-how-cli/ accessed September 7, 2023.

and have risen by 85 percent compared to the average rates over the previous 3 years.[7]

Drought conditions have not only affected the Mississippi River but have also impacted the navigability of other rivers serving as important conduits for freight, such as the Danube, Rhine, Yangtze, Amazon, and Mekong Rivers. While these rivers may not significantly influence U.S. freight movements, the Panama Canal, where 70 percent of its freight is tied to U.S. imports and exports (Table 3-8), has faced ongoing drought-related challenges. Drought-induced reductions in water volumes within Gatun Lake, a critical water source used for meeting the water needs of 50 percent of Panama's population and facilitating vessel transits through the Canal, have compelled the Panama Canal Authority to impose draft restrictions on vessels passing through (Figure 3-14). These restrictions have reduced the allowable draft from 15.24 meters (50 feet) to 13.26 meters (43.5 feet) for Neopanamax locks and from 12.04 meters (39.5 feet) to 11.73 meters (38.5 feet) for Panamax locks between February 2022 and July 2023. Additionally, dry bulk vessels, which normally do not obtain transit reservations and hence are susceptible to extended waiting times when transit restrictions are imposed, experienced waiting times of 282.2 hours and 255.6 hours for northbound and southbound Canal transits, respectively, in August 2023.[8] U.S. shippers importing and exporting bulk commodities, especially those tied to the Mississippi River system, will incur added charges for shipping delays.

Table 3-8 Panama Canal Cargo Volumes by Principal U.S. Vessel Trade Routes, Fiscal Year 2022

Vessel trade route	Long tons (thousands)
East Coast U.S.—Asia	121,352
East Coast U.S.—West Coast South America	39,517
East Coast U.S.—West Coast Central America	25,194
U.S. Intercoastal, including Alaska and Hawaii	1,747
Europe—West Coast U.S.	5,984
East Coast U.S.—Oceania	4,301
East Coast South America to West Coast U.S.	1,018
East Coast Central America—West Coast U.S.	664
West Indies—West Coast U.S.	757
East Coast U.S.—West Coast Canada	399
East Coast U.S.—Pacific World	4,476
TOTAL U.S. vessel trade routes	205,409
TOTAL Panama Canal transits tonnage	291,749
Percent U.S transit trade tons	70.40%

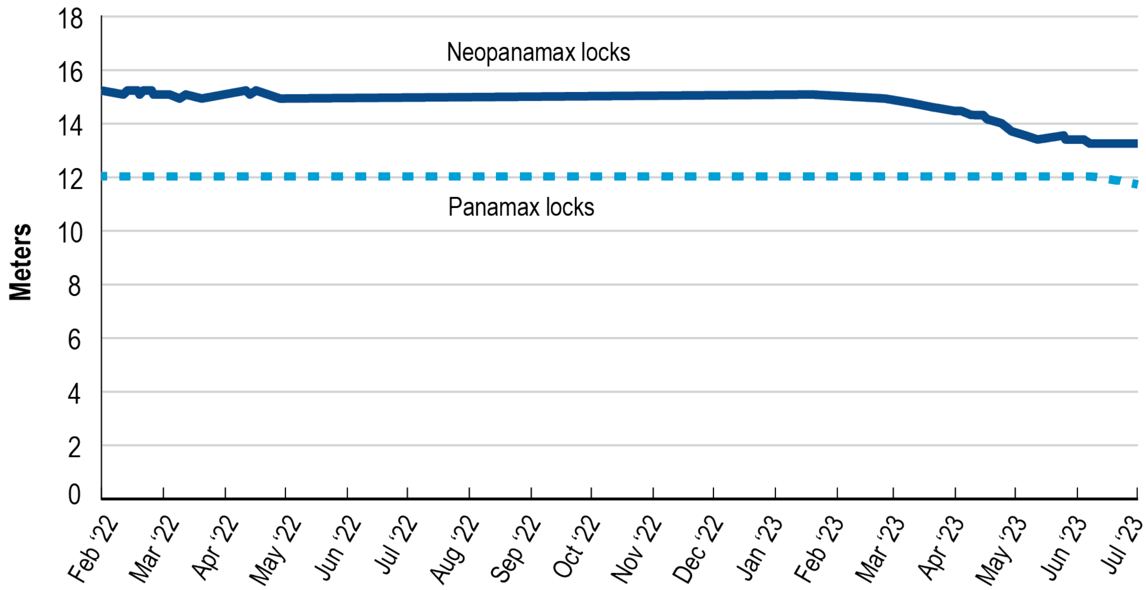
SOURCE: Statistics and Models Administration, Panama Canal Authority, available at https://pancanal.com/wp-content/uploads/2022/10/Table00.pdf, as of September 2023.

The draft restrictions also have significant implications for laden container vessels that cannot meet the new draft requirements. To navigate through the Canal, they must pay additional fees for container discharge, loading, and truck or rail transport. These added costs, along with potential delays, may prompt container ships engaged in the Asian trades to consider alternative routes. Some vessels may divert from U.S. east coast ports to U.S. west coast ports for U.S. intermodal transfers, while others may explore routes using the Suez Canal

[7] U.S. Department of Agriculture, Grain Transportation Report, August 31, 2023, p. 1, available at https://www.ams.usda.gov/sites/default/files/media/GTR08312023.pdf as of September 2023

[8] Panama Canal Authority, Historical Average Waiting Time for Panama Canal Non-Booked Transits, available at https://bidashboard.pancanal.com/t/TI/views/AverageWaitingTime/AverageWaitingTime?%3AisGuestRedirectFromVizportal&%3Aembed=y, accessed on September 2023. Note the data refer to Nonbooked transits; these are transits that are made without vessel transit reservations and are therefore subject to transit waiting times. Container ships normally obtain reservations and thus would not experience more than nominal waiting. Dry bulk vessels, which carry U.S. grains and other bulk commodities, normally do not acquire reservations and thus are susceptible to extended waiting times when the Canal Authority imposes transit restrictions, that is, the number of transits that are permitted to proceed through the Canal each day.

Figure 3-14 Vessel Draft Restrictions on the Panama Canal (in Meters) by Locks



NOTES: Panamax and Neopanamax refer to the maximum vessel size that each lock can handle. Panamax vessels typically have maximum dimensions of approximately 965 feet (294.13 meters) in length, 106 feet (32.31 meters) in width, and a draft (the submerged depth of the ship) of about 39.5 feet (12 meters). For container ships, these dimensions will allow vessels of about 4,500-5,000 TEU capacity. Ships that exceed these dimensions transit through the Neopanamax locks. Neopanamax vessels have lengths of up to 1,200 feet (366 meters), widths of up to 160 feet (49 meters), and drafts generally within the range of generally between 39.5+ feet (12+ meters) to 50 feet (15.2 meters).

SOURCE: Panama Canal Authority, Advisory to Shipping, 2022 and 2023, available at https://pancanal.com/en/maritime-services/advisory-to-shipping/ as of September 2023.

as alternatives to maintain cost-efficiency. Such diversions have the potential to impact container volumes handled by west, east, and gulf coast ports as well as rail services, as shipping companies seek the most efficient and cost-effective means of transporting goods.

Additional Data Needs

In the realm of freight transportation analysis, the pursuit of comprehensive data remains an ongoing endeavor. The latest developments in the transportation sector underline the pressing need for more up-to-the-minute and granular data on freight movements. This necessity extends to a range of aspects, including but not limited to enhancing data on the domestic transportation of U.S. foreign trade, shipping freight costs, and last-mile freight movements. This would enable analysts to gain a clearer view of the freight transportation system's performance.

In a proactive response to filling the domestic transportation data gap relative to U.S. foreign trade, BTS has embarked on a series of initiatives aimed at fortifying the foundation of freight statistics, including improvements in measuring containerized freight volumes and the accessibility and effectiveness of the containerized freight system. Notably, a milestone was reached in June 2022 with the signing of the Ocean Shipping Reform Act (OSRA) into law (Pub. L. 117-146). This legislation, in its Section 16, entrusted BTS with the responsibility to generate statistics concerning total street dwell times, that is, the duration an empty or loaded container or a bare or loaded chassis spends between exiting the gate and returning to the terminal in intermodal shipping. Moreover, BTS is now responsible for calculating the average out-of-service percentage for the chassis. The data collected by BTS encompass essential details that are needed for these performance measurements, such as information about the chassis and container operators, location data, fleet availability, and usage patterns.

The Freight Logistics Optimization Works (FLOW) initiative has been established as a USDOT/freight industry collaborative effort aimed at optimizing freight logistics.[9] The initiative represents a significant stride forward, offering industry stakeholders the opportunity to make more informed decisions by efficiently sharing and utilizing freight data. As the independent steward of this groundbreaking data-sharing initiative, BTS plays a pivotal role in managing data across a diverse spectrum of privately operated enterprises. These entities encompass shipping lines, ports, terminal operators, trucking companies, railroads, warehouses, and beneficial cargo owners, collectively contributing to the dynamic tapestry of freight transportation.

Shipping Freight Cost

BTS has made significant strides in generating performance and other data related to ports, trucking, rail, and employment figures within the freight transport industry, reported as "Latest Supply Chain and Freight Indicators."[10] While BTS provides cost indicators for specific routes, such as 40-foot container freight rates to Central China and Los Angeles to Shanghai, there is an important need for more comprehensive cost data across various components of the supply chain. Shipping freight costs encompass a range of elements, including freight rates, tariffs, and fees from shipping lines, ports, airports, trucking companies, inland water transport operators, and distribution centers. Enhanced data on these aspects is vital for monitoring cost trends, understanding the impact of events on freight expenses, and supporting policy formulation. Such detailed information would empower stakeholders, including logistics companies, manufacturers, retailers, and policymakers, to make more informed decisions, optimize operations, and contribute to the competitiveness and sustainability of the transportation sector.

Last-Mile Freight Movements

E-commerce has driven a shift in shipment patterns, making last-mile deliveries more complex due to the multitude of delivery locations. The challenges include the need for more deliveries to residential areas, which may not be designed for frequent freight vehicle use, and the requirement for someone to be available to accept packages, potentially leading to missed deliveries and additional trips.

With the growing frequency of curbside deliveries, the designation of delivery locker locations offers a potential solution for last-mile deliveries. These lockers, strategically placed near residential areas, serve as a solution to streamline last-mile deliveries by reducing the number of stops freight carriers need to make. The challenges related to curbside deliveries, including balancing the needs of various transportation users, further highlight the importance of efficient last-mile logistics. This aligns with efforts to optimize the final leg of the supply chain and overcome challenges associated with direct-to-home deliveries.

Though e-commerce demand leveled off in 2022 from its COVID-19 high in 2021, e-commerce deliveries still significantly influence last-mile freight movements by shaping the delivery patterns, creating challenges in residential and

[9] For more information on FLOW, visit https://www.bts.gov/flow.

[10] See Bureau of Transportation Statistics' "Latest Supply Chain and Freight Indicators" at https://www.bts.gov/freight-indicators#freight.

commercial areas, and necessitating innovative solutions like designated locker locations and alternative delivery methods, such as cargo bikes. Understanding and addressing these changes is crucial for optimizing the last-mile in freight transportation infrastructure.

The evolution of e-commerce has intricately reshaped last-mile freight movements, presenting both challenges and opportunities. With a surge in delivery points in residential areas and the necessity for someone to be present for package acceptance, the last mile has become more complex. To effectively monitor and address these dynamics, essential data needs include insights into delivery density, rates of missed deliveries, the utilization of designated locker locations, and the impact of curbside deliveries on transportation users. Metrics on alternative delivery methods, ongoing e-commerce trends, consumer preferences, and the readiness of infrastructure in various areas are important for stakeholders seeking to optimize last-mile logistics. As e-commerce continues to exert a significant influence on last-mile freight, the acquisition and analysis of such data become paramount for informed decision making, route optimization, and the development of innovative solutions to enhance the efficiency and responsiveness of the final leg of the supply chain.

BTS developed a technical report on eCommerce and Home Delivery Logistics in 2023. Both the eCommerce technical report and the Home Delivery Logistics provided findings, a literature review, and identified data gaps and made recommendations for statistical products, and potential data programs that may fill these gaps. These potential data programs and statistical products should provide a timely, accurate, and complete picture of the transportation impacts, including goods movement and travel (both long distance and last-mile) associated with the four aspects of eCommerce.

Based on the literature and sources reviewed to date, it appears that analyzable data on eCommerce and Household Logistics Data and its transportation impacts are scarce. The scarcity of usable statistics implies that a statistical understanding of eCommerce and its transportation impacts will need to be based on inference, comparison, estimation, and modeling. While less satisfying than a comprehensive, data-driven analysis, a well-structured high-level approach should yield valuable policy guidance and information for transportation planners.

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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 nontransportation industries (e.g., manufacturing) to produce goods and services.
- Demand for transportation services as an economic indicator.

Highlights

- Transportation accounted for 9.0 percent of the U.S. gross domestic product in 2022, up from 8.4 percent in 2021 and from 7.7 percent in 2020.
- 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 has grown since the 2020 economic recession and reached a new all-time high in August 2022. It fluctuated in 2023 but, overall, grew month-over-month for most of 2023.
- Transportation and transportation-related industries employed 15.8 million people (10.4 percent of the U.S. labor force) in 2022—up 5.0 percent from 2021.
- Employment in the transportation and warehousing sector grew at a faster rate than that in other transportation-related industries (8.2 versus 2.7 percent, respectively).
- The racial/ethnic composition of the labor force in the transportation and warehousing sector is more diverse than the U.S. labor force, employing a larger share of minorities than the overall U.S. labor force.
- The unemployment rate in the transportation and warehousing sector has fallen since the May/July 2020 all-time high. The transportation and warehousing unemployment rate was 4.9 percent in September 2023; up from 3.3 percent in September 2019.
- Layoffs and discharges remain stable after peaking during the February to April 2020 economic recession. Job openings are above pre-pandemic levels but down from their December 2021 peak.

Continued »

Highlights Continued

- Adjusted for inflation, total investment in new transportation infrastructure and equipment increased 7.3 percent from 2021 to 2022.
- The downward trend in transportation CPI means that transportation contributed less and, from March to July 2023, dampened year-over-year price increases in 2023.
- The prices consumers faced for transportation began to decline in July 2022 and have fallen month-over-previous month in 8 of the 15 months since the June 2022 peak of 134.9 to 132.3 in September 2023.
- Similar to consumers, businesses purchasing transportation services faced falling costs in 2022 as seen through the truck spot rates, inland waterway transport rates, and ocean freight rates each returning to their pre-pandemic levels.
- In 2022, the costs for rail, truck, air, and water transportation services, as shown by the Producer Price Index (PPI) reached their all-time high, suggesting an increase in the costs businesses face for providing these transportation services.
- Highway construction costs rose an unprecedented 26 percent in 2022; seven percentage points more than the previous all-time annual increase of 20 percent in 2005 per the National Highway Construction Cost Index..

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

The average overall inflation rate in 2023 was 4.3 percent [USDOL BLS 2023a]. Inflation can spur growth, but unchecked, inflation can erode the purchasing power of consumers. Economists use the Consumer Price Index (CPI) to measure inflation. Specifically, the CPI measures the average change over time in the prices paid by consumers for a basket of goods and services, including transportation goods and services, such as vehicle insurance, fuel, and public transportation. This chapter discusses transportation's contribution to inflation and the price changes due to inflation.

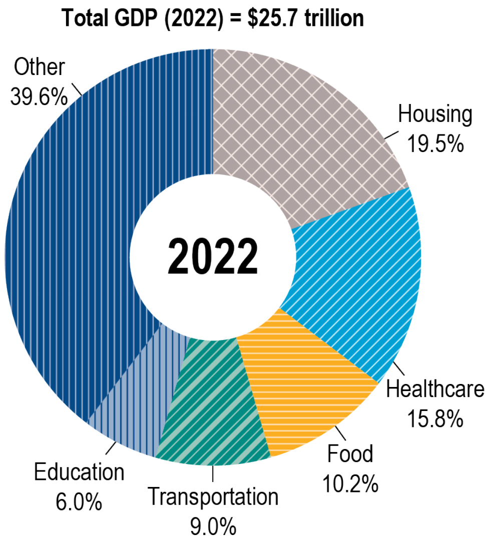
Transportation's Contribution to GDP

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 single year (without double counting the intermediate goods and services used to produce them).[1] Figure 4-1 divides GDP into six categories (transportation, healthcare, housing, food, education, and all other goods and services). In 2022, transportation accounted for 9.0 percent of GDP, up from 8.4 percent in 2021 and 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).

[1] 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.

Figure 4-1 Shares of U.S. GDP: 2022



NOTE: Percents may not add to 100 due to rounding.

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 2023.

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 specific transportation services to GDP using the Transportation Satellite Accounts (TSAs).[2] In addition to the contribution of for-hire transportation as measured by the Bureau of Economic Analysis (BEA), BTS developed the TSAs to include the contribution of in-house transportation services to the economy and the contribution of transportation carried out by households using household vehicles.[3]

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.[4] In-house transportation services (air, rail, truck, and water) provided by nontransportation 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

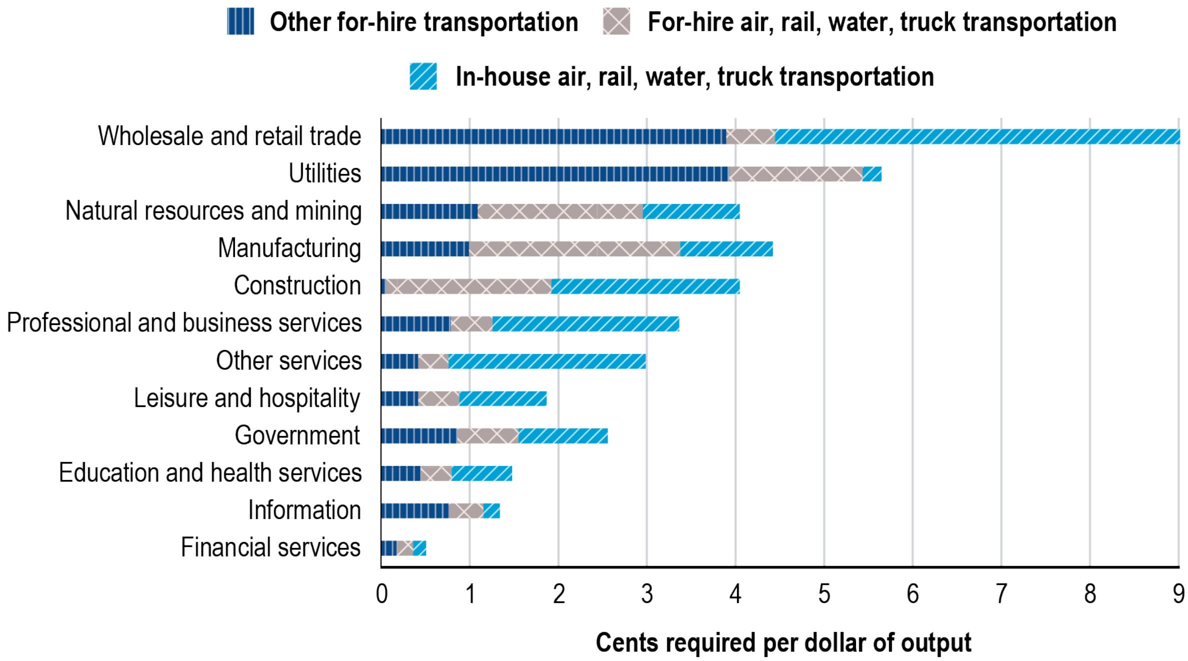
Transportation indirectly contributes to the economy by enabling the production of goods and services by nontransportation industries. The amount of transportation services required to produce each dollar of output indicates how much a sector depends on transportation

[2] For further information on how to measure transportation's contribution to GDP, refer to The Contribution of Transportation to the Economy in BTS' *Transportation Economic Trends*, available at https://www.bts.gov/tet as of October 2023.

[3] 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 nontransportation 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 October 2023.

[4] 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 October 2023.

services. In 2021, the wholesale and retail trade sector required the most transportation services, 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 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 [USDOT BTS 2023a]. For-hire transportation services makes up approximately 60 percent of total transportation services. COVID-19 disrupted the U.S. economy, causing decreases in industrial production and manufacturers' shipments, which in turn reduced the demand for freight transportation services as seen through declines in the Freight TSI.

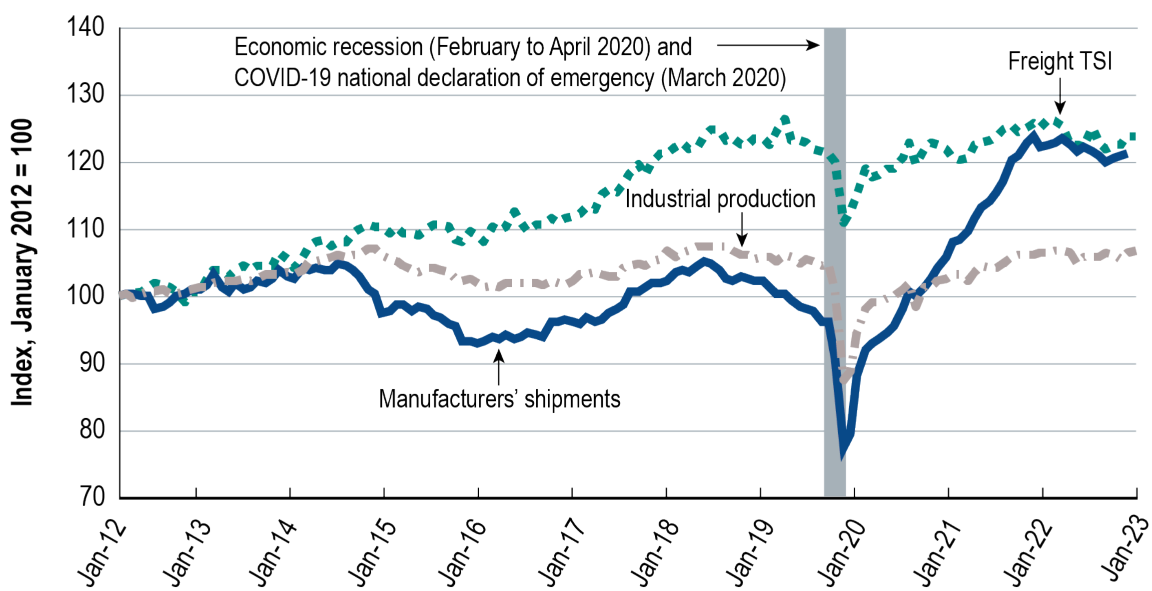
The Freight TSI began to rise in May 2020 as COVID-19 restrictions eased, mirrored by increases in industrial production and manufacturers' shipments (Figure 4-3). Manufacturers' shipments reached a new all-time high in July 2022 due to significant economic growth seen through a 64.2 percent increase in new manufacturing orders from April 2020 (COVID-19 low) to July 2022 and a 14.8 percent increase in real GDP from Q1 of 2020 through Q3 of 2022 [FRED 2023]. Increases in manufacturers' shipments as well as industrial production create demand for freight transportation services which in turn caused the Freight TSI to rise and reach a new all-time high in August 2022. In 2023 the Freight TSI fluctuated, overall increasing 1.3 percent from January 2023 to August 2023.

BTS research shows that changes in the TSI occur before changes in the economy, making the TSI a potentially useful economic indicator.[5] This relationship is particularly strong for freight traffic as measured by the Freight TSI. The TSI's increase between January 2020 and August 2023 correlates with increases in manufacturers' shipments and industrial production as well as real GDP, which are indicators of economic growth.

Figure 4-4 illustrates the relationship between the Freight TSI and the national economy from January 1979 through June 2023. 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 an economic slowdown begins and hits a trough and turns upward before the economic slowdown ends. The TSI indicated an economic slowdown in August 2019. The slowdown deepened

[5] Refer to 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 October 2023.

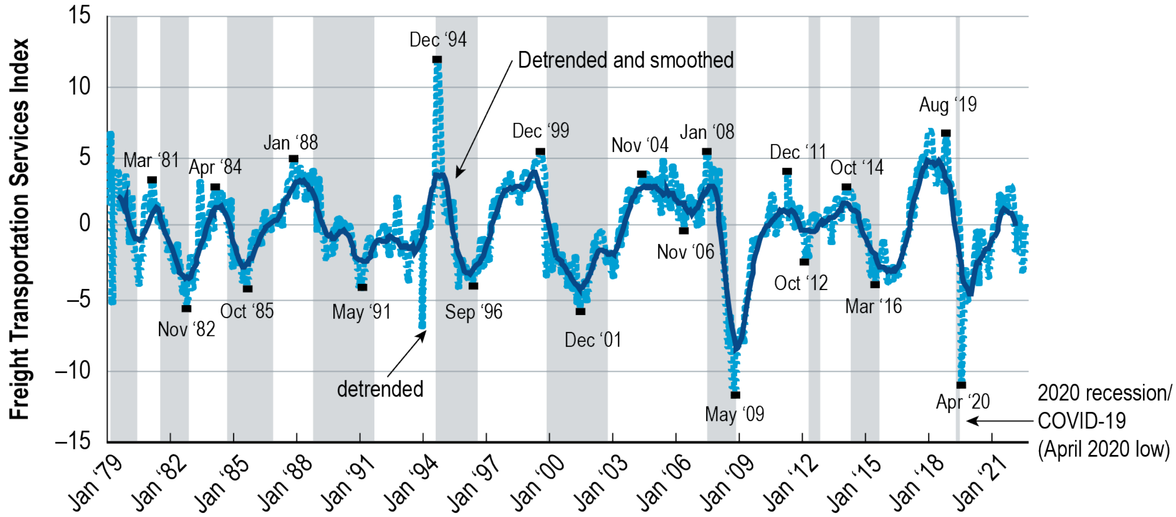
Figure 4-3 Industrial Production, Manufacturers' Shipments, and Freight Transportation Services Index (Seasonally Adjusted): January 2012–August 2023



NOTES: The Transportation Services Index is a weighted and chained index. All indexes were 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 August 2023. **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 August 2023. **Freight TSI:** U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Services Index, available at www.transtats.bts.gov/OSEA/TSI/ as of October 2023.

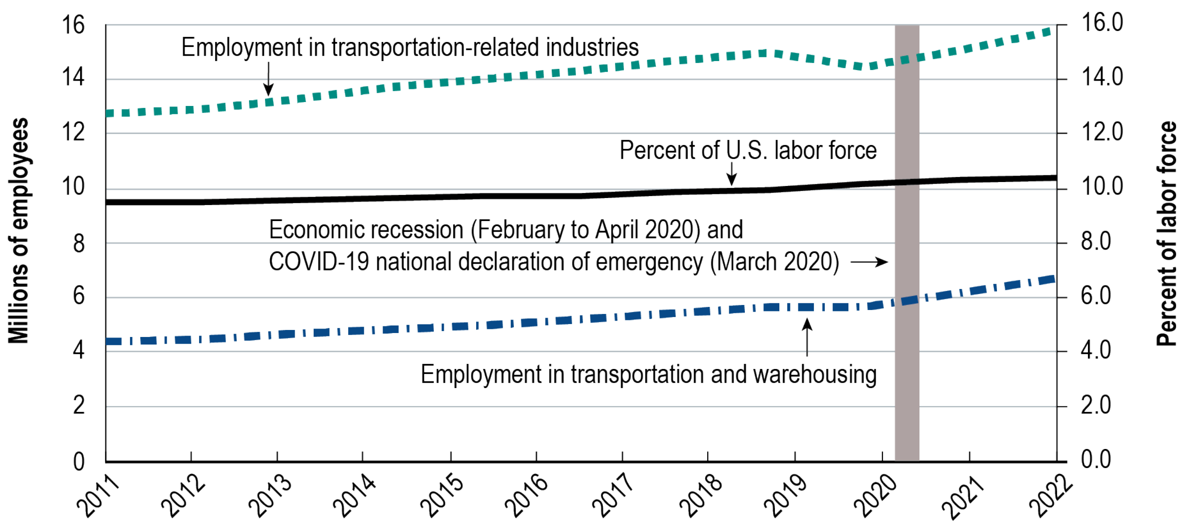
Figure 4-4 Freight Transportation Services Index and the Economic Growth Cycle: January 1979– June 2023)



NOTES: Shaded areas indicate decelerations in the economy, and areas between are accelerations in the economy (growth cycles). The endpoint for deceleration began 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 October 2023.

Figure 4-5 Transportation-Related Labor Force Employment in the United States: 2012–2022 (Millions)



NOTES: The 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 October 2023.

in early 2020 when the economy entered a recession, reaching a low in April 2020 and then entering a period of economic growth. The detrended and smoothed TSI began a downward trend following May 2022. This possibly indicates an economic slowdown, but it is unclear due to insufficient data since May 2022 to make the determination.

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 15.8 million people (10.4 percent of the U.S. labor force) in 2022 in a variety of roles, from driving buses to manufacturing cars, to building, operating, and maintaining ports and railroads [USDOT BTS 2023b]. In 2021 the total number employed in transportation recovered from the decline in 2020 (caused by the February to April 2020 economic recession and COVID-19) and continued to grow, increasing 5.0 percent from 15.1 million in 2021 to 15.8 million people in 2022.

The transportation and warehousing sector directly employed 6.7 million U.S. workers in 2022 — an increase of 8.2 percent from 2021. The 6.7 million workers comprised 4.4 percent of the U.S. labor force (Figure 4-5), up from 4.0 percent in 2020 and 4.2 percent in 2021 [USDOT BTS 2023b]. Employment in transportation-related industries (e.g., automotive manufacturing) likewise increased from 2021 to 2022 (by 0.2 million). However, from 2021 to 2022, employment grew slower in transportation-related industries (2.7 percent) than in the transportation and warehousing sector (8.2 percent). Additionally, employment in transportation-related industries has not returned to the pre-COVID-19 level, remaining 0.2 million below the 2019 value of 9.3 million. By contrast, employment in the transportation and warehousing sector fell below the 2019 level in 2020 but then rose above the 2019 level in 2021, remaining above it in 2022.

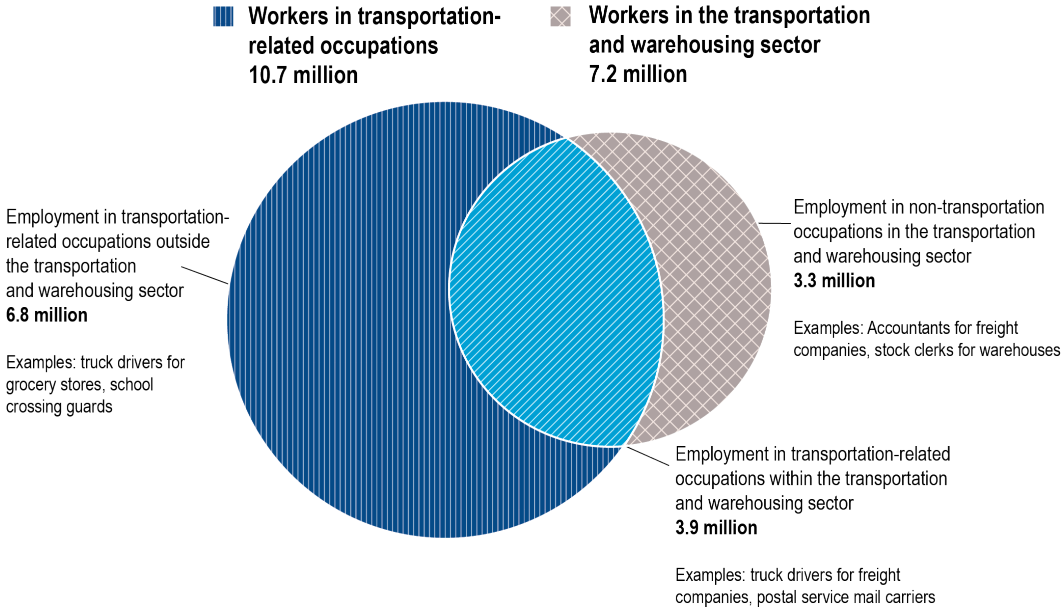
The total count of workers in the transportation industry includes all occupations, such as administrative staff employed by the trucking industry. Some workers holding transportation occupations work outside of the transportation and warehousing sector, such as truck drivers employed by retail stores (Figure 4-6).

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 than they do in the overall U.S. labor force by about 10 percentage points (Figure 4-7). This difference is mainly attributable to persons who identify as Black or African American accounting for nearly 10 percentage points more of the labor force in the transportation and warehousing sector than found in 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 they do in the overall U.S. labor force. The racial and ethnic differences between the transportation and warehousing labor force versus the U.S. labor force have remained relatively stable over the past decade (Figure 4-8).

Transportation Wages

Workers with transportation occupations earned a lower average hourly compensation ($33.60) than workers in all occupations ($43.07) in Q1 2023 [USDOL BLS 2023b]. Notably, wages for all occupations increased 5.3 percent from Q1 2022 rising from $40.90 to $43.07, while transportation

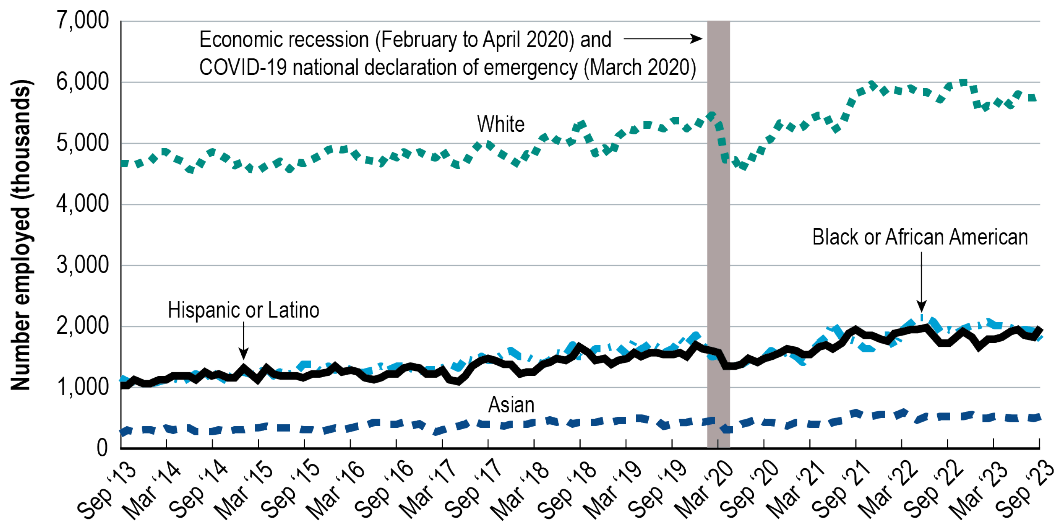
Figure 4-6 Relationship Between the Transportation and Warehousing Sector and Transportation-Related Occupations: 2022



NOTES: Data do not include self-employed or independent contractors and therefore differ from the Bureau of Labor Statistics' occupational employment projections (https://www.bls.gov/emp/) which include these workers. Totals differ because occupational statistics are collected from a different survey than the survey used to collect annual industrial employment. "Transportation-related occupations" refers to these occupations.

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics, available at http://bls.gov/oes as of October 2023.

Figure 4-7 Employment in the Transportation and Warehousing Sector by Race and Hispanic/Latino Ethnicity: September 2013–September 2023 (Not Seasonally Adjusted)

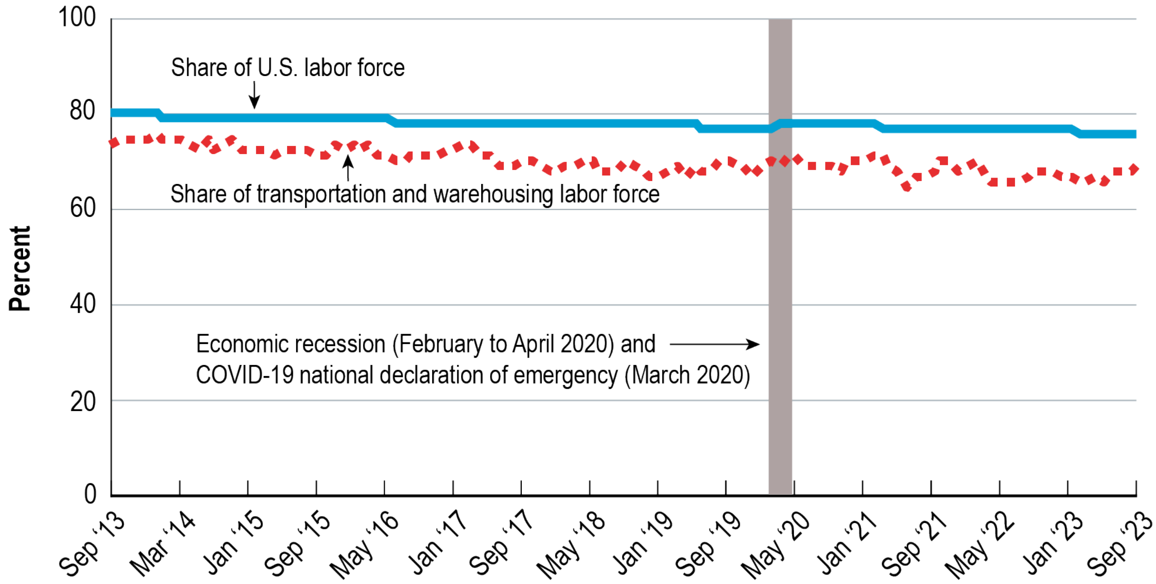


NOTES: Persons of Hispanic or Latino ethnicity may also identify as being any race. The sum of all persons employed in the transportation and warehousing sector is the sum of persons identifying as White, Black or African American, Asian, and other (not shown).

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 October 2023.

Figure 4-8 Percent of Total Employed by Race and Hispanic/Latino Ethnicity: July 2013–September 2023 (Not Seasonally Adjusted)

A. White



B. Black or African American

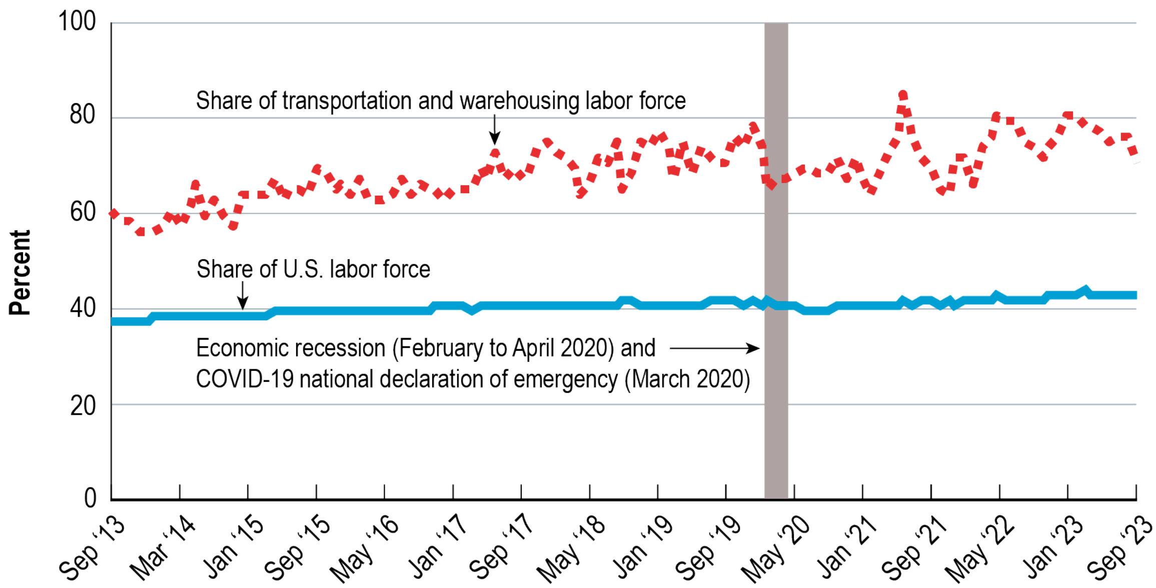
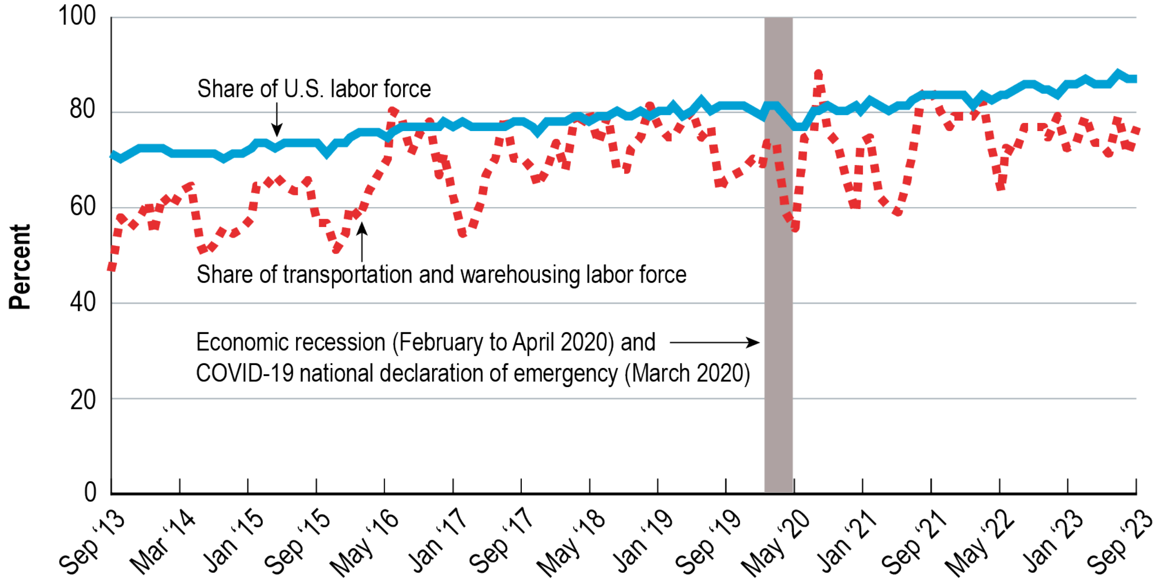
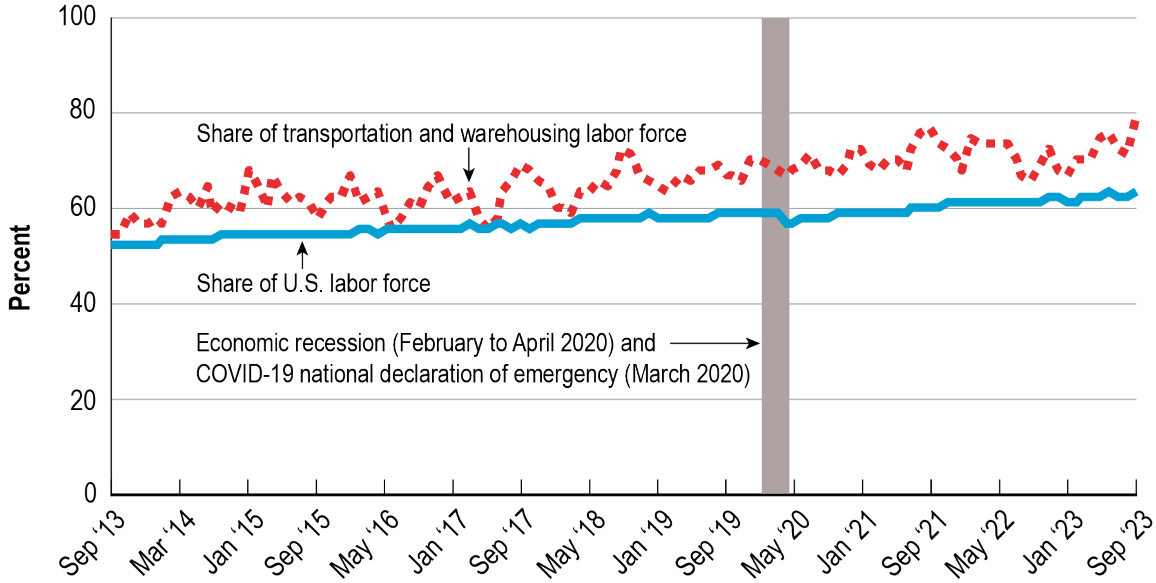


FIGURE 4-8 Continued

C. Asian



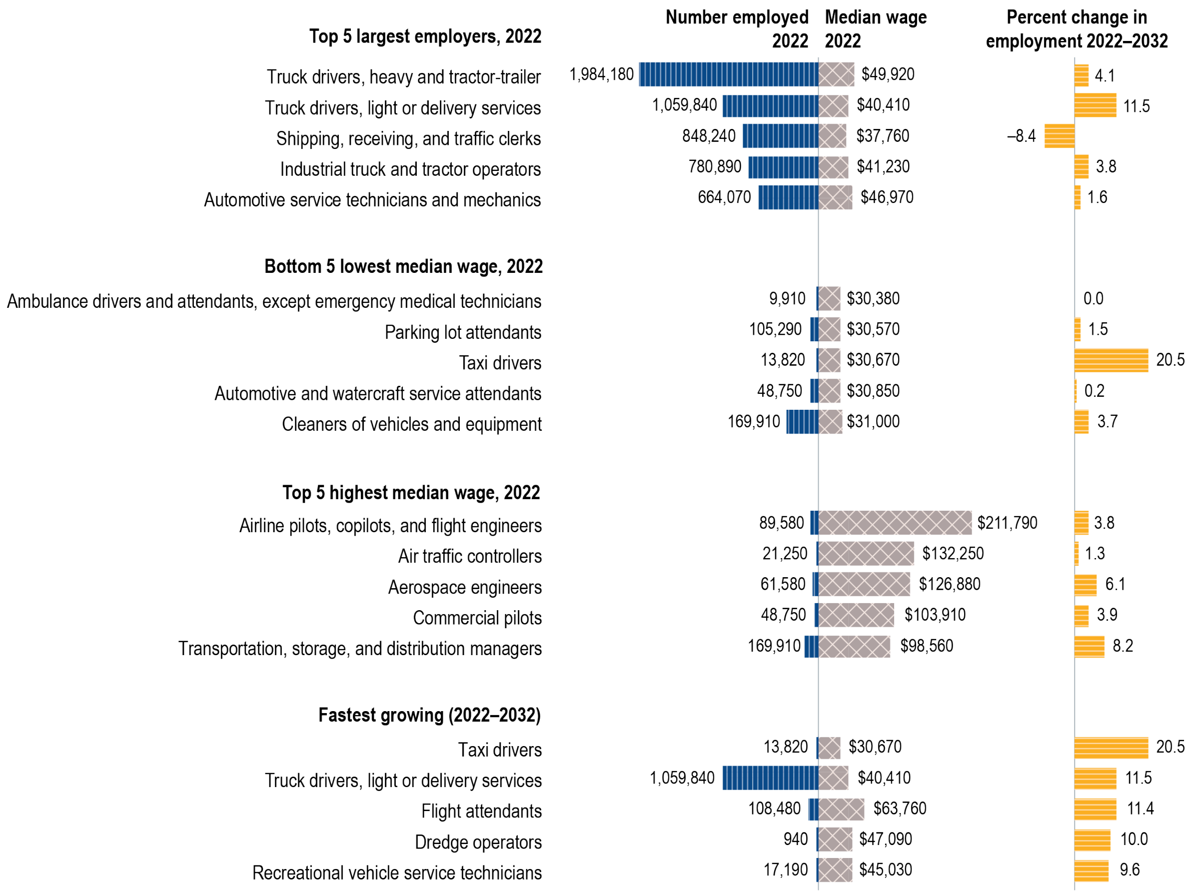
D. Hispanic or Latino



NOTES: The Y-axis is 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). The shaded area indicates economic recession (February to April 2020) and COVID-19 national declaration of emergency (March 2020).

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 October 2023.

Figure 4-9 Employment and Wages in Select Transportation Occupations: 2022



NOTES: Airline pilots typically fly on scheduled air carrier routes to transport passengers and cargo, while commercial pilots fly on nonscheduled 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 October 2023.

occupations experienced a 2.1 percent decrease in their wages from $34.32 in Q1 2022 to $33.60 in Q1 2023. Figure 4-9 shows annual median wages for the largest, the lowest-paid, the highest-paid, and the fastest growing transportation occupations in the United States in 2022.

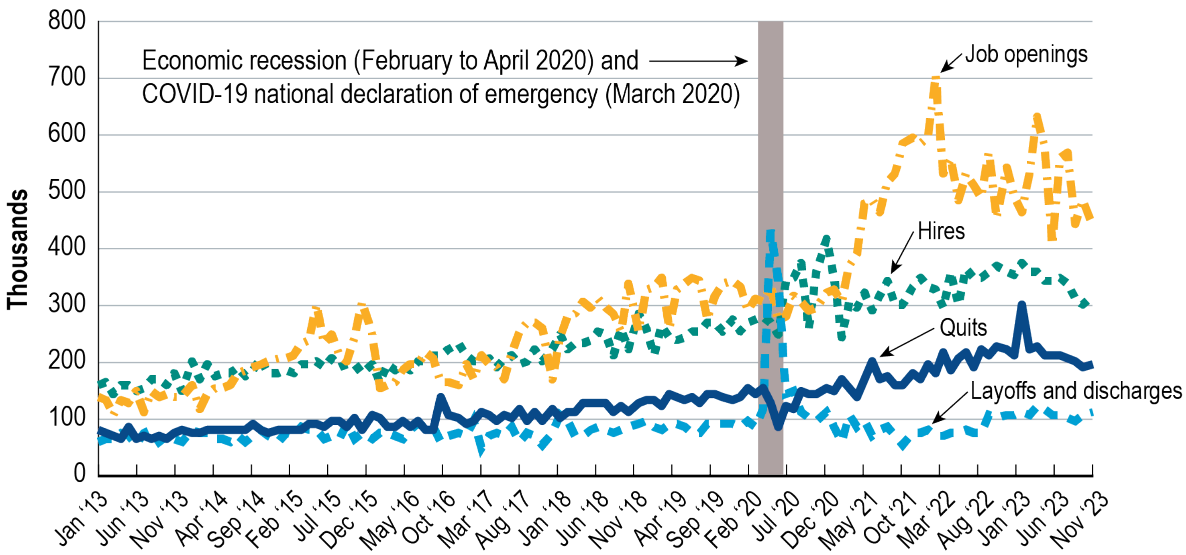
Annual wages vary widely, from a median annual wage of over $211,000 for airline pilots and over $132,000 for air traffic controllers to a median annual wage of just over $30,000 for ambulance drivers and attendants. The 5 lowest-wage transportation-related occupations collectively employed about 580,000 workers, while the 5 highest-wage occupations employed about 390,000 workers in 2022. In 2021, the five lowest-wage transportation related occupations employed about 900,000 workers which is notably higher than the 2022 levels as it included nearly 500,000 drivers/sales workers. In 2022, drivers/sales workers were no longer one of the five lowest paid occupations. It is unclear whether this is a real change or a data abnormality due to significantly lower response rates due to COVID-19, which the Bureau of Labor Statistics notes affected the 2021 data. Automation of transportation and technological changes affect which transportation occupations will gain or lose employment. From 2022 to 2032, 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 20.5 percent—the 17th fastest growing occupation out of the 832 occupations identified by the Bureau of Labor Statistics.[6]

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 129.6 percent from December 2020 to December 2021—the largest 12-month gain over the past decade (Figure 4-10). The number of job openings fell 38.2 percent from the December 2021 high to August 2023 (the latest available data). The decline in openings has reduced hirings. Over the most recent 12-month period for which complete data is available, hiring slowed; dropping 15.3 percent from August 2022 to August 2023 and falling month-over-previous month in 8 of those 12 months. Despite fewer openings and hirings, the number of quits has risen, reaching the highest level over the past decade in November 2022. However, the number of those who quit their job dropped 34.7 percent from November 2022 to August 2023. Layoffs and discharges remain stable after the combined impacts of the February to April 2020 economic recession and the COVID-19 pandemic caused a 401.2 percent increase in

[6] Refer to 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 October 2023. Summary occupations excluded from count.

Figure 4-10 Job Openings and Labor Turnover: Transportation, Warehousing, and Utilities Sector (Seasonally Adjusted): January 2013–August 2023



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Job Openings and Labor Turnover, available at https://www.bls.gov/jlt/ as of October 2023.

layoffs and discharges from January 2020 to March 2020—the highest level reached in the past decade.

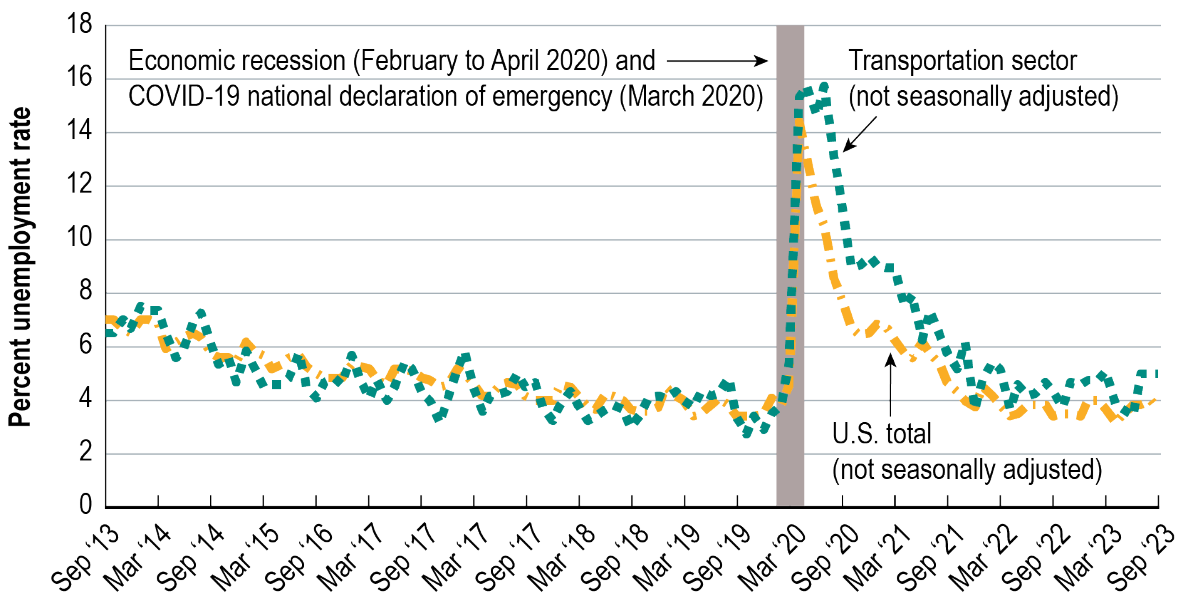
Layoffs and discharges caused unemployment in the transportation and warehousing sector to reach an all-time high in May 2020—a level matched again in July 2020 (Figure 4-11). The unemployment rate in the transportation and warehousing sector has recovered substantially since reaching an all-time high in 2020, but it is not yet back to pre-pandemic levels. In 32 out of the 38 months since July 2020, the unemployment rate in the transportation and warehousing sector exceeded the 2019 pre-pandemic level for the same month. This trend exists for both men and women in the transportation and warehousing sector. However, women in the transportation and warehousing sector experienced a higher level of unemployment than men during the COVID-19 pandemic, reaching 26.2 percent in July 2020, and are still experiencing higher rates of unemployment (Figure 4-12).[7]

Transportation Expenditures and Revenues

BTS develops a compendium of transportation public finance statistics, currently known as Government Transportation Financial Statistics (GTFS). It generally provides statistics on (1) the expenditures on transportation systems, programs, and activities that are made by government agencies and entities at all levels of government; and (2) the revenues that are allocated to those transportation systems, programs, and activities. GTFS is the only statistical compilation of government financial

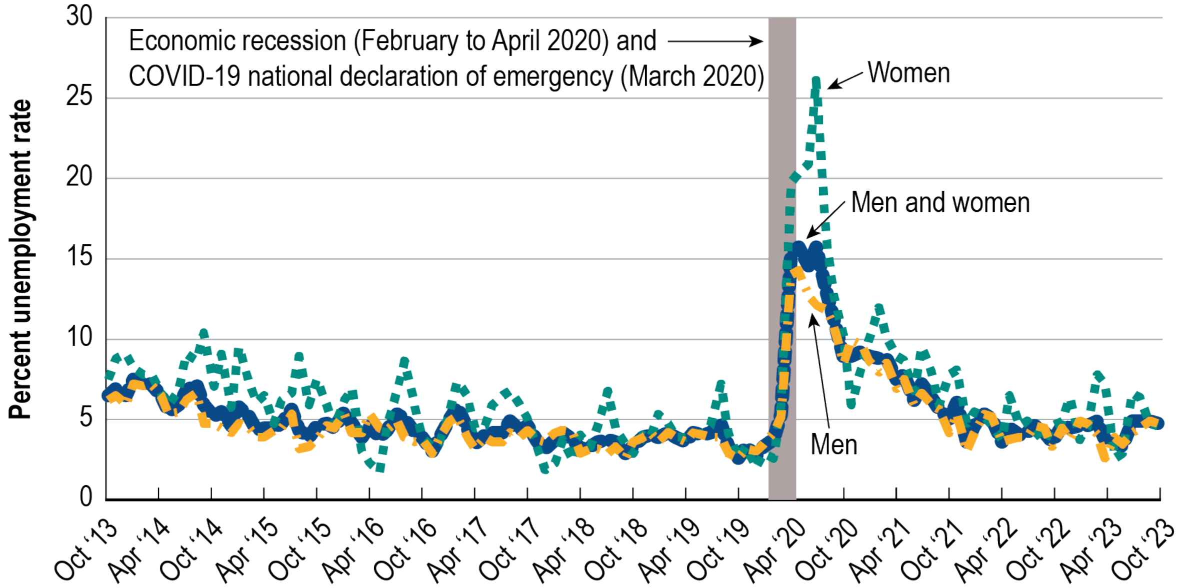
[7] Refer to U.S. Department of Transportation, Bureau of Transportation Statistics, *Unemployment in Transportation Remains Above Pre-Pandemic Levels; Women Experiencing Higher Rates Than Men*, available at https://www.bts.gov/data-spotlight/unemployment-transportation-remains-above-pre-pandemic-levels-women-experiencing as of October 2023.

Figure 4-11 Transportation Sector and U.S. Total Unemployment Rate: September 2013–September 2023



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 October 2023.

Figure 4-12 Transportation Sector Unemployment Rate for Men and Women: October 2013–October 2023



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey, series LNU04034168, LNU04034170, and LNU04034169 available at http://www.bls.gov as of October 2023.

statistics covering all modes of transportation at all levels of government. While it is a long-standing and well-used product, BTS has identified several ways GTFS can be improved. Currently, BTS is working to improve the timeliness and the granularity of the statistics. The new financial statistics program will release preliminary statistics, allowing the data to be available to the public six months earlier, and then publish the actual data once it is available. This allows stakeholders and current GTFS users to access the data when they are more relevant. The increased level of detail will focus on specifying expenditures as capital and noncapital expenditures, better detailing funds provided from trust funds, and adding and clarifying Amtrak funds. The improvements, which will be known as the Transportation Public Financial Statistics (TPFS), will be premiered in 2024.

Public and Private Sector Expenditures and Revenue

Expenditures

The most recent data show that federal, state, and local governments spent $403.8 billion on transportation in 2020. Most government transportation spending takes place at the state and local levels, although state and local capital expenditures are often paid for in part with federal funds. In 2020, state and local governments spent $362.0 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 $41.8 billion directly on transportation, excluding federal transfers to states [USDOT BTS 2023c].

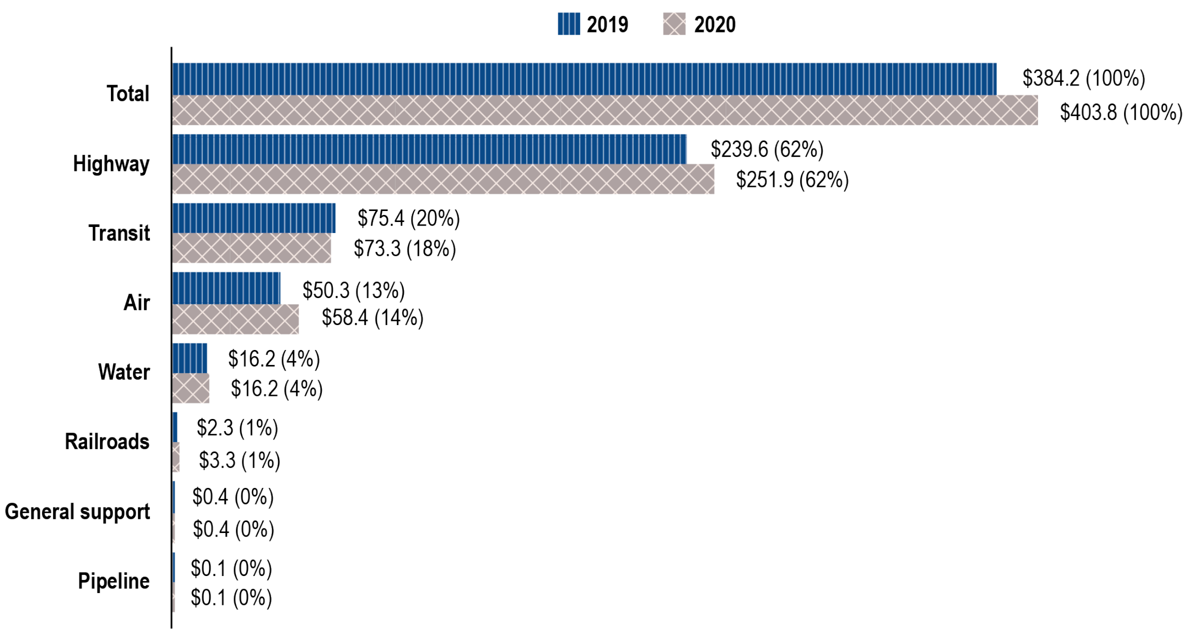
Government transportation expenditures rose in 2020 due to the passage of three appropriation bills providing emergency funding in response to COVID-19.[8] Total expenditures made by federal, state, and local governments increased by 5.1 percent from 2019 to 2020. (Figure 4-13). The largest increase is seen in railroad expenditures which increased by 47.8 percent from 2019 to 2020.

Government transportation revenue comes from user taxes and fees, such as gasoline taxes and tolls, air ticket taxes, and general revenues, as well as income from investing transportation funds and receipts from fines and penalties. In 2020, federal, state, and local government revenue collected and dedicated to transportation programs totaled $367.5 billion (in 2020 dollars) (Figure 4-14) [USDOT BTS 2023c]. Over half of the revenue ($198.8 billion, or 54.1 percent) came from taxes and charges levied on transportation-related activities (own-source revenue) [USDOT BTS 2023c]. The remaining $168.7 billion (45.9 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).

COVID-19 caused levels of travel to drop to historic lows which significantly reduced government transportation revenues. Total federal, state, and local transportation revenue fell 7.0 percent between 2019 to 2020 with

[8] For more information on these bills, refer to U.S. Department of Transportation, Bureau of Transportation Statistics, "COVID-19 Stimulus Funding for Transportation in the CARES Act and Other Supplemental Bills," *Transportation Economic Trends*, available at https://data.bts.gov/stories/s/2cyr-4k8j as of November 2023.

Figure 4-13 Federal, State, and Local Transportation Expenditures by Mode: 2019 and 2020 (Billions of Current Dollars)



NOTES: 2020 data are the latest available. Federal expenditure includes direct federal spending, excluding grants to state and local governments. Percents may not add to 100 due to rounding.

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 October 2023.

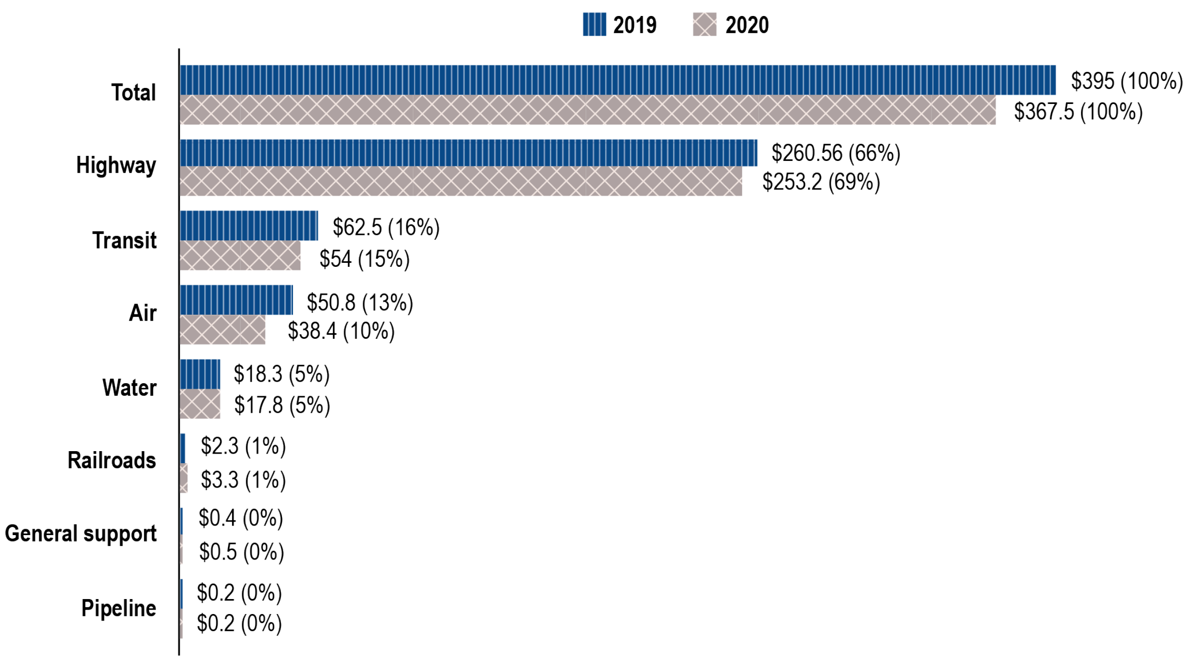
air transportation declining the most, falling 24.5 percent. Railroad revenue increased between 2019 and 2020 likely due, in part, to the Infrastructure Investment and Jobs Act.

Total government transportation expenditures increased from 2019 to 2020 (from 384.2 billion to 403.8 billion), but at the same time, government transportation revenues decreased (from 395.0 billion in 2019 to $367.5 billion in 2020). In 2020, total (own-source and supporting) transportation revenues ($367.5 billion) fell short of transportation expenditures ($403.8 billion) by 36.3 billion. However, total transportation revenues exceeded transportation expenditures in 2019 by $10.8 billion [USDOT BTS 2023c].

Infrastructure Investment and Jobs Act

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 4-15). Much of these transportation funds ultimately will result in transportation expenditures that will be reflected in the future Transportation Public Financial Statistics. 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.

Figure 4-14 Federal, State, and Local Transportation Revenue by Mode: 2019 and 2020 (Billions of Current Dollars)

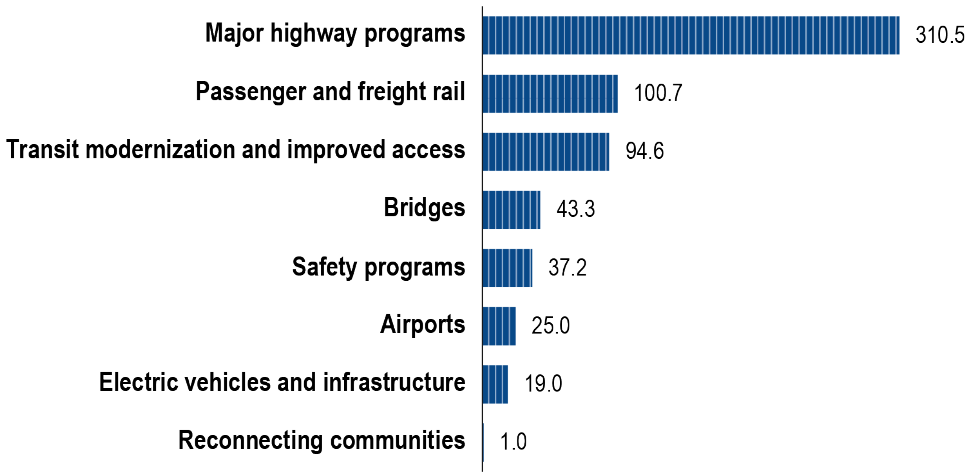


NOTES: 2020 data are the latest available.

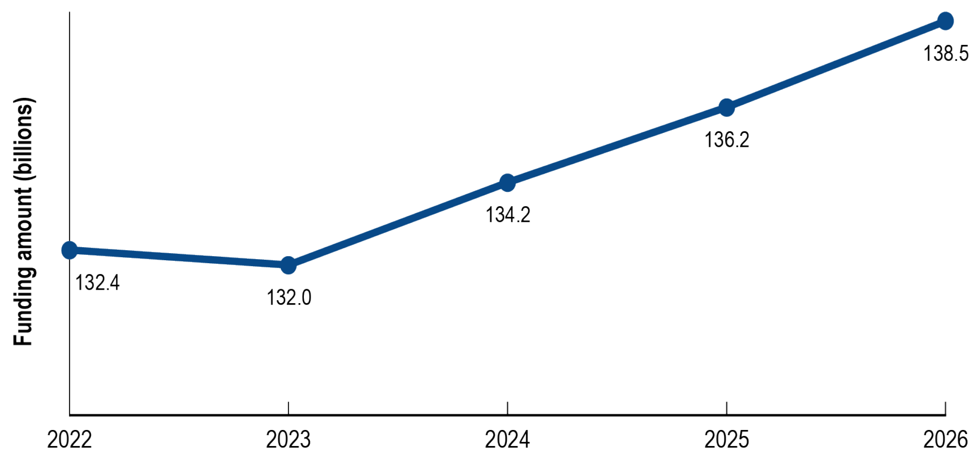
SOURCE: .S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at https://data.bts.gov/Research-and-Statistics/Government-Transportation-Financial-Statistics-GTF/nu8j-7gmn as of October 2023..

Figure 4-15 Overview of the Transportation Component of the Infrastructure Investment and Jobs Act (IIJA), Known as the Bipartisan Infrastructure Law (BIL)

A. IIJA Funding for Transportation by Major Program (Billions of Dollars)



B. IIJA Transportation Funding Amounts by Year (Billions of Dollars)



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 October 2023.

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 2022, public and private investment in transportation infrastructure and equipment totaled $403.9 billion, or 7.4 percent of the $5,476.1 billion of total national investment in all infrastructure, equipment, and intellectual property products (Figure 4-16)—a significant drop from 14.2 percent in 2018 but a small drop from 7.5 percent in 2021 [USDOT BTS 2023d]. Public and private investment in new transportation infrastructure accounted for $171.9 billion (3.1 percent), and private transportation equipment accounted for $232.0 billion (4.2 percent) of that national investment. Adjusted for inflation, total investment in new transportation infrastructure and equipment increased 7.3 percent from 2021 to 2022.

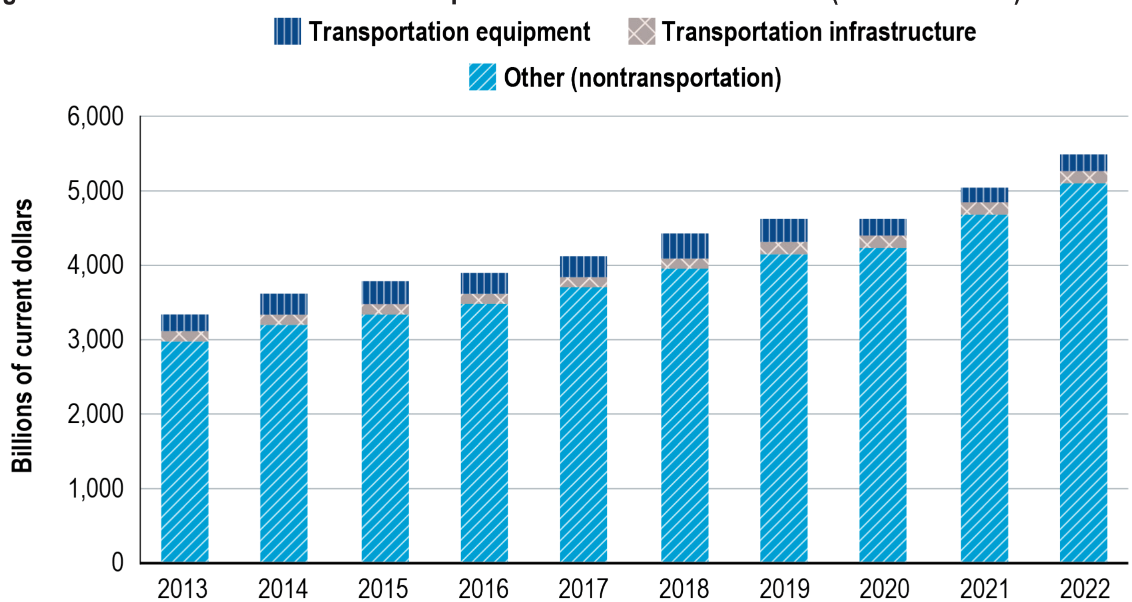
Emerging Issues: Inflation and Transportation

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) 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. This section shows how transportation costs can impact inflation from the perspective of the consumer, transportation providers, and nontransportation industries purchasing transportation services.

Cost of Transportation

The cost to produce transportation services stems from the resources firms purchase, such as fuel and labor, that are required to produce these 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. Sustained increases in those costs, driven by price increases for materials (e.g., fuel) and services (e.g., trucking), cause inflation. Inflation is a sustained rise in prices, which can cause purchasing power to

Figure 4-16 Total Investment and Transportation Investment: 2013–2022 (Current Dollars)



NOTES: Totals may not sum due to rounding. The investment includes spending on new structures and equipment and excludes 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 October 2023.

decline. Which goods and services drive inflation can change over time.

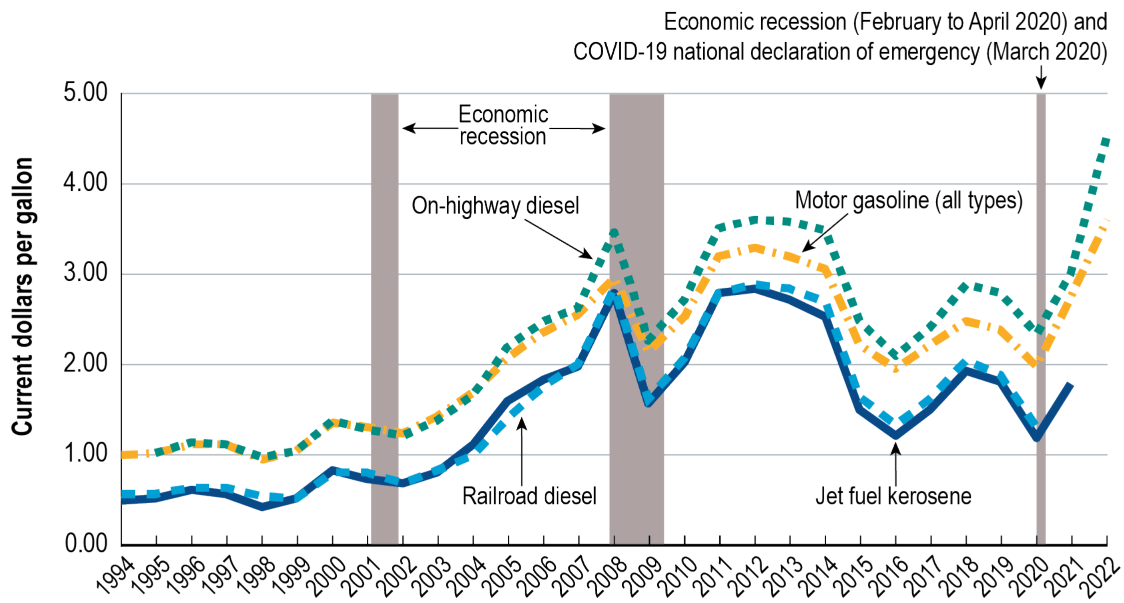
Fuel Prices

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. Motor gasoline (all types) reached a new average high of $3.95 per gallon in 2022 which was its second largest year-over-year price increase, jumping 31.3 percentage points from 2021 to 2022 (Figure 4-17). The 2022 peak is 9.2 percent higher than the previous peak reached in 2012. On-highway diesel also reached a new average high in 2022 of $4.99 per gallon; 51.8 percent higher than 2021 and 25.7 percent higher than the previous 2012 peak. The latest jet fuel data available is from 2021; jet fuel had the second largest year-over-year increase between 2020 and 2021 (51.1 percent) but is still 37.0 percent below the peak reached in 2012.

Prices Faced by Businesses Purchasing Transportation Services

Fuel, labor, and shipping rates, 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

Figure 4-17 Sales Price of Transportation Fuel to End-Users (Current Dollars/Gallon): 1994–2022



NOTES: Regular motor gasoline (all formulations) and on-highway diesel fuel prices are retail prices and include taxes paid by the end-user. 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. Data are an annual average of monthly fuel prices. The average price for gasoline and diesel fuel no 2. in this figure differs from the Bureau of Transportation Statistics, National Transportation Statistics, Table 3-11. Diesel fuel prices in Table 3-11 exclude taxes paid by the end-user, while the series in this figure includes them. Gasoline prices in Table 3-11 are from the Bureau of Labor Statistics' Consumer Price Index Average Price Data (as reported on the Energy Information Administration's website), while the series in this figure are those collected by the Energy Information Administration. Differences in methodology cause the price values across the two sources to differ slightly. Shaded bars indicate economic recessions.

SOURCE: All data except rail: U.S. Department of Energy, Energy Information Administration, available at https://www.eia.gov/opendata/qb.php (series id = EMA_EPJK_PTG_NUS_DPG, EMM_EPMR_PTE_NUS_DPG, EMD_EPD2D_PTE_NUS_DPG, EMA_EPPV_PTG_NUS_DPG). **Rail:** Association of American Railroads, Railroad Facts (Washington, DC: Annual Issues), p. 46 and similar tables in earlier editions, as featured in Bureau of Transportation Statistics, National Transportation Statistics, Table 3-11: Sales Price of Transportation Fuel to End-Users (current cents/gallon), available at https://www.bts.gov/content/sales-price-transportation-fuel-end-users-current-cents-gallon as of October 2023.

producers receive for their output. The amount of money received by producers for selling their transportation services (e.g., airfares) is 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 2022, the costs for air, rail, truck, and water transportation services each reached their all-time highest level, suggesting an increase in the costs businesses face for providing these transportation services. Water transportation services saw the largest year-over-year price increase of 25.3 percent from 2021 to 2022, followed by air (21.6 percent), truck transportation (20.0 percent), and rail (9.3 percent) (Figure 4-18). 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 purchased transportation services.

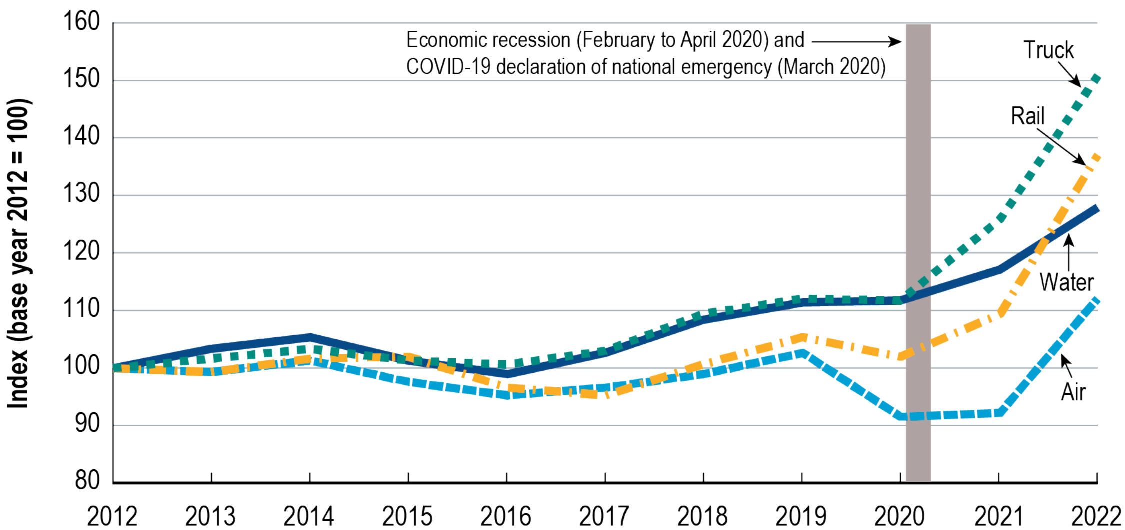
Highway Construction Costs

Highway construction costs rose an unprecedented 26 percent in 2022; seven percentage points more than the previous all-time annual increase of 20 percent in 2005 per the National Highway Construction Cost Index. Increases in crude oil prices, used to produce asphalt, and supply chain issues contributed to the growth in highway construction costs. The most recent data, through the first quarter of 2023, show continued growth, with construction costs rising 25 percent from the first quarter of 2022 to the first quarter of 2023 [USDOT FHWA 2023].

Contribution of Transportation to Overall Inflation

After steadily increasing since June 2020 to reach a new high in June 2022, the seasonally adjusted transportation CPI began to decline in

Figure 4-18 Producer Price Indices for Producers of Selected Transportation and Warehousing Services: 2012–2022



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 October 2023.

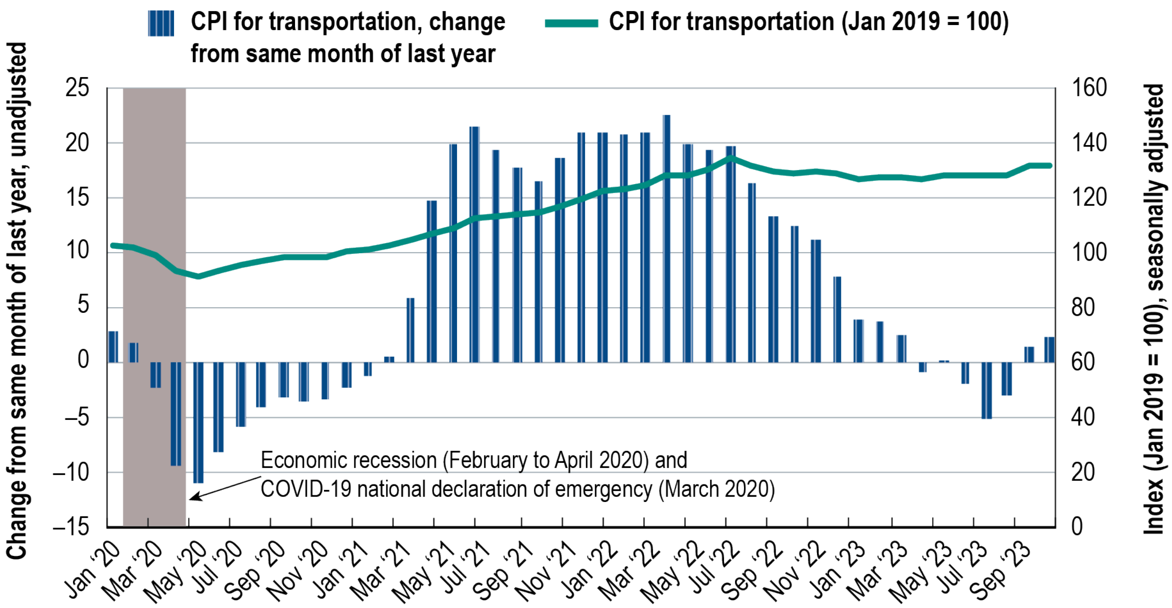
July 2022 (Figure 4-19) — falling month-over-previous month in 8 of the 15 months since the June 2022 peak.[9] The downward trend in transportation CPI, due to declines in fuel and used car and truck prices, dampened overall year-over-year price increases in all goods and services in 5 consecutive months, starting March 2023. However, in August and September 2023, those prices as well as the price for vehicle insurance began to increase and transportation once again positively contributed to the year-over-year price increase of all goods and services (Figure 4-20). Transportation's contribution to inflation 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, but transportation's contribution has fallen in each month from the previous month in 21 of the 27 months since that peak [USDOT BTS 2023d].

In 2022 transportation providers faced increasing fuel and transportation equipment costs and as a result, producers saw price increases for transportation services. As external factors influencing those price increases, such as supply chain issues and the COVID-19 pandemic, have subsided, prices declined in 2023 across multiple modes.

Truck spot rates rose from mid-2020 (after falling during the February to April 2020 economic recession) through late 2021/early 2022, corresponding to the increase in diesel fuel prices from 2020 to May 2022 (Figure 4-21). Spot rates have declined since late 2021/early 2022, falling from 2022 to 2023 to near pre-

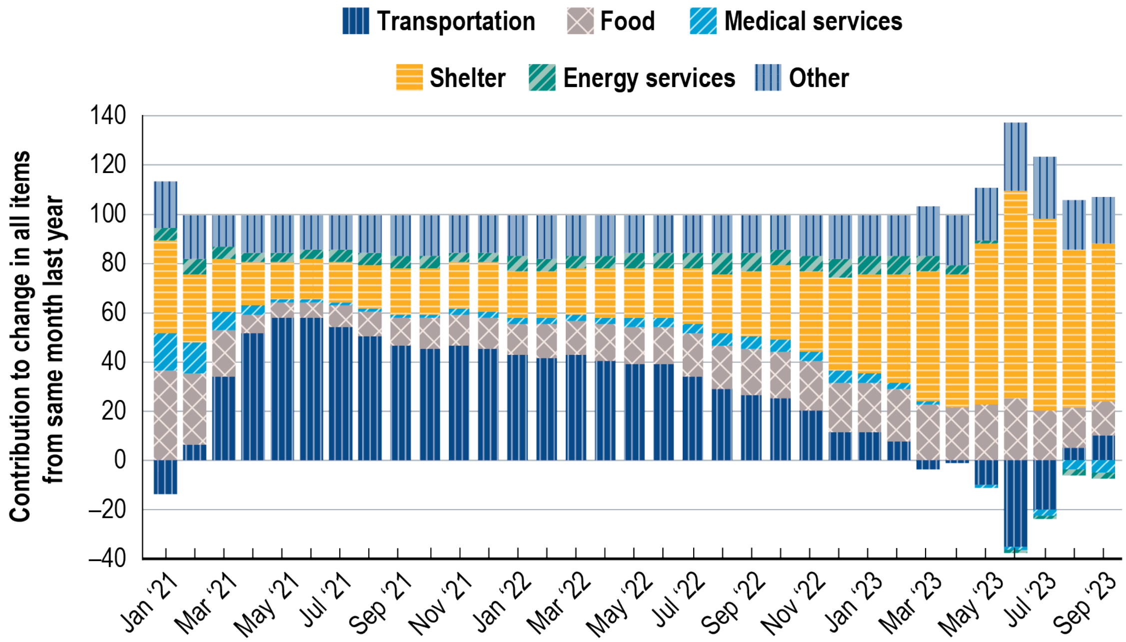
[9] The transportation CPI is the official measure of the price paid by consumers for transportation goods and services over time and hence a measure of inflation. Overall transportation includes private transportation (made up of new and used motor vehicles, motor fuel, motor vehicle parts and equipment, 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 4-19 Consumer Price Index for Transportation, Change from Same Month of the Previous Year (Unadjusted) and Seasonally Adjusted Value: January 2020–September 2023



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 October 2023.

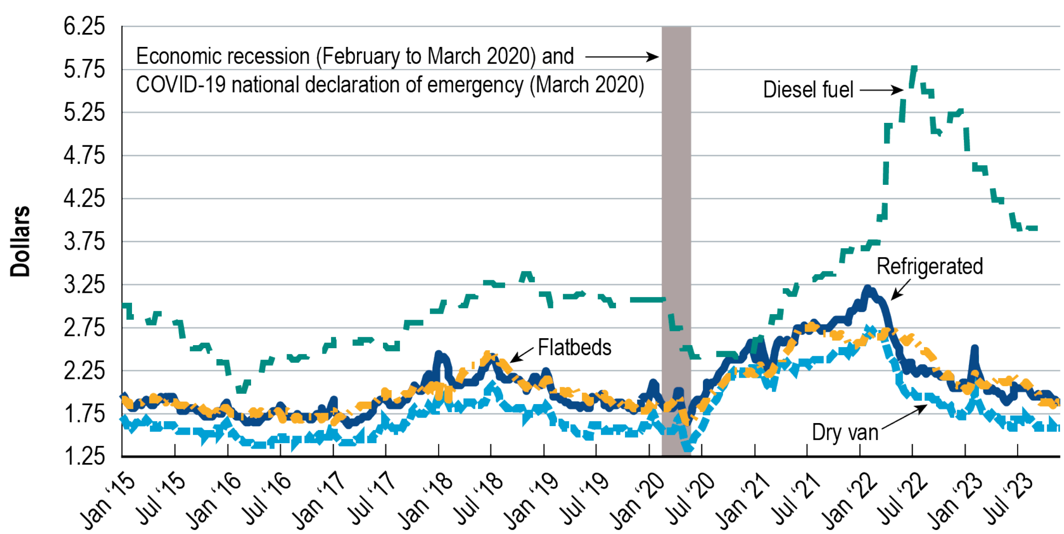
Figure 4-20 Contribution of Transportation to Inflation Compared to Food, Shelter, and Medical Services: January 2021–September 2023



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 as of October 2023.

Figure 4-21 Truck Spot Rates in Dollars Per Mile and Price of Diesel Fuel per Gallon: January 2015–October 2023



NOTES: 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.

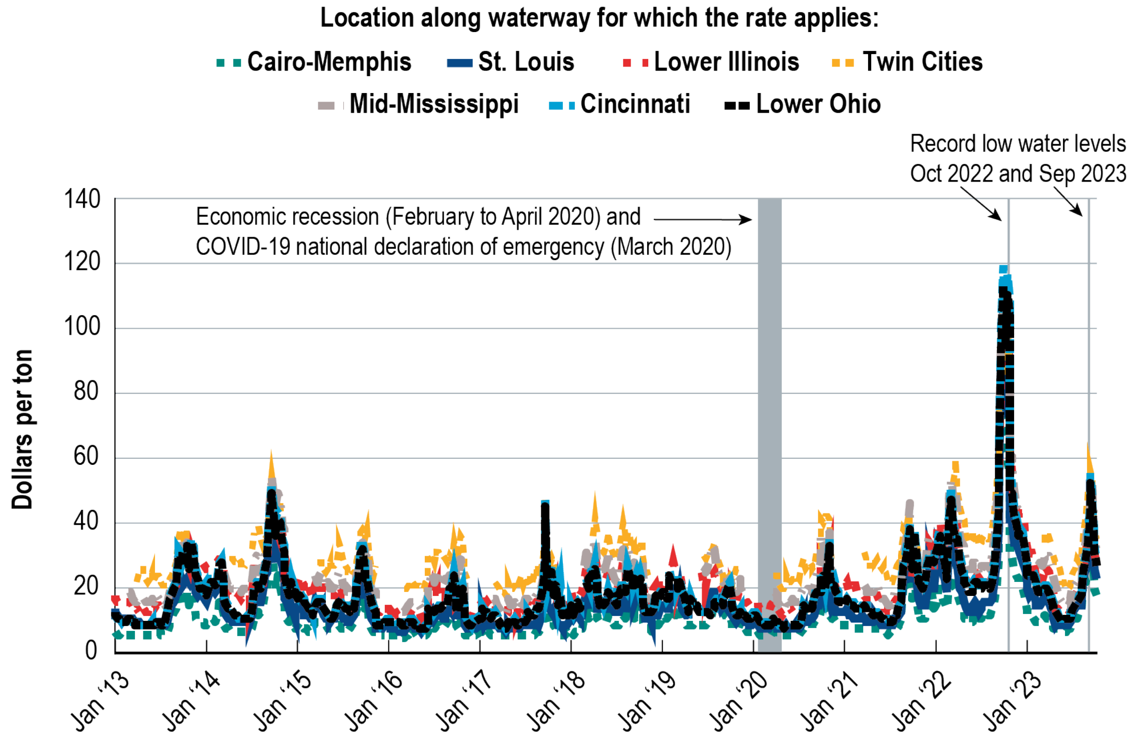
SOURCE: DAT Freight Analytics as of October 2023.

pandemic levels. In September 2023, flatbed truck spot rates were an average of 14.5 percent below their 2022 rate for the same week in the previous year, dry van spot rates were an average of 14.3 percent below their 2022 rate for the same week in the previous year and refrigerated truck spot rates were an average of 11.4 percent below their 2022 rate for the same week in the previous year.

When the Mississippi River fell to record low levels, downbound barge rates peaked in the fall of 2022 (Figure 4-22) but have since become more stable. The rates follow seasonal trends of dipping during in the spring and summer when water levels are higher and rising in the fall and winter as water levels fall. Refer to Chapter 3 Freight and Supply Chain for more discussion on the impact of the record low water level at the Mississippi River.

Spot ocean freight rates both to and from Shanghai have fallen in 2023 from their 2022 levels. Freight rates from Shanghai to the U.S. West Coast were down 54.8 percent from $5,389 per 40-ft container in September 2022 to $2,430 in September 2023, and rates from the West Coast to Shanghai are down 33.8 percent from $1,330 per 40-ft container in September 2022 to $880 in September 2023 (Figure 4-23).

Figure 4-22 Downbound Grain Barge Rates (Dollars per Ton): January 2013–October 2023



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). 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 Agriculture, Downbound Grain Barge Rates, available at https://agtransport.usda.gov/Barge/Downbound-Grain-Barge-Rates/deqi-uken as of October 2023.

The eastbound rate from a 40-ft container in September 2022 was almost four times the westbound rate during the same month.

Declines in freight rates caused transportation's contribution to year-over-year price increases in all goods and services faced by producers to fall in 2023. Since August 2022, transportation and related services, such as freight forwarding, contributed a decreasing share to the year-over-year increase in the price for all services faced by producers in 6 of the 14 months since August 2022. The declining costs in transportation and related services have dampened increases to overall inflation since April 2023 (Figure 4-24).

Data Gaps: Needs for the Future

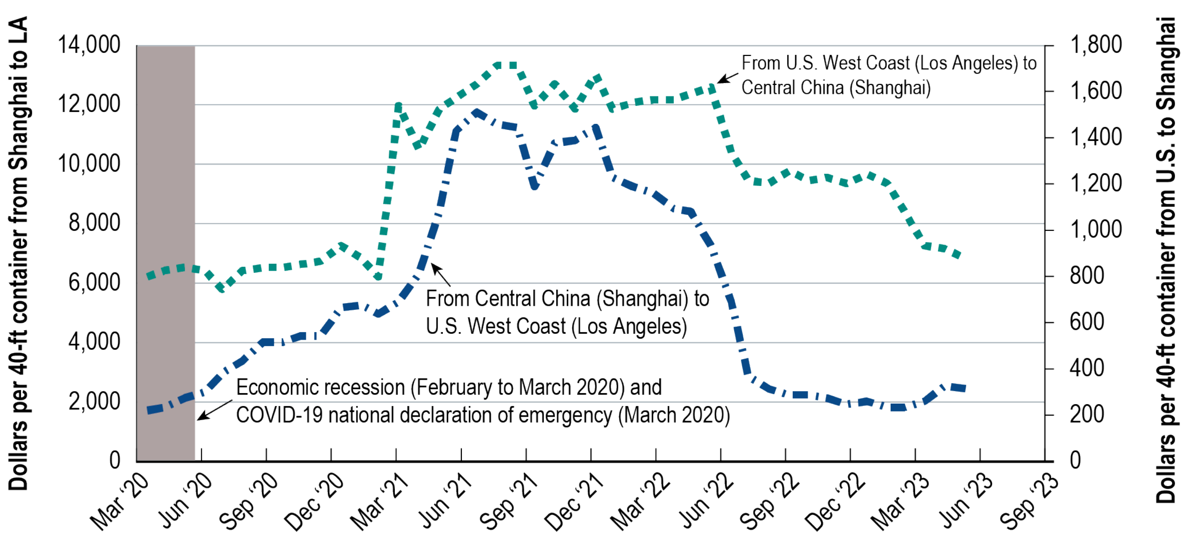
As the landscape of the COVID-19 pandemic continues to change, understanding which affects were temporary and which will be permanent, including price increases, hybrid work, and supply chain issues, underscore the need for the following:

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

The Infrastructure Investment and Jobs Act section 25003 requires BTS to assist planning and infrastructure decision-making officials in local government and to help build a plan for the Federal government to support local communities with their infrastructure investment decisions [USDOT BTS 2023e]. This endeavor necessitates the following:

- More granular and timely data especially at the state and local level to create a benchmark and track progress, including nonvehicular and non-National Highway

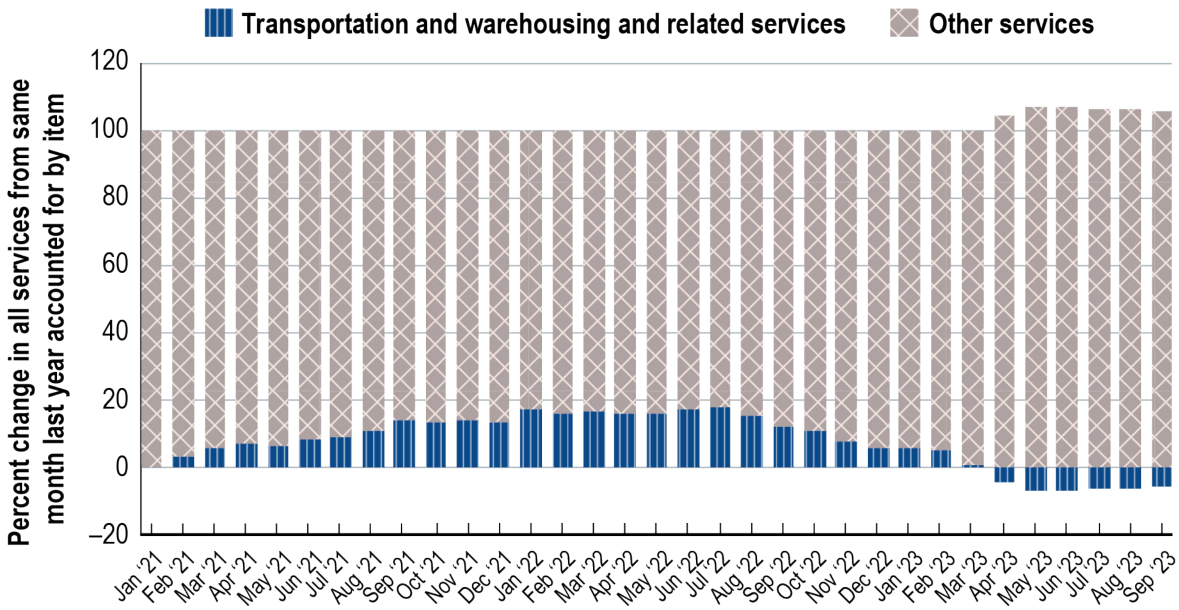
Figure 4-23 Freight Rates in Dollars per 40-foot Container for East Bound (Central China (Shanghai) to U.S. West Coast (Los Angeles)) and West Bound (Los Angeles to Shanghai): March 2020–September 2023



NOTE: Spot ocean freight rates for a single container transaction in the selected westbound and 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 as of October 2023.

Figure 4-24 Contribution of Transportation and Related Services to Inflation Faced by Producers of Goods and Services: January 2021–September 2023



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 as of October 2023.

System data, multimodal network model and analysis, private-sector data, and multijurisdictional collaboration.

- Understanding and standardizing any data that is already available and clarifying and standardizing definitions and expectations of metrics.
- Identifying data and analysis tools that can keep pace with technology advancements and benefit infrastructure decision-making by local governments.

In addition, decision-makers would benefit from the following:

- 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.
- 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.

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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 roughly 95 percent of the fatalities and well over 99 percent of the injuries from transportation incidents. Transportation incidents claimed 44,959 lives in 2021, of which all but 2,020 involved highway motor vehicles.

After declining in 2017–2019, fatalities involving highway motor vehicle crashes and collisions rose sharply in 2020 and even more sharply again in 2021. In 2020, the first

Highlights

- At the height of the COVID-19 pandemic in 2021, the most recent year with complete data, nearly 45,000 people died in transportation incidents, nearly 10 percent more than in 2020 and the most since 2006, and more than 2.5 million were injured in transportation incidents.
- Highways remained the dominant cause of transportation fatalities (over 95 percent in 2021), people injured (over 99 percent), and crashes and accidents (about 99.6 percent) in 2021, the last year for which crash and injury data are complete.
- Highway fatalities in 2020, the first year of the pandemic, increased by about 2,650 in spite of the decline in vehicle-miles traveled (VMT).
- Highway travel increased in 2021 and so did motor vehicle involved deaths—just under 43,000, a level of fatalities last observed in 2005. The 2021 fatality rate of 1.37 deaths per 100 million VMT also was the highest rate since 2006.
- In 2021, rural areas continued to have a highway fatality rate notably higher per 100 million VMT than urban areas: 1.74 vs. 1.19. However, the rural fatality rate decreased about 4 percent from 2020 to 2021, while the urban rate increased by 5 percent.
- Contributing factors to the rise in the highway fatality rate during 2020 and 2021 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 2021 were found to have an alcohol-impaired Blood Alcohol Content (BAC) of 0.08 or above compared to just 17 percent of non-speeding drivers in fatal crashes.
  - About 51 percent of the drivers in passenger vehicles in fatal speeding-related crashes in 2021 were not wearing seat belts at the time of the crash, versus 23 percent of drivers involved in non-speeding fatal crashes.

Continued »

Highlights Continued

- While highway fatalities went up in 2020, people injured fell by 460,000, to 2.3 million, before rising in 2021 to 2.5 million.
- The 2021 traffic fatality rate per 100 million VMT is 1.37, a bit more than the 2020 rate of 1.34. The projected 2022 traffic fatality rate per 100 million VMT for 2022 is 1.35.
- Between 1996 and 2020, the share of fatalities of people inside motor vehicles fell while the share of fatalities outside vehicles rose—from an 80:20 percent ratio in 1996 to a 66:34 percent ratio in 2021.
- In 2021, there were 4,149 deaths of people in other vehicles in crashes involving large trucks, the most since 1999.
- A Consumer Products Safety Commission study of e-scooters, e-bikes, and hoverboards found 360,000 emergency room visits by injured riders of these devices from 2017 to 2022, with visits increasing linearly each year. Deaths rose from 5 in 2017 to 76 in 2022 and totaled 233 over this period.
- As is the case in most years, transportation incidents were the most frequent cause of the 5,190 on-the-job fatalities in 2021.
- In 2021, 954 people died in work zones, a 15-year high.
- Data on injuries from the fast-growing transportation (US CPSC) examined injury, fatality, and hazard patterns covering e-scooters, e-bikes, and hoverboards from 2017 through 2022 found 360,000 emergency room visits by injured riders of these devices.

year of the COVID-19 pandemic, there were 39,007 fatalities—2,600 more than in 2019. This was unexpected given the reduced level of highway travel in 2020 when, due to the pandemic, vehicle miles declined 11 percent from 2019. Highway travel increased in 2021 and so did motor vehicle involved deaths—just under 43,000, a level of fatalities last observed in 2005. The National Highway Traffic Safety Administration's (NHTSA) early estimates for 2022 suggest a slight decrease of 0.3 percent compared to 2021, and its projections for the first half of 2023 show a 3.3 percent reduction compared to the first half of 2022 [USDOT NHTSA 2023k].

As for the non-highway transportation modes, rail and transit rail, air, water, and pipelines collectively had almost a 2 percent decrease in fatalities between 2019 and 2020—2,069 vs. 2,034, falling further in 2021 to 2,020.

This chapter discusses recent transportation fatality and injury statistics, focusing especially on 2020 and 2021 (and partial 2022 data as available). It thus illuminates changes in transportation safety during the 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 2022, so a full view of COVID-19 consequences for transportation safety after the pandemic is limited. The declaration of the COVID-19 public health emergency in the United States began in March 2020 and formally ended on May 11, 2023 [USDHHS CDC].

Fatalities and People Injured by Mode

Transportation's toll in fatalities and people injured is notably high—the number two cause of unintentional fatalities in the United States [USDHHS CDC WISQAR]. Figure 5-1 shows the transportation fatalities by mode in 2021, when nearly 45,000 people died, and Table 5-1 shows deaths from 2016– 2022 (2022 data are incomplete).[1] About 2.5 million people were injured in transportation crashes and accidents in 2021, with 99.5 percent of injuries attributable to highway motor vehicles (Table 5-2).

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

Highway Motor Vehicles[2]

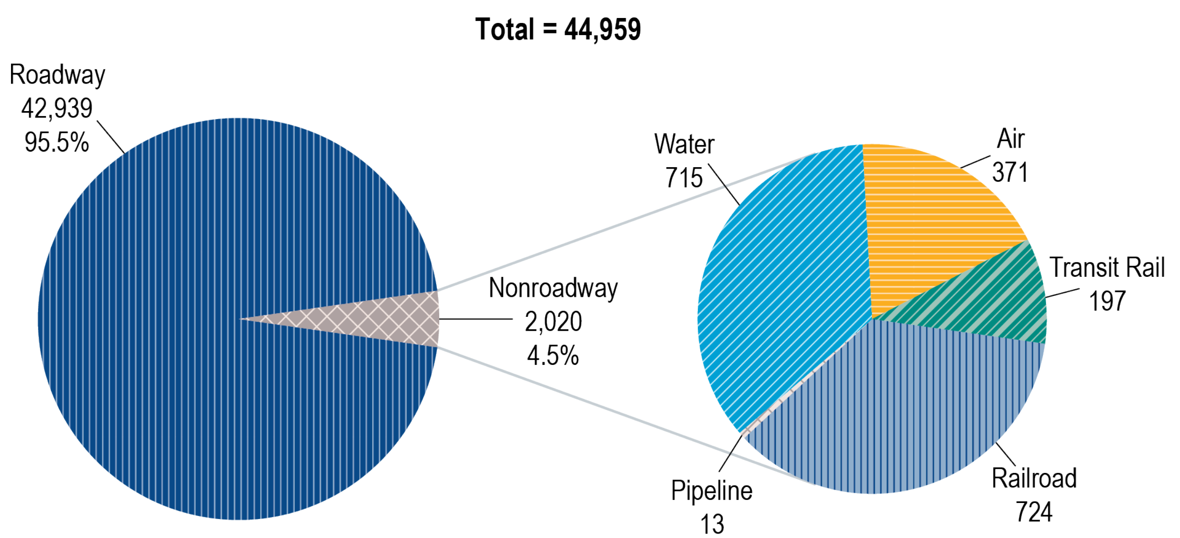
As shown in Figure 5-1, highway motor vehicles were involved in 95.5 percent of U.S. transportation fatalities in 2021 and also, as shown in Table 5-2, 99.5 percent of the people injured in transportation crashes and incidents. Both the number and rate of highway fatalities have decreased notably over 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, at 21 percent it is the largest annual rise on record, with a further increase to 1.37 in 2021 [USDOT NHTSA 2023a].

As context, it is useful to review the year-to-year change in motor vehicle fatalities in recent years. In 2011, after decades of decline, motor vehicle related fatalities had fallen to 32,479, the lowest number since 1949. Over the next 5 years, fatalities rose by about 5,400, reaching 37,806 in 2016. As shown in Table 5-1, deaths then declined each year in 2017, 2018, and 2019 to 36,355, but were still 12 percent more than that in 2011. Then came the COVID-19

[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.”

Figure 5-1 Transportation Fatalities by Mode: 2021



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 2-1, available at www.transportation.gov as of August 2023.

Table 5-1 Transportation Fatalities by Mode: 2016–2022

Mode	2016	2017	2018	2019	2020	2021	2022	Change from 2020 to 2021
TOTAL fatalities	**39,753**	**39,364**	**38,755**	**38,424**	**41,041**	**44,959**	**NA**	▲
Air	413	347	396	455	358	371	NA	▲
Highway	37,806	37,473	36,835	36,355	39,007	42,939	(EE) 42,795	▲
Railroad[1]	631	677	661	723	632	724	777	▲
Transit rail[2]	150	151	174	173	176	197	222	▲
Water	737	709	682	707	853	715	686	▼
Pipeline	16	7	7	11	15	13	5	▼
Other counts, redundant with above								
U.S. Air carrier[3]	0	0	1	4	0	0	NA	►
On-demand air taxi and commuter carrier	27	16	16	34	26	27	NA	▲
General aviation	386	331	379	417	332	344	NA	▲
Railroad, trespasser deaths not at highway-rail crossing	468	505	499	534	503	581	619	▲
Railroad, killed at public crossing with motor vehicle	130	140	132	128	94	128	145	▲
Rail, passenger operations	254	307	254	262	186	203	296	▲
Rail, freight operations	507	510	539	589	540	649	626	▲
Transit, non-rail	109	98	86	95	113	124	116	▲
Recreational boating	701	658	633	613	767	658	636	▼
Commercial waterborne	36	51	49	94	86	57	50	▼

[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.

KEY: NA = data not available at the time of publication; EE = early estimate based on statistical projection.

NOTES: Highway-2022 is a statistical projection of fatalities. For more information, refer to 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 the above*** help eliminate double counting in the Total fatalities. Refer to NTS table 2-1 in the 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 2023. **Highway-2022:** U.S. Department of Transportation, National Highway Traffic Safety Administration, *Early Estimate of Motor Vehicle Traffic Fatalities in 2022*, DOT HS 813 428, available at https://crashstats.nhtsa.dot.gov as of October 2023.

Table 5-2 Transportation Injuries by Mode: 2016–2021

Mode	2016	2017	2018	2019	2020	2021	Change from 2020 to 2021
TOTAL	**3,079,612**	**2,763,144**	**2,727,529**	**2,757,462**	**2,295,146**	**2,510,848**	▲
Air	241	229	270	260	204	247	▲
Highway[a]	3,061,885	2,745,268	2,710,059	2,740,141	2,282,209	2,497,657	▲
Railroad	8,027	8,212	7,748	7,375	5,053	5,384	▲
Transit rail	6,015	6,319	6,370	6,648	4,097	4,473	▲
Water	3,357	3,084	3,004	3,002	3,546	3,054	▼
Pipeline	87	32	78	36	37	33	▼
Other counts, redundant with above							
U.S. Air carrier[b]	18	19	26	17	8	14	▲
On-demand air taxi and commuter carrier	20	4	17	14	9	12	▲
General aviation	199	206	227	229	189	221	▲
Railroad, injured at public crossing with motor vehicle	675	680	620	666	508	527	▲
Transit, non-rail	17,589	16,515	16,468	16,714	11,324	12,093	▲
Recreational boating	2,903	2,629	2,511	2,559	3,191	2,641	▼
Commercial Waterborne	454	455	493	443	355	413	▲

[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.

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 2023; **Highway-2021:** U.S. Department of Transportation, National Highway Traffic Safety Administration, *Overview of Motor Vehicle Crashes in 2021*, DOT HS 813 435, available at https://crashstats.nhtsa.dot.gov as of August 2023.

pandemic, announced as a national health emergency in March 2020. With fewer people driving, one might expect highway fatalities would decline for the year. Instead, there was a dramatic and unprecedented increase in fatalities followed by an even higher increase in 2021, with road fatalities reaching 42,939, a level not observed since 2005 [USDOT NHTSA (a)]. Early estimates for 2022 project a slight decrease of 0.3 percent in highway fatalities over NHTSA's 2021 number [USDOT NHTSA 2023k].[3]

Figure 5-2 shows the change in fatalities in relation to vehicle-miles of travel before and during the pandemic. The rise in highway fatalities since 2019 partly arises from risky behaviors by vehicle occupants, as suggested by major increases in deaths involving the following:

- speeding-related fatalities—up 17 percent from 2019 to 2020, and a further 8 percent from 2020 to 2021.
- alcohol-impaired driving fatalities—up 14 percent from 2019 to 2020, and a further 14 percent increase from 2020 to 2021.
- ejections from passenger vehicles in fatal crashes (largely due to passenger vehicle occupants not wearing restraints)—up 22 percent from 2019 to 2020, and a further 7.5 percent from 2020 to 2021.

[3] For further discussion of the month to month change in VMT and fatalities between 2019 and 2020, refer to Transportation Statistics Annual Report 2022, pp 5-7 and 5-8.

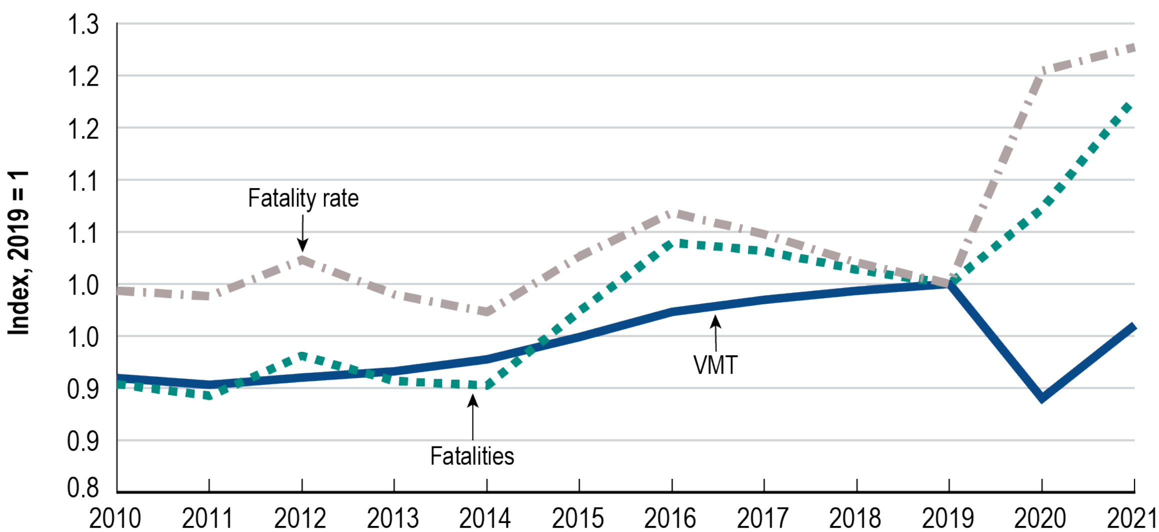
NHTSA estimates that these three behavioral factors only account for about half the increase, so further research is needed to quantify the other factors at play [USDOT NHTSA 2023a].

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. The EU also fared better during the pandemic: EU road deaths in 2022 were 10 percent fewer than their pre-pandemic number in 2019, while U.S. road deaths were an estimated 18 percent more [EU and USDOT NHTSA 2023a].

Analysts often examine two categories of people when looking at safety data: those inside the vehicle and those outside the vehicle (including motorcycle riders/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 2021. In 2021, all categories of fatalities, whether inside or outside vehicles, increased from 2020, as was also the case between 2019 and 2020 [USDOT NHTSA 2023a]. Figure 5-3 shows the changing ratio in occupant and nonoccupant fatalities since NHTSA began collecting this data in 1975. As shown, nonoccupants accounted for 34 percent of U.S. motor vehicle related deaths in 2021, compared to 20 percent in 1996 [USDOT NHTSA 2023a]. Fatalities of pedestrians, bicyclists, other cyclists,[4] and bystanders increased from 5,110 in 2010 to 7,420 in 2019 and then rose another 4.7 percent in 2020 and a further 11.3 percent in 2021 [USDOT NHTSA 2023a]. However,

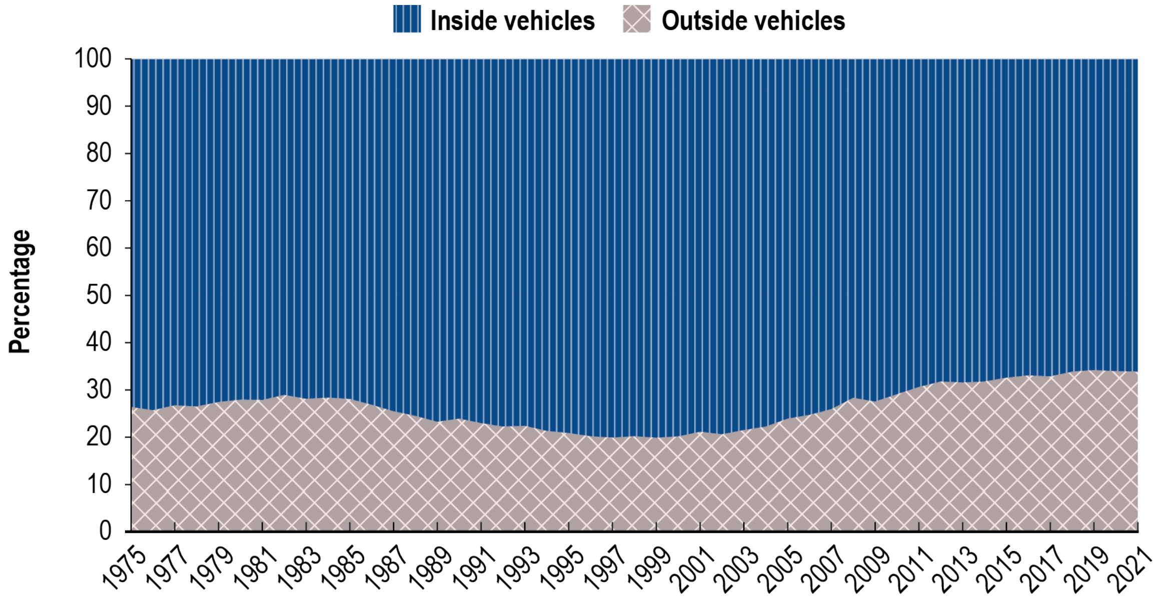
[4] Bicyclists and other cyclists including riders of two-wheel, non-motorized vehicles, tricycles, and unicycles powered solely by pedals.

Figure 5-2 Motor Vehicle Related Fatalities, Vehicle-Miles, and Fatality Rates Before and During Covid: 2010–2021



SOURCES: 2019–2021: U.S. Department of Transportation, National Highway Traffic Administration. Overview of Motor Vehicle Crashes in 2021. April 2023. DOT HS 813 435. April 2023; **Pre-2019 data:** U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics* (NTS), Tables 1-35, 2-1, and 2-7.

Figure 5-3 Proportion of Traffic Fatalities Inside/Outside Vehicles: 1975–2021



SOURCE: Department of Transportation, National Highway Traffic Safety Administration. Overview of Motor Vehicle Crashes in 2021. April 2023. DOT HS 813 435. Available at www.nhtsa.gov/ as of August 2023.

pedestrian deaths, the largest category of nonoccupant deaths, remain below the high point of 8,096 in 1979 [as cited in USDOT BTS NTS table 2-1].

In 2021, 5,932 motorcyclists died, up 426 from 2020 and the highest number since NHTSA began collecting statistics in 1975.[5] This tally was a 7.7 percent increase from 2020, and nearly 900 more deaths than in pre-pandemic 2019. Some of the factors contributing to the increase over the decades include the increasing age of riders, reduced helmet usage, speeding, and alcohol impairment [USDOT NHTSA 2023a].

In the 10 years between 2011 and 2020, motorcyclist fatalities for the 55-and-older age group rose from 23 to 27 percent of motorcycle deaths. The average age of motorcycle riders who died in crashes increased from 40 in 2008 to 43 in 2021. The number of motorcyclist fatalities per 100 million VMT (30.20) was about 24 times greater than that for passenger car occupants (1.26) and 40 times that for light truck occupants (0.76) [USDOT NHTSA 2023c].

Large-truck occupant fatalities jumped 23 percent in 2021, exceeding 1,000 and up 186 from the pandemic lull in 2020. Every year, several times as many people outside large trucks (e.g., occupants of other vehicles and nonoccupants) die in large truck crashes as do the truck occupants. Deaths of people in other vehicles in large truck crashes had fallen to under 3,000 in 2009, but subsequently increased and have exceeded 3,500 in every year since 2017. In 2021, there were 4,149 deaths of people in other vehicles in crashes involving large trucks, the most since 1999 [USDOT NHTSA 2023a].

Some fatalities and people injured from motor vehicle incidents take place off public roadways (e.g., pedestrians struck in driveways, people

[5] The 2020 tally of 5,506, was the prior record.

injured in parking lot collisions, bicyclists hit on private roads, and children and other people unintentionally run over in driveways) are not usually included in roadway statistics. The National Highway Traffic Safety Administration (NHTSA) has been surveilling[6] these incidents (which it calls “non-traffic motor vehicle crashes”) since 2007 and released its latest annual estimates for the 2016 through 2020 period in September 2022 [USDOT NHTSA 2023j]. NHTSA found that 12,247 people died in these non-traffic motor vehicle 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 years, 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. As is discussed in Appendix D, some organizations such as the National Safety Council do include these off-roadway incidents in their published totals, which may create an impression of inconsistency but is a reflection of different coverage.

Box 5-A shows the impacts of the first COVID year (2019–2020) and the impact during COVID-19 (2020–2021) for deaths from fatal motor vehicle crashes, people injured in crashes, and the estimated outcomes from non-fatal crashes.

As for non-fatal crashes in 2021, there was a 9.4 percent increase in people injured in motor vehicle crashes and a 20 percent increase in property damage-only crashes compared to 2020. Despite these increases, the absolute numbers of injured people and property damage-only crashes were still below 2019 levels [USDOT NHTSA 2023a].

Differences in Highway Fatalities by Sex and Age

The number of highway fatalities varies significantly by sex and age. Although males comprise just under 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 2021. Statistically expressed, about 2.6 males died in highway crashes to every 1 female that year—30,747 males vs. 12,051 females [USDOT NHTSA 2023a]. The number of males killed in 2020 was up 9.1 percent from 2019, versus 2.4 percent for females, while in 2021, female fatalities increased 12.1 percent compared to 9.2 percent for males.

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 the following percentages:

- 70 percent of pedestrian fatalities.
- 86 percent of bicycle fatalities.
- 92 percent of motorcycle fatalities in 2021.

Males are the drivers in 72 percent of fatal crashes in 2021 and have a higher risk than females of being the driver in fatal crashes as measured by 100 million miles of vehicle travel. They are also more likely than females to be speeding (20 vs.13 percent) and to be alcohol-impaired (33 vs. 23 percent) when they are in fatal crashes [IIHS, no date].

[6] NHTSA has established what it calls its Non-Traffic Surveillance System, described as a virtual data collection system using several sources to collect the relevant information. For more details, refer to U.S. DOT NHTSA, Non-Traffic Surveillance: Fatality and Injury Statistics in Non-Traffic Crashes, 2016 to 2020 (Revised).

Box 5-A Highway Safety Just Before and During the Pandemic: 2019–2021

Deaths

36,355 in 2019 < 39,007 in 2020 < 42,939 in 2021.

Impact of 1st Covid Year (2019–2020)

- ▲ 20.7% fatalities per 100 million VMT
- ▼ 11% vehicle-miles traveled
- ▲ 7.3% overall fatalities
- ▲ 19% killed in speeding-related crashes
- ▲ 4.7% pedestrian fatalities
- ▼ 9.4% older population (65+) fatalities

During Pandemic (2020–2021)

- ▲ 2.2% fatalities per 100 million VMT
- ▲ 8.1% vehicle-miles traveled
- ▲ 10% overall fatalities
- ▲ 7.9% killed in speeding-related crashes
- ▲ 13% pedestrian fatalities
- ▲ 14% older population (65+) fatalities

Estimated Injuries

2,757,277 in 2019 > 2,304,701 in 2020 < 2,497,657 in 2021.

Impact of 1st Covid Year (2019–2020)

- ▼ 17% people injured estimates
- ▼ 25% property-damage-only (PDO) crash estimates
- ▲ 9.4% overall
- ▲ 1.3% rate per 100 million VMT
- ▲ 9.6% drivers and passengers
- ▲ 4.7% motorcyclists
- ▲ 11% pedestrians
- ▲ 7.0% pedalcyclists

During Pandemic (2020–2021)

- ▲ 9.4% people injured estimates
- ▲ 20% PDO crash estimates
- ▲ 9.4% people in large-truck crashes
- ▼ 7.7% large-truck occupants in single-vehicle crashes
- ▲ 6.6% large-truck occupants in multi-vehicle crashes
- ▲ 13% other vehicle occupants in large-truck crashes
- ▲ 16% nonoccupants in large-truck crashes

Estimated Nonfatal Crashes

6,722,597 in 2019 > 5,215,071 in 2020 < 6,063,428 in 2021.

Impact of 1st Covid Year (2019–2020)

- ▲ 16% overall
- ▼ 8.4% injury crashes
- ▲ 20% PDO crashes

During Pandemic (2020–2021)

- ► 0.0% injury crash rate per 100 million VMT
- ▲ 10% PDO crash rate per 100 million VMT

SOURCE: U.S. Department of Transportation, National Highway Traffic Administration. Overview of Motor Vehicle Crashes in 2021. As of November 2023.

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-old 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

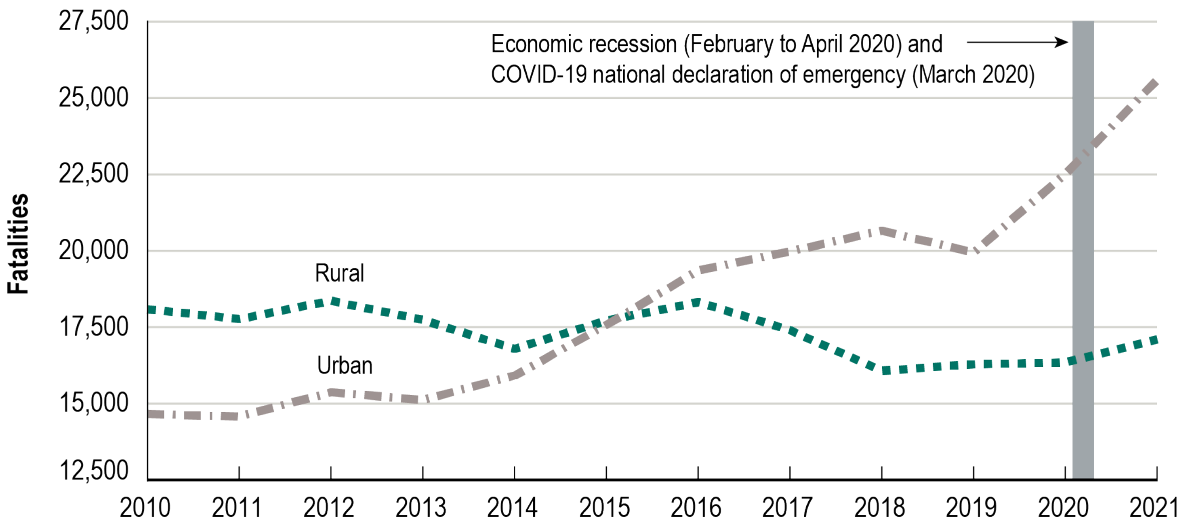
Urban area highway fatalities first exceeded those in rural areas in 2016, a trend that has continued in subsequent years, so that in 2021 there were about 8,500 more urban than rural deaths (Figure 5-4). Rural fatalities decreased by 7 percent between 2012 and 2021 while urban fatalities increased by 67 percent [USDOT NHTSA 2023a].

In comparison to 2019, traffic fatalities in urban areas increased by 13 percent in the first pandemic year in 2020, and an additional 14 percent in 2021, compared to increases of less than 0.5 percent and 5 percent respectively in rural areas. Urban area fatalities involving an alcohol-impaired driver increased 17 percent versus 9 percent in rural areas. In 2021, some 29 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 in 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 2023d]. 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 2020].

The fatality rate in rural areas declined in 2021 from the 2020 level but was still above the 2019 rate. Rural areas continue to have a fatality rate that is much higher per 100 million VMT than urban areas: 1.74 in rural areas compared to 1.19 in urban areas (Figure 5-5). Accounting for only 31 percent of total VMT in 2021, rural areas were the location for 40 percent of 2021 traffic fatalities, a decline from 42 percent in 2020.

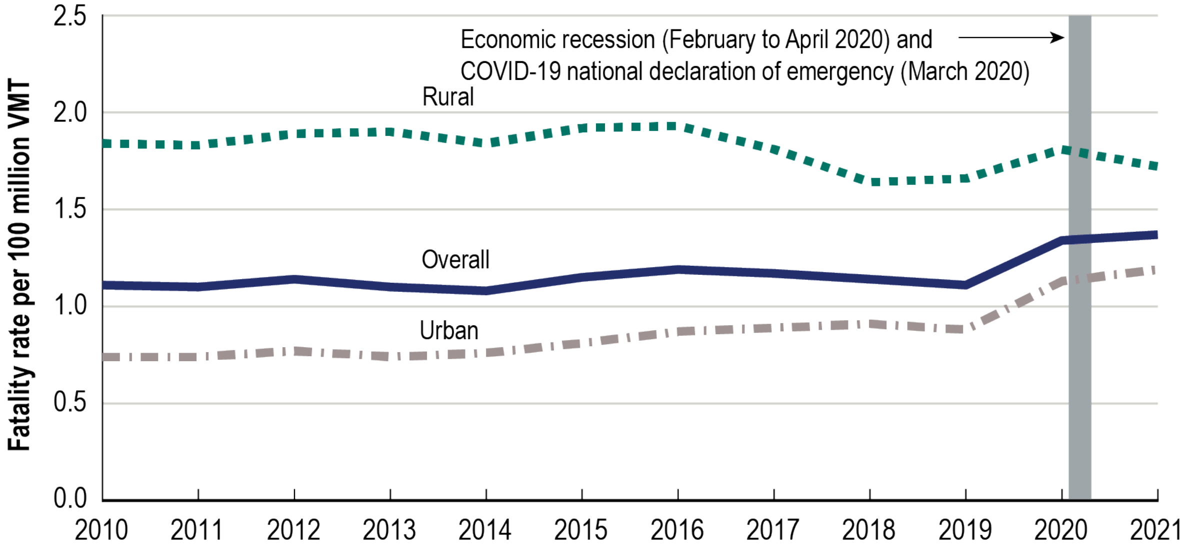
Figure 5-4 Motor Vehicle Traffic Fatalities, by Rural or Urban Location: 2010–2021



NOTE: The change in 2012–2021 fatality numbers between urban and rural areas could be affected to some extent by differing criteria used to identify urban and rural boundaries in the 2010 and 2020 Censuses. For more information about the criteria changes, refer to the U.S. Bureau of the Census report "Differences to the Final 2020 Census Urban Area Criteria and the 2010 Census Urban Area Criteria" available at 2020 Census Urban Area FAQs as of November 2023.

SOURCE: Department of Transportation, National Highway Traffic Safety Administration. Overview of Motor Vehicle Crashes in 2021, "Figure 9. Traffic Fatalities, by Land Use." April 2023. DOT HS 813 435. Available at www.nhtsa.gov/ as of November 2023.

Figure 5-5 Fatality Rates per 100 Million VMT, by Rural or Urban Location: 2010–2021



KEY: VMT = vehicle-miles traveled.

SOURCE: Department of Transportation, National Highway Traffic Safety Administration. Overview of Motor Vehicle Crashes in 2021, Tables 9 and 12, April 2023. DOT HS 813 435. Available at www.nhtsa.gov/ as of August 2023.

NHTSA's analysis of fatal crashes indicates a notably slower emergency medical response time in rural areas than in urban areas. In 2020, in 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 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

Estimates of people injured in motor vehicle incidents increased dramatically between the first pandemic year (2020) and the second (2021), partially recouping the dramatic 17 percent drop in people injured between 2019 and 2020. The reduction reflected far fewer injury-only crashes in the first year of the pandemic. Estimated injuries in 2021 were 2.5 million, compared to 2.3 million in 2020 and 2.7 million in 2019.

Motor vehicle occupants were the third largest category of people treated in hospital emergency rooms for non-fatal injuries in 2021, after lowering to fifth largest in 2020, from third largest in 2019 [USDHHS CDC WISQARS]. 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. (Refer to Appendix D for discussion of the redesigned sample.)

The human and economic costs of injuries from motor vehicle crashes are great, as most recently estimated by NHTSA for data year 2019. The analysis estimated $340 billion in economic costs, and a much larger total societal cost of $1.4 trillion when lost quality of life was factored in. Quality of life estimates include hard-to-quantify factors such as pain, trauma, emotional distress, and lifelong impairment. The comprehensive costs of motorcycle crashes in 2019 were estimated to be $107 billion, including $17 billion in economic costs [USDOT NHTSA 2023n].

Much consideration is now being given to the safety implications of new technologies that can assume some or all functions of driving. While these technologies have much promise as a way to reduce highway deaths and injuries and their economic costs, several high-profile crashes involving vehicles equipped with advanced driver assistance systems have occurred in which a human driver may not have been playing an active role as a driver, leading to concerns about the safety of these systems, especially those involving full automation. Box 5-B discusses efforts to collect data on these driving systems.

Other Transportation Modes

Non-highway modes—civil aviation (both commercial air carriers and general aviation), railroads, rail transit, water (commercial and recreational boating), and hazardous liquid pipelines (oil and gas)—account for slightly over 5 percent of total transportation fatalities and less than 1 percent of injuries in most years. In 2021, 2,020 people died in accidents/incidents involving these non-highway modes compared to 2,034 in 2020.

As for injured people, air, railroad, water, and pipeline injuries fell from 17,321 in 2019

Box 5-B Safety Data and Advanced Driving Assistance Technologies

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 is 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).

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 fatalities 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 2022b]. 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].

to 12,937 in the first pandemic year in 2020 and increasing a bit to 13,191 in the second pandemic year 2021 (Table 5-2). People injured on transit rail fell from 6,648 in 2019 to 4,097 in 2020, before rising to 4,473 in 2021. On the bus and other non-rail transit modes (e.g., ferry) injured people averaged slightly more than 16,500 per year between 2017 and 2019, but then declined to about 11,300 in 2020 when far fewer people took transit, and then rose to about 12,100 in 2021, and further still to 13,800 in 2022, still well below the pre-pandemic level [USDOT BTS NTS table 2-2 and USDOT FTA].[7]

As discussed below, the safety record of the nonhighway modes pre- and post-pandemic has been mixed.

Transit[8]

Transit deaths increased during the pandemic, despite the precipitous drop in transit use beginning in March 2020 due to pandemic shutdown effects on local travel. From 268 in 2019, fatalities rose 9 percent to 289 in 2020, and continued to rise in 2021 and 2022, reaching 338 in 2022, the highest number since 1990 [USDOT BTS NTS]. The data show most of the increases in transit fatalities occurred outside the transit vehicle (e.g., occupants of other vehicles, and pedestrians struck by light rail trains). 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.

Sixty-five percent of the 2022 fatalities involved transit rail and about 34 percent involved bus (with the remainder a death on ferry transit). 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 only 7 percent of the transit fatalities (Figure 5-6). 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 died in the vehicle. In 2022, 18 percent of the transit fatalities were suicides on transit property or involving transit assets, compared with 22 percent in 2021.

Water

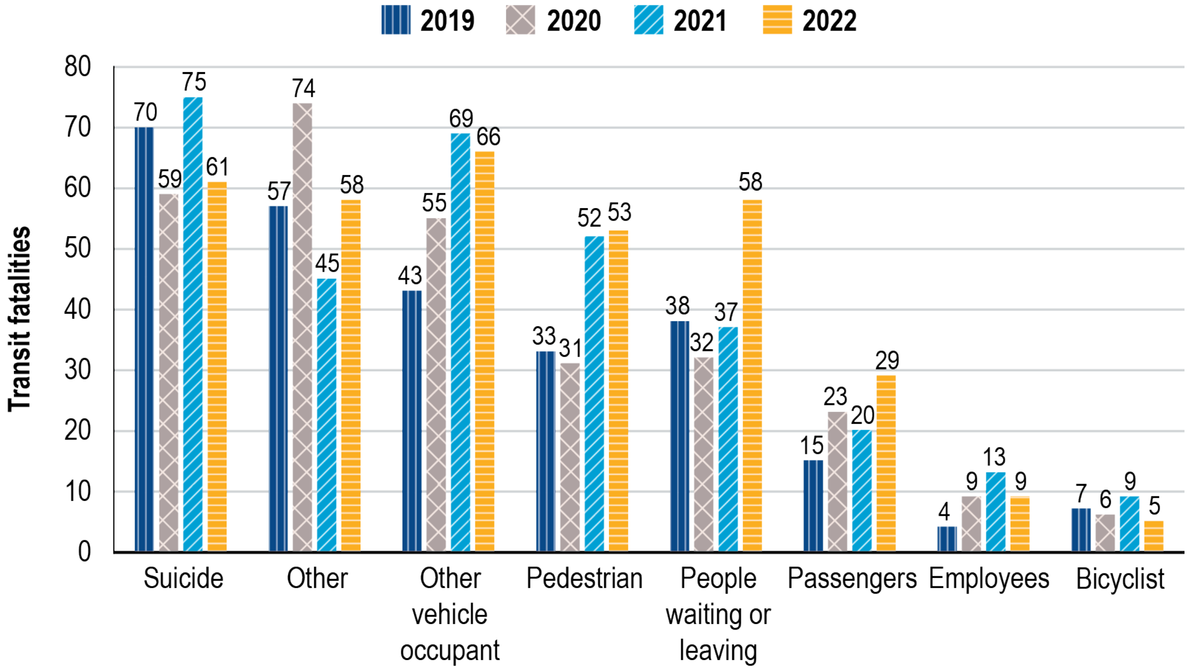
Fatalities in water transportation, both commercial and recreational boating (also called boating below), totaled 715 in 2021 and 686 in 2022, down from the pandemic high of 853 in 2020 due to fewer boating fatalities. Boating accounts for the lion's share of water transportation fatalities in most years and is 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 before the pandemic, but in 2020, the U.S. Coast Guard (USCG) reported a 25 percent increase—767 fatalities. Boating fatalities fell to 658 in 2021 and to 636 in 2022 (but were still more than in 2019) [USDOT BTS NTS table 2-1].

In addition to the 636 people who died while boating in 2022, an additional 2,222 people were injured, and $62.8 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 them. 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 2023].

[7] While bus is a highway mode, it is highlighted here because it is not separated out below the line in Table 5-2.

[8] 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 5-6 Transit Fatalities by Category: 2019–2022



NOTES: Pedestrian fatalities includes in crossings, not in crossings, and walking along track. "Other" includes those killed outside of a vehicle that do not fit in any other category. Other vehicle occupant includes the number of occupants of other vehicles killed.

SOURCE: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, available at https://www.transit.dot.gov/ntd as of November 2023.

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 2022 boating accidents involved motorized craft; the remaining one-third involved kayaks, canoes, rowboats, and other non-motorized boats [USDHS USCG 2023]. In terms of number of fatalities, recreational boating clearly has become safer over the decades. In 1980, there were twice as many fatalities as in 2022—1,360 vs. 636 [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 86 vessel-related fatalities in 2020, down from 94 in 2019, and a further reduction to 57 in 2021 and 50 in 2022.[9]

Railroad

Railroad fatalities (including grade crossing and trespasser deaths) declined 15 percent overall

[9] 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.

between 2019 and 2020, reflecting a one-third decline in fatalities at rail-highway grade crossings consistent with decreased highway usage in the first pandemic year. Highway-rail crossing deaths were 289 in 2019 but fell to 194 in 2020.[10] Rail related fatalities rose in 2021 and again in 2022 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 discussed further in the ignoring risks and warnings section of this chapter.

Of the people who died in railroad-related accidents in 2022, 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 371 in 2021, compared to 358 in 2020, and 455 in 2019.

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 8 years between 2010 and 2021 with no passenger fatalities on U.S. passenger airlines, with a total of 16 fatalities reported over the entire 12-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 23 total fatalities over the other 6 years. Air taxis, an on-demand service, registered fatalities in every year, with 21 deaths in 2020 and 25 deaths in 2021 (including 1 death outside the plane in each year). While roughly comparable to the annual averages of 22 deaths between 2010 and 2019, a continuation of the rapid decline from 44 fatalities per year between 2000 and 2009, and about 54 fatalities annually between 1990 and 1999 may have tapered off [as cited in USDOT BTS NTS, table 2-10].

General aviation (GA) fatalities fell from 417 in 2019 to 332 in 2020 (with 9 of the deaths outside the plane), and then rose a bit to 344 in 2021 (with 3 deaths outside the plane). 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 235 in 2019, 205 in 2020, and 210 in 2021. 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 (0.984) and 2017 (0.935), has subsequently ticked upwards and was slightly over 1 in 2018 (1.025), 2019 (1.073), and 2020 (1.054), before lowering below 1 again in 2021 (0.951) [NTSB no date b].

Unmanned aircraft systems (UAS), or "drones," pose several challenges to 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, most reports of close calls or near misses have depended on human observation, hindering analysis of the risks of collision with planes piloted by humans or damage on the ground to people or facilities. However, a recent academic study examined

[10] To avoid double counting, highway-rail crossing fatalities in Table 5-1 are counted under the highway subtotal but shown separately under the redundancy line in the table.

telemetry data from 1.8 million piloted flights and 460,000 UAS operations near the Dallas-Fort Worth International Airport between August 2018 and July 2021 and found 24 near-misses. The researchers noted that extending drone exclusion zones near the ends of high risk runways would reduce risks [Embry-Riddle].

Oil/Hazardous Liquid and Gas Pipelines

In 2021, 13 people died and 33 were injured in 631 pipeline incidents, while in 2022 five people died and 22 were injured also in 631 incidents. Gas pipelines (especially gas distribution pipelines—such as to residences and commercial buildings—account for most of the fatalities in most years and all the 2021 and 2022 fatalities [USDOT PHMSA portal]. Pipeline incident costs averaged $575 million per year over the 2020–2022 period, about 60 percent of which involved oil or other hazardous liquid spills [USDOT PHMSA portal].

On-the-Job Transportation-Related Fatalities and Injuries

As is the case in most years, transportation incidents were the most frequent cause of the 5,190 on-the-job fatalities in 2021.

This was an overall increase of 8.9 percent from 2020, reflecting the return to employment as the pandemic's effect lessened. Transportation's share of the 2021 on-the-job deaths was 38.2 percent, or 1,982 fatal workplace injuries, according to the latest census by the Bureau of Labor Statistics (BLS) [USDOL BLS 2023]. Motor-vehicle operators accounted for 56 percent of transportation-related on-the-job fatalities (1,103); of that total, heavy or tractor-trailer truck drivers accounted for 874 fatalities. Drivers had the sixth highest occupational fatality rate (28.8 deaths per 100,000 workers). There were 48 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 3.6 per 100,000 workers) in 2021.

Transportation events accounted for under 6 percent of the non-fatal occupational injuries and illnesses in 2018 [USDOL BLS 2019].[11]

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 2021, 954 people died in work zones, a 15 year high. Of these, 51 were work zone workers. About 42,151 people were injured in crashes in work zones in 2021 [NSC]. The data suggest that most of those injured or killed in work-zone crashes are people in vehicles, not workers in the work zone [USDOT NHTSA]. A separate data source estimates that about 55 worker-pedestrians are killed in work zones each year [as cited in NCS].

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. People working in transportation jobs are also subject to harassment and assaults, such as transit workers and flight attendants.

[11] Includes non-fatal occupational injuries/illnesses requiring at least 1 day away from work.

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 enforcement actions initiated grew from 54 in 2020 to 350 in 2021, to 567 in 2022. Many of these incidents involved face-mask wearing, which for a period had been mandatory on public transportation [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 from the 2019 level in 2020, and 2021. Robberies and assaults fell in 2020; they both increased in 2021 but were still below 2019 levels. The data are from jurisdictions serving at least 50,000 people and operating 30 vehicles or more [USDOT BTS NTS table 2-38].[12] A recent Urban Institute analysis, using data from the Federal Transit Administration's National Transit Database, found that assaults on transit workers in 2023 have tripled since 2008 [Urban Institute].

Suspected Crimes on Cruise Ships

Cruise ship companies that pick up or drop off passengers in the United States are expected to report suspected onboard 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 little cruise ship activity in 2020 and 2021, due to the pandemic, with few incidents reported by the cruise lines. Cruise ship reports for 2022 show increasing incidents, although well below the pre-pandemic level, and consisted of mostly sexual assaults [USDOT].

Harassment

A 2020 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, operating vehicles or carrying out transportation

[12] 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.

operations while under the influence of alcohol or drugs, or while distracted or fatigued. These often occur in combination.

In 2020, 54.6 percent of passenger vehicle drivers in fatal crashes were cited for at least one driver-related factor, with speeding, driving under the influence of alcohol, drugs, or medication, failure to yield the right of way, and operating vehicle in a careless manner being the top factors. In contrast, about one-third (31.6 percent) of large truck drivers in fatal crashes were cited for driver-related factors, with speeding, distraction, and impairment (including fatigue) being the top 3 in 2020 [USDOT FMCSA 2022].

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 2020, vehicle factors, most commonly tires, were recorded for 3.9 percent of large trucks and 2.5 percent of passenger vehicles involved in fatal crashes [USDOT FMCSA 2022].

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), 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. Speeding-related deaths were less than 10,000 before the pandemic in 2019, but increased to 12,330 in 2021, an additional 2,700 speeding-related deaths. Prior to these increases, speeding-related fatalities had been falling, dropping from 31 to 26 percent of highway fatalities between 2012 and 2018. About 33 percent of motorcyclists in fatal crashes in 2021 were speeding, the highest share among vehicle driver types, as were 22 percent of passenger car drivers, 15 percent of light-truck drivers, and 7 percent of large-truck drivers.

Males, especially young males, account for a high proportion of speeding drivers in fatal crashes. In 2021, 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 21 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 2021 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 51 percent of the passenger vehicle drivers involved in fatal crashes who were speeding in 2021 were not wearing seat belts at the time of the crash, versus 23 percent of passenger vehicle drivers in fatal crashes who were not speeding, based on known restraint use [USDOT NHTSA 2023a].

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 2021, an average of one alcohol-impaired-driving fatality occurred every 39 minutes [USDOT NHTSA 2023h].

As shown in Table 5-3, in 2021, 13,384 people died in motor vehicle crashes in which at least one driver had a BAC of 0.08 g/dL or higher; this was an increase of 14.2 percent from the first pandemic year 2020, and 31 percent above the pre-pandemic year 2019, and the most since 2006.[13]

[13] 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.

Table 5-3 Fatalities by Highest Blood Alcohol Concentration (BAC) in Highway Crashes: 2010 and 2017–2021

Mode	2010	2017	2018	2019	2020	2021
TOTAL fatalities	**32,999**	**37,473**	**36,835**	**36,355**	**39,007**	**42,939**
BAC = 0.00						
Number	21,005	24,589	24,186	24,251	25,038	27,221
Percent	64	66	66	67	64	63
Fatalities in alcohol-related crashes (BAC = 0.01+)	**11,906**	**12,775**	**12,560**	**12,029**	**13,793**	**15,650**
Percent	36	34	34	33	35	36
BAC = 0.01–0.07						
Number	1,771	1,895	1,850	1,834	2,075	2,266
Percent	5	5	5	5	5	5
BAC = 0.08+						
Number	10,136	10,880	10,710	10,196	11,718	13,384
Percent	31	29	29	28	30	31

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.

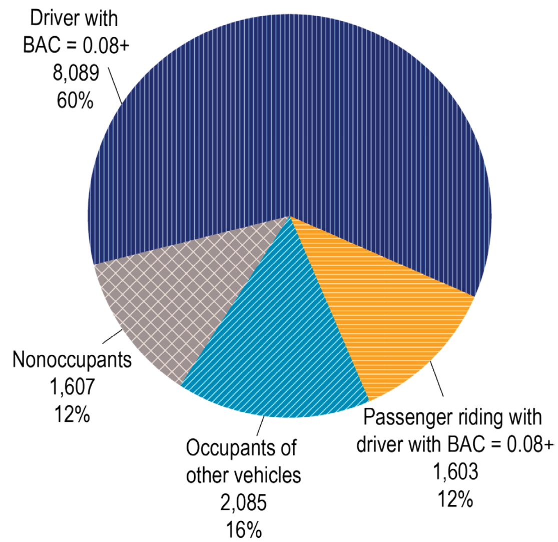
SOURCE: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, *Traffic Safety Facts: Alcohol-Impaired Driving* (Annual Issues) as of December 2023.

Many inebriated drivers have a BAC that greatly exceeds the 0.08 g/dL level and/or are repeat offenders. In 2021, 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 than drivers in fatal crashes in which no alcohol was involved [USDOT NHTSA 2023h].

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 repeat offender requirements that meet federal standards [GHSA no date a].

Figure 5-7 displays categories of people who died in fatal crashes in 2021 when the driver had a BAC of 0.08 g/dL or higher. Drivers accounted for 8,089 (60 percent) of the fatalities; 3,688 (28 percent) were either passengers in a vehicle with an impaired driver or occupants of other vehicles, and 1,607 were pedestrians or other nonoccupants (12 percent). Some 28 percent of motorcycle riders in fatal crashes were alcohol-impaired, the highest share among highway motor vehicle driver types.

Figure 5-7 Fatalities, by Role, in Crashes Involving at Least One Driver with a BAC of 0.08 or Higher: 2021



KEY: BAC = blood alcohol concentration.

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 2021* (November 2023).

The estimated economic costs of alcohol-impaired crashes in 2019 was $58 billion, and $340 billion when full societal costs were included. This was 26 percent of the estimated total societal cost of motor vehicle accidents in 2019 [USDOT NHTSA 2023n].

The U.S. Coast Guard (USCG) found operator alcohol use to be the primary contributing cause in 16 percent of fatal boating accidents in 2022, resulting in 108 fatalities; drug use was the primary contributing factor in 8 accidents, resulting in 6 fatalities [USDHS USCG 2023]. As of January 1, 2021, 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.[14] 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,[15] Federal transportation agencies have required testing on the job for safety-sensitive transportation operators and workers in many industries.[16]

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 2022, according to the U.S. Coast Guard—resulting in 45 deaths and 308 injuries [USDHS USCG].

As for motor vehicles, the number of fatalities in distraction-affected highway crashes rose to 3,522 or 8 percent of total motor vehicle related fatalities in 2021 (Figure 5-8). Drivers aged 25 to 34 represent 25 percent of all distracted drivers involved in fatal crashes [USDOT NHTSA 2023f]. Vehicle occupants comprised 82 percent of fatalities in distraction-affected crashes in 2021. In addition, 644 nonoccupants, mostly pedestrians and pedalcyclists, 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 2021 (3,211) were affected by driver distraction. In 377 of these, a cell phone was in use at the time of the crash. 34 states, the District of Columbia, and Puerto Rico prohibit drivers' use of handheld cell phones, and 49 states plus the District of Columbia and Puerto Rico ban texting while driving.

Drowsy driving was found to be a factor in 622 fatal crashes (about 1.6 percent), resulting in 684 fatalities in 2021 [USDOT NHTSA online a]. However, it is likely that the role of fatigue in crashes has been underestimated [AAA 2018].

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].

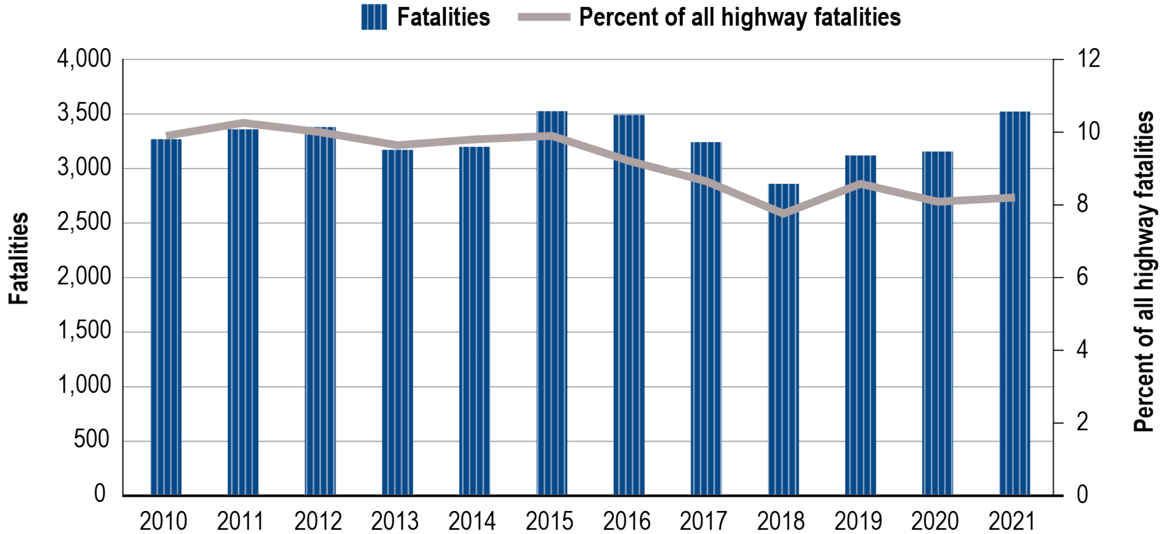
Distracted or inattentive driving by commercial motor vehicle drivers was a contributing factor

[14] 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.

[15] The testing is required by the Omnibus Transportation Employee Testing Act of 1991, Public law 102-143.

[16] 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, refer to Bureau of Transportation Statistics, Transportation Statistics Annual Report 2018, box 6-C, page 6–17.

Figure 5-8 People Killed in Distracted-Driving Crashes: 2010–2021



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 2021*, available at www.nhtsa.gov as of November 2023.

in approximately 5.2 percent of fatal crashes involving large trucks in 2020. In addition, truck driver impairment (e.g., fatigue, drugs/alcohol, illness, etc.) was a factor in 5.2 percent of these fatal crashes, the same percentage as distracted driving [USDOT FMCSA 2022a].

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 trespassers dying on railroad property (much of which is marked with keep-out signs) equals or exceeds the number of deaths in the transit or air modes in most years. After reaching a historic low of 399 in 2011, trespasser fatalities on railroad property have since risen. In 2020, the first full year of the pandemic, trespasser fatalities fell to 503, but then increased to 581 in 2021, and 619 in 2022, the most since at least 1975. While trespassers accounted for about 61 percent of the total railroad fatalities between 2010 and 2019, the 2022 number comprised 67 percent of the 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 years 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 236 fatalities at grade crossings, followed by 274 in 2022 [as cited in USDOT BTS NTS].[17]

[17] 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.

Many railroad-related deaths each year involve people committing suicide, averaging about 260 people a year between 2013 and 2022. This is about one-third of rail deaths over the period. Suicide accounted for 23 percent of transit fatalities in 2021, with all but 6 of the 75 suicides involving transit rail (refer to Figure 5-6).

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 75 percent of people who died in boating accidents in 2022 drowned, and 85 percent of those who drowned were not wearing a life jacket [USDHS USCG 2023].

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 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 92 percent of front seat occupants of passenger cars, pickup trucks, vans, and sport utility vehicles (SUVs) used safety belts in 2022, up from 71 percent in 2000 and 85 percent in 2010 [USDOT NHTSA 2023]. 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 87 percent in 2022 (Table 5-4).

Half of passenger vehicle occupants killed in 2021 were unrestrained. As for fatal crash survivors in 2021, 85 percent used restraints, while 15 percent did not (based on cases where restraint use was noted by officials at the crash scene) [USDOT NHTSA 2023m]. NHTSA estimated that seat belts saved about 14,955 lives in 2017 and that an additional 2,549 lives could have been saved with 100 percent use of seat belts [USDOT NHTSA 2019].

Among states and territories in 2022, observed seat belt use ranged from a low of 67 percent in the U.S. Virgin Islands and 76 percent in New Hampshire to highs of over 95 percent in three states and the District of Columbia. The 35 states with primary enforcement laws, allowing police to ticket vehicle occupants solely for not wearing seat belts, have higher belt usage (92 percent in 2022) than states with weaker or no enforcement (90 percent) [USDOT NHTSA 2023o and 2023m].

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 Percentages of Safety Belt and Motorcycle Helmet Use: 2010 and 2017–2022

Mode	2010	2017	2018	2019	2020	2021	2022
Overall safety belt use[a]	**85**	**90**	**90**	**91**	**90**	**90**	**92**
Drivers	86	90	90	91	91	91	92
Right-Front Passengers	83	88	89	90	90	89	90
Passenger cars	86	91	90	91	91	91	91
Vans and sport utility vehicles	88	92	92	93	92	92	94
Pickup trucks	75	83	84	86	86	85	87
Motorcycle helmet use[ab]	**54**	**65**	**71**	**71**	**69**	**65**	**67**
Operators	55	68	71	75	69	67	68
Passengers	51	51	69	48	72	52	61

[a] Seat belt use is as of the Fall each year. Motorcycle helmet use is as of the Fall each year.

[b] Only those operators and riders wearing safety helmets that met U.S. Department of Transportation (DOT) standards are counted. Those safety helmets that do not meet DOT standards are treated as if the operator/rider were not wearing a helmet.

NOTE: Occupants of commercial and emergency vehicles are excluded.

SOURCES: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, Traffic Safety Facts: Research Notes, *Seat Belt Use* (Annual issues); and *Motorcycle Helmet Use—Overall Results* (Annual issues). Available at http://www-nrd.nhtsa.dot.gov as of August 2022 as cited in USDOT, Bureau of Transportation Statistics, National Transportation Statistics, table 2-30, available at http://www.bts.gov as of November 2023.

NHTSA estimates that DOT-compliant helmets[18] 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) and then rising to about 67 percent in 2022 [USDOT NHTSA 2023b].

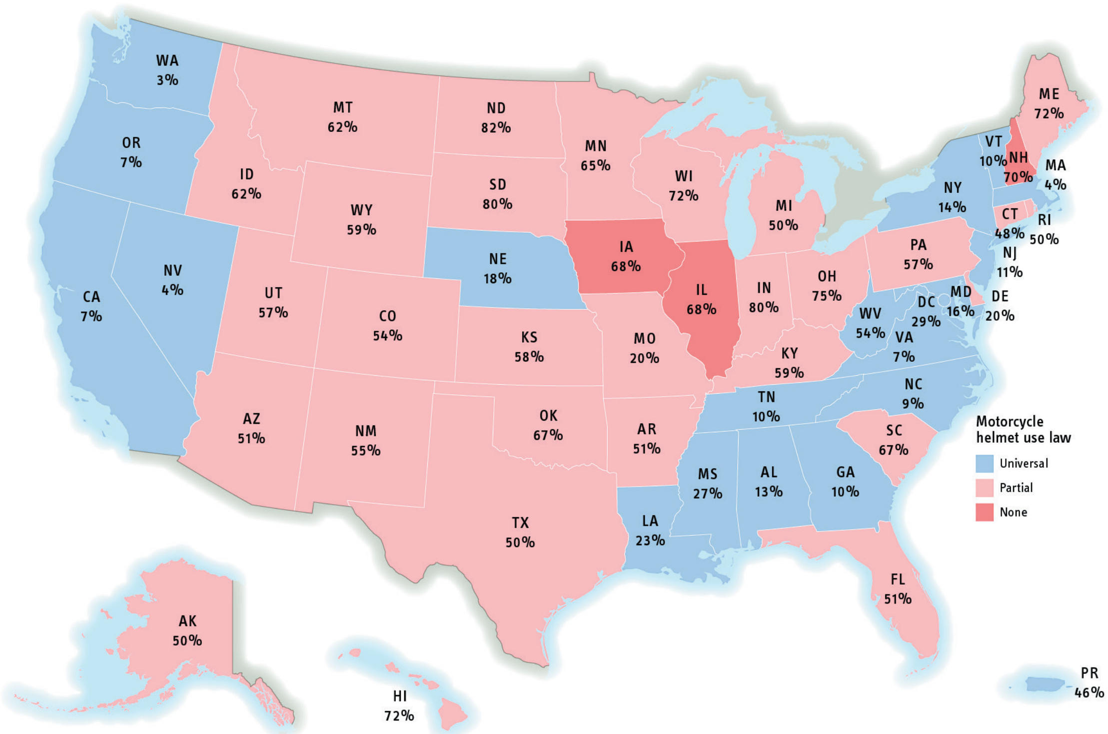
In 1975, 47 states and the District of Columbia had adopted universal helmet use laws that required motorcycle helmets for all riders, but many states subsequently made their helmet laws less restrictive [COSGROVE]. In 2021, only 18 states and the District of Columbia continued to have universal helmet 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 5-9).

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

[18] 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.

Figure 5-9 Percentages of Motorcyclists Killed Not Wearing a Helmet: 2021



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Motorcycle Helmet Use in 2021—Overall Results*. DOT HS 813 70. March 2022. Available at www.nhtsa.gov/ as of November 2023.

micromobility device, and helmet use by new riders often is not monitored. Box 5-C 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. With 233 million licensed drivers in the United States in 2021, motor vehicle driver training is a large endeavor. Driver education courses for teenagers under the age of 18 are needed for a driver's license in many states—23 in 2012, with requirements varying by states [USDOT NHTSA 2012]. Commercial driving licenses require training in the type of highway equipment the driver seeks to operate. An extensive training system in the United States has developed to train the several hundred thousand pilots at all levels in the United States—over 750,000 with active airman certificates in 2022 [FAA 2022]. 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 2023(c)].

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

Box 5-C 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 deemed 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 used to rent the device. 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 elderly and vision impaired.

Data on injuries from these fast-growing transportation options are limited. A study by the U.S. Consumer Products Safety Commission (US CPSC) examined injury, fatality, and hazard patterns covering e-scooters, e-bikes, and hoverboards from 2017 through 2022. It found 360,000 emergency room visits by injured riders of these devices over the 5 years, with the number of visits increasing linearly each year. The number of fatalities increased from 5 in 2017 to 76 in 2022, with deaths totaling 233 over this period. CPSC conducted and completed follow up on 309 e-scooter visits to emergency departments, finding that renters comprised 37 percent of the visits; 63 percent of injuries were on paved roads, and only 13 percent of those interviewed were wearing a helmet [US CPSC a].

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.

Defective micromobility devices themselves are a hazard. In December 2022, CPSC issued a warning to manufacturers of dangers of overheating and fires from batteries of micromobility devices. The agency noted that it had received reports of 19 fatalities in 208 incidents from micromobility device overheating/fires, as well as numerous reports from emergency rooms of injuries, between the beginning of 2021 and the end of November 2022 [US CPSC b]. Defective brakes are another danger.

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 14 percent of deaths in fatal boating accidents in 2022 occurred in boats operated by a person known to have received a certificate for boating safety from a nationally approved provider [USDHS USCG 2023].

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 7.1 percent of the Nation's 234 million drivers in 2020 were stopped by police [USDOJ BJS 2022]. 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 2019, according to the FBI, law enforcement agencies across the country made over 500,000 arrests for driving under the influence (DUI), down from just under 800,000 in 2010. Males accounted for almost three-quarters of the 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.

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 2021, there were roughly 709,000 interstate freight carriers (including a large number of self-employed truckers), 38,400 intrastate hazardous material (HazMat) carriers (in addition to those HazMat carriers counted in the interstate freight carrier category), and 10,300 interstate passenger carriers (e.g., bus companies). That year, there were about 2.9 million roadside inspections of trucks and buses conducted by state and federal inspectors, up by 300,000 from 2020, but still 600,000 fewer inspections then in 2019 before the pandemic, and the number of safety inspectors fell from 13,597 to 12,718, with the number of inspections declining from 3.5 million to 2.9 million [USDOT FMCSA 2022b].

The number of warning letters sent by regulators to motor carriers whose safety data showed a lack of compliance with safety regulations and whose safety performance was unacceptable fell from 26,564 in 2019 to 22,230 in 2020 before rebounding to above 2019 levels, 28,181 in 2021 [USDOT FMCSA no date]. Inspections may reveal violations that must be corrected before the driver or vehicle can return to service. In fiscal year 2021, vehicle violations, such as defective lights, worn tires, or brake defects, put about 32 percent of inspected trucks out-of-service until corrected—an increase from 21 percent in 2019. Truck driver violations put about 7 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.

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 2022, nearly 25,200 hazardous materials incidents (excluding pipeline incidents) associated with these shipments were reported to the USDOT Pipeline and Hazardous Materials Administration (PHMSA)—up about 3,300 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 for 2022, about 4,100 occurred during loading and 12,000 during unloading.[19] 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 15 derailments, 44 vehicular crashes and 22 rollovers in 2022—although these may have major community impacts.

The above incidents do not include pipelines, which are reported separately to PHMSA. In 2022, the United States had about 229,000 miles of oil pipeline and 2,734,000 miles of gas pipeline, according to

[19] The loading/unloading data are not shown in the table but can be found in the same PHMSA data source.

Table 5-5 Hazardous Materials Transportation Incidents: 2010 and 2017–2022

Mode	2010	2017	2018	2019	2020	2021	2022
TOTAL Incidents	**14,805**	**10,698**	**18,652**	**22,776**	**21,892**	**25,150**	**25,158**
TOTAL vehicular accident/derailment incidents	**358**	**200**	**303**	**261**	**169**	**126**	**96**
Vehicular accident-related percent of total incidents	**2.4%**	**1.9%**	**1.6%**	**1.1%**	**0.8%**	**0.5%**	**0.4%**
Air	1,295	1,082	1,414	1,673	1,639	1,633	1,381
Vehicular accident-related	2	14	5	10	4	2	2
Highway	12,658	9,197	16,754	20,684	19,879	23,116	23,405
Vehicular accident-related	320	168	273	228	139	97	78
Rail	747	417	479	413	372	396	367
Vehicular accident-related/derailment incidents	35	18	25	23	26	27	16
Water[1]	105	2	5	6	2	5	5
Vehicular accident-related	1	0	0	0	0	0	0

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

NOTES: *Incidents* are defined in the Code of Federal Regulations (CFR): 49 CFR 171.15 and 171.16 (Form F 5800.1). *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 August 2023.

PHMSA. Table 5-6 shows the severity of pipeline incidents from 2010 through 2022 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 combined number of barrels of oil and petroleum products moved by pipeline increased from 2.2 billion barrels in 2010 to a high of 3.7 billion in 2019 before falling to 3.4 billion in 2021 [USDOT BTS NTS].

Rail Tank Car Safety

The February 2023 derailment of a train with 11 tank cars carrying hazardous materials (including 5 DOT-105 specification tank cars containing vinyl chloride) in East Palestine, Ohio has drawn much national attention [NTSB 2023]. Although not resulting in fatalities, the derailed and burning tank cars were front and center in national news coverage for weeks, as authorities, fearing a greater catastrophe, issued evacuation orders and undertook controlled release and burning of vinyl chloride as safeguards. However dramatic, this was by no means the first time that tank car derailments dominated the news, although many of the earlier derailments involved oil tank cars, not cars carrying vinyl chloride.

The rapid growth in crude oil shipments by freight rail was a surprising transportation trend in the second decade of this century. Rail

Table 5-6 All Reported Hazardous Liquid and Gas Pipeline Incidents: 2010–2022

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	644	11	35	$345	58,869	26,287
2020	560	15	39	$281	156,310	105,559
2021	535	13	33	$208	64,237	41,771
2022	469	13	21	$753	81,483	30,845

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 refer to 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 2023.

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 of October 2023.

shipments grew from 23.7 million barrels in 2010 to a peak of 382.0 million in 2014, before declining to a 2021 level (117.6 million barrels) that was still roughly 5 times that of 2010 [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 14 oil train derailments or other accidents took place in that period that resulted in explosions, fires, and oil spills in the United States or Canada [AP NEWS]. In Canada, a 2013 rail catastrophe in Lac-Magentac, Quebec, involving Bakken crude oil being transported from North Dakota to a refinery in New Brunswick, resulted in 47 deaths and substantial property destruction in the town.

Under a 2015 law,[20] the Bureau of Transportation Statistics (BTS) assembles and collects data on rail tank cars transporting Class 3 flammable liquids[21] in order to track the progress of upgrades to the rail tank car fleet to meet new safety requirements. By the end of 2029, rail tank cars carrying class 3 flammable liquids must meet the DOT-117 or DOT-117R (retrofitted) specification or equivalent.[22]

In 2022, new and retrofitted DOT-117 rail tank cars grew to 59 percent (59,186 tank cars) of the entire fleet used to carry Class 3 flammable liquids, compared to 8 percent in 2016. Of these, 56 percent (32,937 tank cars) are new, and 44 percent (26,219 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 2023].

Filling a Gap in Precursor Safety Data

Information on near-miss and other precursor safety events is an important resource for developing preventive measures to lower the risk of more serious events; however, companies and individuals can sometimes be hesitant to share potentially sensitive precursor safety information due to business and legal concerns. As a principal federal statistical agency, BTS has authority to address these concerns by administering data collection programs under the Confidential Information Protection and Statistical Efficiency Act (CIPSEA).[23] Under CIPSEA, BTS pledges data will be used for statistical purposes and protected from subpoena and legal discovery. Examples of such programs include:

- The Confidential Close Call Reporting Program, administered by BTS and enabled by BTS's authority to protect data under CIPSEA, provides employees of the Washington Metropolitan Area Transit Authority (WMATA) with a confidential platform to report precursor safety events voluntarily without fear of disciplinary action. Information from the program is used to inform preventive safety actions and avoid future adverse events. The program completed its tenth year in 2023.

[20] Section 7308 of the Fixing America's Surface Transportation Act (FAST Act; P. L. 114-94; Dec. 4, 2015).

[21] 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.

[22] 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.

[23] Title III of the Foundations for Evidence-Based Policymaking Act of 2018, Pub. L. 115-435 (reauthorizing 2002 E-Gov Act).

- Safe Outer Continental Shelf (SafeOCS), administered by BTS and sponsored by the Department of the Interior's Bureau of Safety and Environmental Enforcement (BSEE), is a precursor safety event reporting program for the offshore oil and gas industry. It includes both mandatory reporting of equipment failure events sand voluntary reporting of near-miss and other safety events. In 2023, BTS worked with BSEE to kick off an effort to update the data collection form related to failures involving critical safety equipment, such as blowout preventers, to incorporate lessons learned since the start of the program.
- In 2023, BTS and the Maritime Administration (MARAD) completed a pilot effort to test the feasibility of a voluntary near-miss reporting program for the maritime industry, titled Safe Maritime Transportation System (SafeMTS) Such a program would provide a trusted, proactive means for the industry to report sensitive and proprietary information for the purpose of identifying early warnings of potential safety issues. Seven maritime companies participated in the pilot by sharing sample near-miss records and providing input on the program design. BTS and MARAD are working to plan for program implementation beyond the pilot.

Emerging Issues: New Normal in Transportation

Highway Fatalities

Given recent increases in fatalities, is an upward "new normal" occurring? U.S. highway fatalities declined from over 50,000 per year in the 1970s to a low of 32,500 in 2011, but have since risen, and were just under 43,000 in 2021 and are projected to be only marginally fewer in 2022. Is the rise to over 40,000 deaths a lingering consequence of risky behaviors during the pandemic or will those risky behaviors continue further into the decade of the 2020s and beyond? Good data and research will be needed to track the future direction.

With U.S. highway fatalities rising, what explains the continued downward fatality trend in the European Union which in some metrics is broadly comparable to the United States? EU traffic fatalities rose slightly (3 percent) in 2022 but were still 10 percent below the pre-pandemic number in 2019, while U.S. deaths were an estimated 18 percent more. Comparative data will be critical to this evaluation, especially whether different rates of adoption of advanced safety technology are part of the explanation.

Railroad Derailments

Several derailments in the past few years have resulted in substantial damage to surrounding communities due to hazardous chemical releases or deaths and injuries of passengers or train personnel. As previously mentioned, several oil train derailments in the 2010–2015 period resulted in major disasters, including a derailment in Canada that resulted in 47 deaths. While the yearly average number of derailments has declined, over 1,000 still occur each year. Damage from hazardous materials releases has been escalating in dollar terms. Notable freight train derailments in Ohio in 2023 required evacuations in nearby communities and have focused greater public attention on this issue. Several Amtrak, commuter rail, and transit rail derailments have also occurred in recent years, with some resulting in passenger deaths and on train injuries. Data on track conditions can help pinpoint more precisely problem tracks, as can automated inspection programs. However, manual inspection, reduced in recent years, can often detect problems not picked up by instrumentation [NTSB 2023].

Transportation Safety Data Needs

Data gaps and needs related to transportation safety include the following:

- Fatal and serious-injury crashes involving pedestrians, pedal cyclists, 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.
- More granular data and analyses to reveal the factors behind the decline in U.S. road safety records 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).
- 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. BTS is working with the Intelligent Transportation Systems Joint Program Office (ITS JPO) to develop this database.
- 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

U.S. transportation vehicles, cars, trucks, buses, trains, planes, and ships used 27.5 quadrillion Btus of energy in 2022, more than residential, commercial, or industrial end-use sectors. The use of electricity by transportation and its full environmental effects are becoming increasingly important as sales and stocks of electric cars, trucks and buses

Highlights

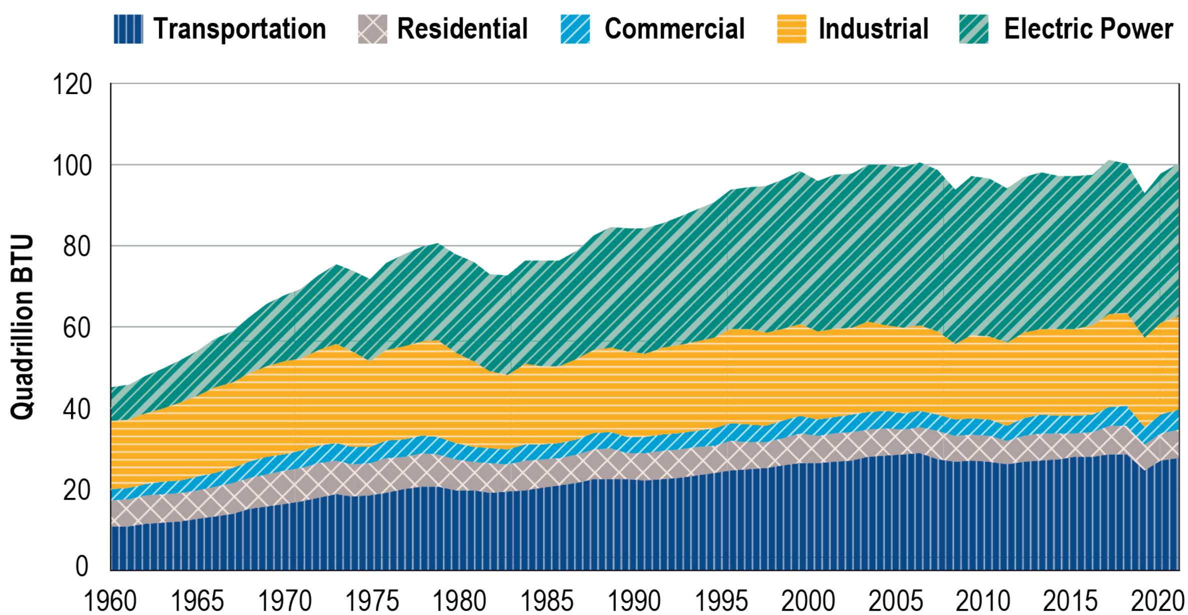
- Transportation energy use in 2022 rebounded from the 14.7 percent decrease experienced in 2020 due to steep reductions in vehicle travel caused by the COVID-19 pandemic but remained 3.4 percent below 2019 energy use.
- Data for the first eight months of 2023 indicate a continuing increase of transportation energy use to 97.6 percent of the 2019 level despite higher 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 89.7 percent of its energy in 2021 and 89.4 percent in 2022, the lowest level of petroleum dependence since 1953.
- Only the entire economies of China and India used more energy than the U.S. transportation system.
- The strategic threat of a Russian oil boycott to the U.S. was greatly diminished by the fact that the U.S. was a net exporter of oil in 2022.
- Fuel savings in 2021 are estimated at just over 75 billion gallons, saving drivers almost $250 billion on fuel that year. The sum of all fuel estimated to have been saved is 2.3 trillion gallons, more than all the fuel used by cars and light trucks from 2005–2021.
- 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 CO_2 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 of 80–85 percent in motor vehicle pollutant emissions over 2000 rates.

rapidly increase. The U.S., along with China, Europe, and many other nations are putting policies in place to transition to a sustainable transportation energy system with the goal of net zero greenhouse gas emissions by 2050 and greatly reducing environmental impacts [US DOT, DOE, HUD, EPA, 2023]. However, such large-scale energy transitions take decades, for car makers to introduce new vehicles, for energy suppliers to deploy charging stations, for investments in supply chains, manufacturing and maintenance facilities and provide technical training to a workforce with the skills to operate it all. The stock of vehicles in use will take time for the turnover and to decarbonize the production of electricity. In the meantime, our transportation system continues to rely overwhelmingly on fossil energy and especially petroleum fuels.

Energy used by cars, trucks, buses, planes, ships, trains, and pipelines accounted for 27 percent of total U.S. primary energy use in 2022, making transportation the second largest user of energy in the economy, behind only electricity generation (Figure 6-1). Only the entire economies of China and India used more energy than the U.S. transportation system [Energy Institute, 2023]. The U.S. transportation system used 27.5 quadrillion Btu of energy to produce six trillion passenger-miles of travel and to move more than five trillion ton-miles of freight in 2022. From the global perspective, the U.S. accounted for about 16 percent of world energy use and 13 percent of global greenhouse gas (GHG) emissions in 2021 [Energy Institute, 2023; EPA, 2023c; Climate Watch, 2023].

While reductions in transportation's emissions have improved air quality in urban areas, air quality, including impacts on the global climate,

Figure 6-1 U.S. Consumption of Energy from Primary Sources by Sector: 1960–2022



KEY: Btu = British thermal unit.

NOTES: Percentages do not sum to 100 due to rounding. In September 2023, the EIA adopted a new method of calculating primary energy use in the electric power sector that reduced estimated primary energy use in 2022 by 12 percent. The data cited in the text and shown in Figure 6-1 are based on the prior method.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, tables 2.1, 3-8a–c, as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 4-2, available at www.bts.gov as of November 2023.

remains the biggest adverse 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 and more effective emissions controls, recycling of vehicles and infrastructure and improved operating practices, despite increases in passenger and freight transportation. The world's transportation system has begun an energy transition from fossil fuel-based internal combustion engines to electric motors powered by renewable and carbon-neutral energy. Reliable, relevant, and timely data are essential for tracking progress, informing decision-making, and planning for the future.

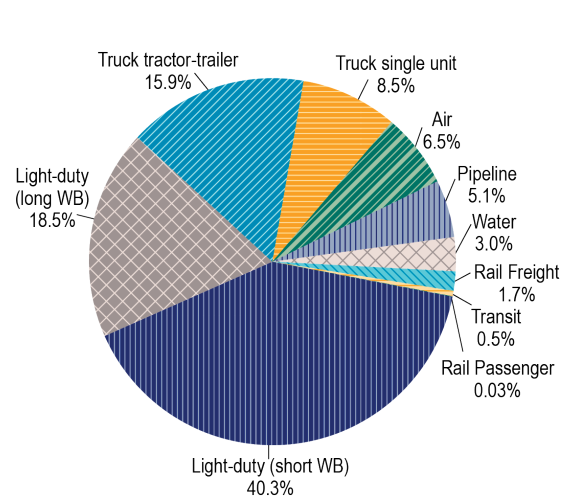
This chapter describes the status, patterns, and trends of transportation energy use in the United States and the environmental effects of the quantity and variety of mobility services provided by our transportation system. The closing section identifies data gaps and information needed to anticipate and plan for changes in transportation's energy requirements and their environmental effects.

Energy Use Patterns and Trends

Transportation's recovery from the impact of the COVID-19 pandemic continued in 2022. Although transportation energy use in 2022 was 4.0 percent below the 2019 high, highway traffic volumes were only 2.8 percent lower than in 2019, and in the first six months of 2023, traffic volume was only 1.1 percent below the same period in 2019 [USDOT FHWA, 2023]. Data for the first eight months of 2023 show transportation energy use at 2.4 percent below the same period in 2019, suggesting a modest improvement in energy efficiency over 2019 [EIA, 2023a].

The highway travel mode continued to dominate transportation energy use in 2021, the latest year for which data are available, accounting for 83.2 percent of the total 24.8 quads Btu of energy used by transportation modes [USDOT BTS, 2023d]. On the highways, passenger cars and light trucks are the biggest energy users at 58.8 percent of total transportation energy use, up from 54.4 percent in 2021 (Figure 6-2).

Figure 6-2 Transportation Energy Use by Mode: 2021



KEY: WB = wheelbase.

NOTE: Energy use by water transport in 2021 was not available at the time of writing. Water energy use is for the year 2000.

SOURCES: U.S. Department of Transportation's Federal Aviation Administration, Federal Aviation Administration, Federal Highway Administration, and Federal Transit Administration; U.S. Department of Energy; National Railroad Passenger Corporation (Amtrak); and Association of American Railroads as cited in Bureau of Transportation Statistics, National Transportation Statistics, table 4-6, available at www.bts.gov as of November 2023.

Together, tractor trailers and single-unit trucks accounted for almost one-fourth of transportation energy use, and their share is likely to decrease 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 16.8 percent of transportation energy use, up from 14.7 percent in 2020, chiefly due to a 37.6 percent increase in aircraft energy use from 2020 to 2021 as air travel rebounded from the impact of the COVID-19 pandemic with an increase in passenger miles of 88.3 percent.

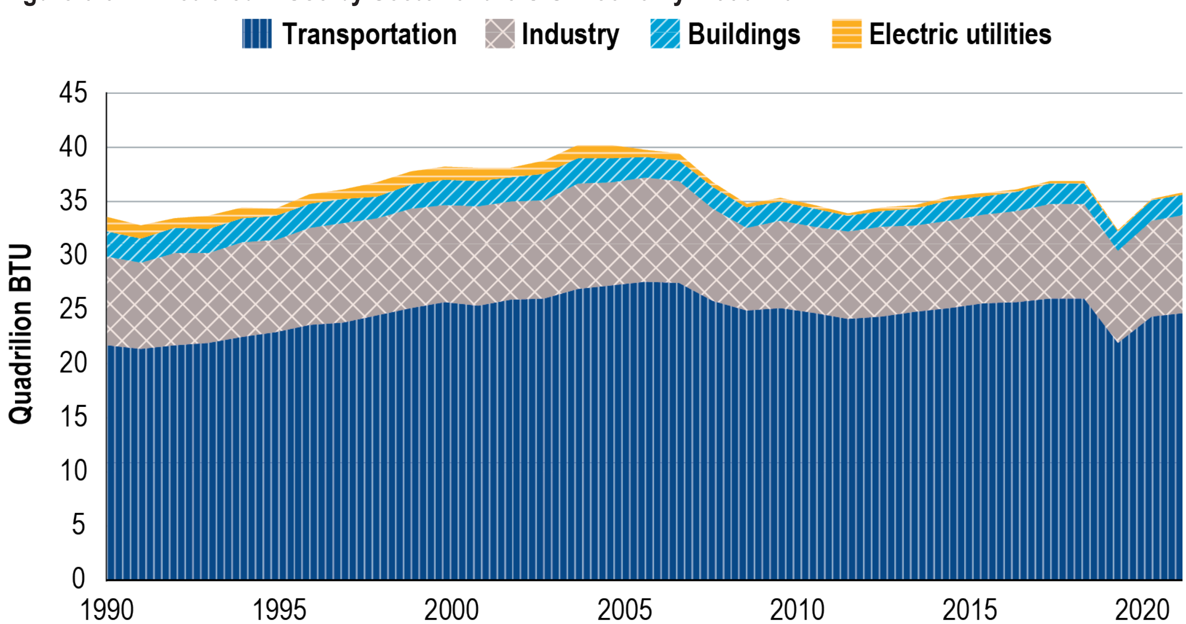
Reliance on Petroleum

Department of Energy statistics indicate that for the first time since 1953 transportation's reliance on petroleum dipped below 90 percent in 2020 during the COVID-19 pandemic. Transportation's petroleum dependence remained below 90 percent, at 89.7 percent in 2021 and 89.4 percent in 2022 [EIA, 2023a].

For the first eight months of 2023, transportation relied on petroleum for 88.8 percent of its energy requirements. However, transportation remains by far the largest consumer of petroleum in the U.S. economy, accounting for 68.7 percent of U.S. petroleum use (Figure 6-3). In 2022, the U.S. consumed 24.6 quadrillion (quads) Btu of petroleum, exceeding every other country's petroleum consumption except for China's 30.3 quads [Energy Institute, 2023].

U.S. oil imports are predominantly crude petroleum, while U.S. oil exports are predominantly refined petroleum products. In 2022, the United States imported slightly more than 8.3 million and exported slightly less than 9.6 million barrels of oil per day (mmbd) [USDOE EIA, 2023a] (Figure 6-4). In 2022, world oil markets were disrupted by Russia's invasion of Ukraine on February 24, 2022. The U.S. and other member countries of the International Energy Agency (IEA) responded by releasing

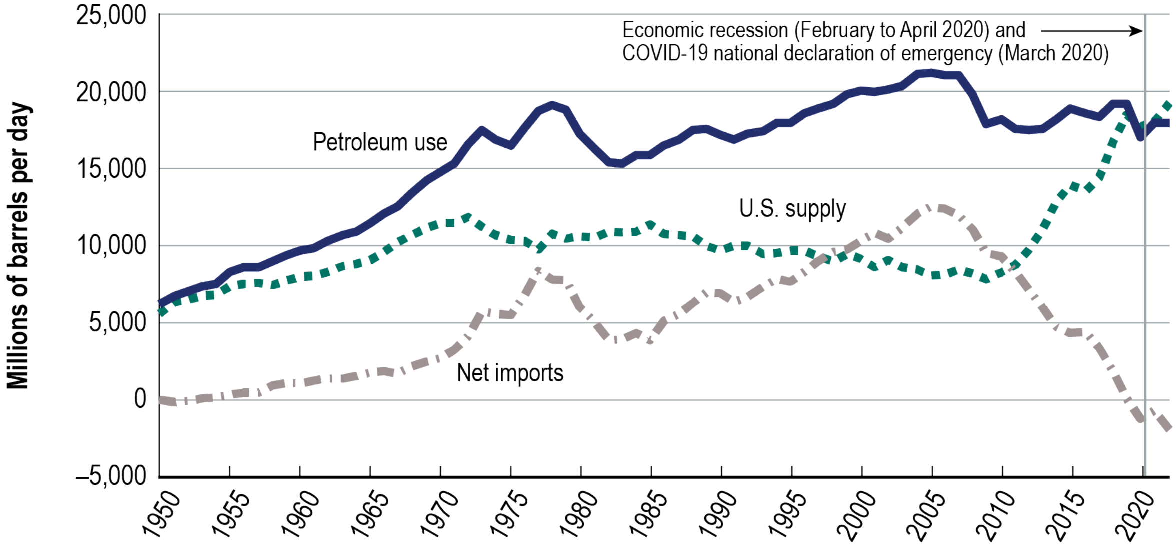
Figure 6-3 Petroleum Use by Sector of the U.S. Economy: 1990–2022



KEY: Btu = British thermal unit.

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 November 2023.

Figure 6-4 U.S. Petroleum Use, Domestic Supply, and Net Imports: 1950–2022



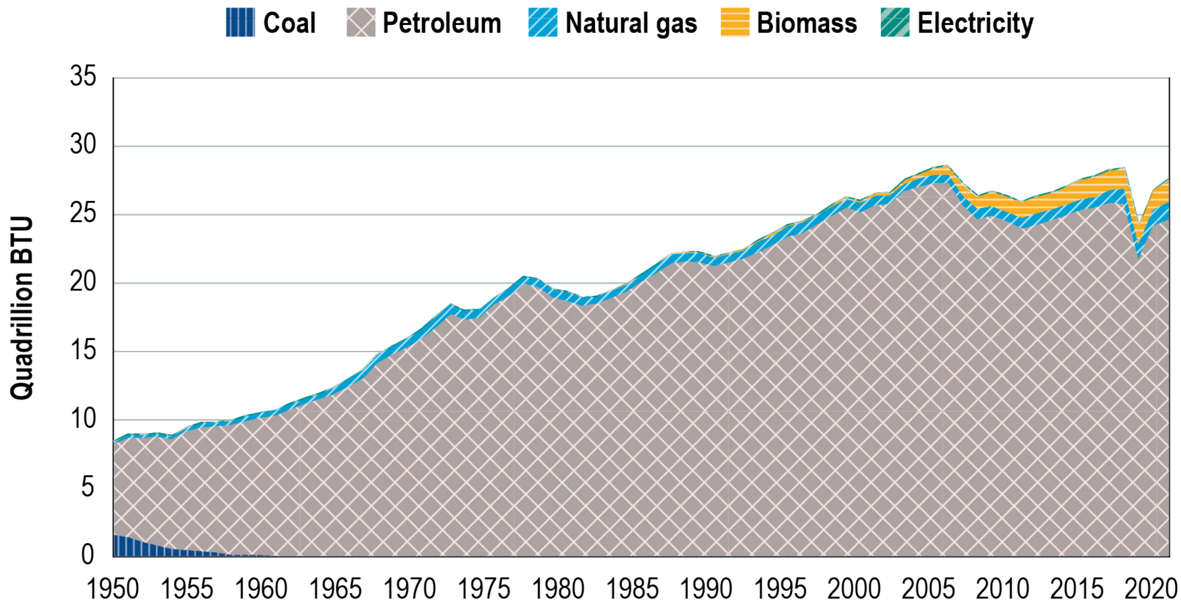
SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 3.1, available at www.eia.gov/ as of November 2023.

180 million barrels of oil from strategic reserves created in response to the oil crisis of 1973–74. The strategic threat of a Russian oil boycott to the U.S. was greatly diminished by the fact that the U.S. was a net exporter of oil in 2022. Increased domestic petroleum production of 10.2 mmbd from 2010–2022 [USDOE EIA, 2023a] and a savings of approximately 5 mmbd from fuel economy improvements attributable to the CAFE standards [Greene et al., 2020] enabled the U.S. to respond effectively to the supply disruption with minimal impact on the transportation sector and the economy as a whole.

Although transportation relies on petroleum for 89.4 percent of its energy needs in 2022, 89.4 percent is the lowest level of transportation's petroleum dependence since 1954 (Figure 6-5). Blending biomass-derived ethanol with gasoline at 10 percent by volume has displaced the greatest amount of petroleum but energy efficiency improvements driven by fuel economy and GHG standards have helped restrain the growth of energy use [Greene, et al. 2020a]. Ethanol blended with gasoline and biodiesel supplied 5.7 percent of transportation energy in 2022.

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 (data in Figure 6-2 represent electricity use by only transit and intercity rail). Although future projections vary considerably, the transition toward electrification might require substantial changes in grid infrastructure, operations, and planning. The trend toward increasing electrification has accelerated recently because of the many environmental and economic benefits of electric technologies compared to fossil fuel technologies. As the electric grid becomes powered with more low-carbon technologies, end-use electric technologies will produce fewer carbon emissions and can be considered a key component of a decarbonization strategy [Blonsky]. As the trend toward electrification continues and its impacts

Figure 6-5 Transportation Energy Use by Fuel Type: 1950–2022



KEY: Btu = British thermal unit.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 2.5, available at www.eia.gov/ as of August 2023.

become, we will need more critical research in these key topic areas. 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 [USDOE EIA, 2010–2023]. 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 9 billion kWh in 2022. Despite this rapid growth including these estimates indicates that electricity accounted for 0.35 percent of transportation's energy use in 2022 versus 0.23 percent excluding electric highway vehicles.

The use of domestic natural gas has almost doubled since 2004 and provided 4.7 percent of transportation's energy needs in 2021 (Figure 6-5). 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 or liquified natural gas. Over the past decade, natural gas use in pipelines increased from 0.7 to 0.9 quads in 2023 as a result of increased domestic natural gas production and consumption. An additional 0.3 quads were used to liquefy natural gas for export by ship. Natural gas use by vehicles, whether in compressed or liquefied form is notably smaller. From 2011 to 2022, use by motor vehicles increased from 0.031 to 0.078 quads per year, peaking at 6.3 percent 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, current and past editions of the *Annual Energy Outlook* [USDOE 2023d] include 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 2022 light-duty use had fallen to 3 percent, with medium and heavy-duty trucks and buses consuming 97 percent.

Energy Efficiency

Although the COVID-19 pandemic interrupted the long-term trend of increasing energy efficiency hitting air travel especially hard, energy efficiency improvement rebounded in 2022. 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 and 2021 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 due to higher load factors. The energy intensity of transit motor buses averaged 3,198 Btu/passenger-mile over the decade from

Table 6-1 Energy Intensities of Transportation Modes: 2000, 2020, and 2021

Passenger Modes	2000	2020	2021
Air, certificated carrier (Btu/passenger-mile)			
Domestic operations	3,892	3,373	3,961
International operations	3,857	6,797	9,183
Highway (Btu/passenger-mile)			
Light -duty vehicle, short wheelbase	3,454	2,854	2,892
Motorcycle	2,187	2,271	2,271
Light-duty vehicle, long wheelbase	4,339	3,928	3,939
Bus	1,081	921	906
Transit motor bus	3,677	4,069	5,458
Rail (Btu/passenger-mile)			
Amtrak	2,665	2,861	2,574
Rail transit*	923	851	NA
Commuter rail*	1,542	1,583	NA

Freight Modes	2000	2020	2021
Air Freight	NA	NA	NA
Highway (Btu/vehicle-mile)			
Single-unit truck	18,635	10,541	9,601
Combination truck	26,114	22,299	22,402
Rail (Btu/ton-mile)			
Class I railroad	347	282	276
Classes II and III	NA	NA	NA
Water			
Waterborne domestic*	270	NA	NA
Waterborne international	NA	NA	NA

* Energy Intensity (Btu/passenger-mile) is calculated by converting the fuel consumption in gallons to the energy equivalent Btu units and dividing by the passenger-miles.

KEY: Btu = British thermal unit; NA = not available.

SOURCES: National Transportation Statistics, Tables 4-20 and 4-25. Waterborne, domestic, Rail Transit and Commuter Rail, Davis & Boundy (2022), and *Transportation Energy Data Book: Edition 40*, tables 2.16 and 2.15.

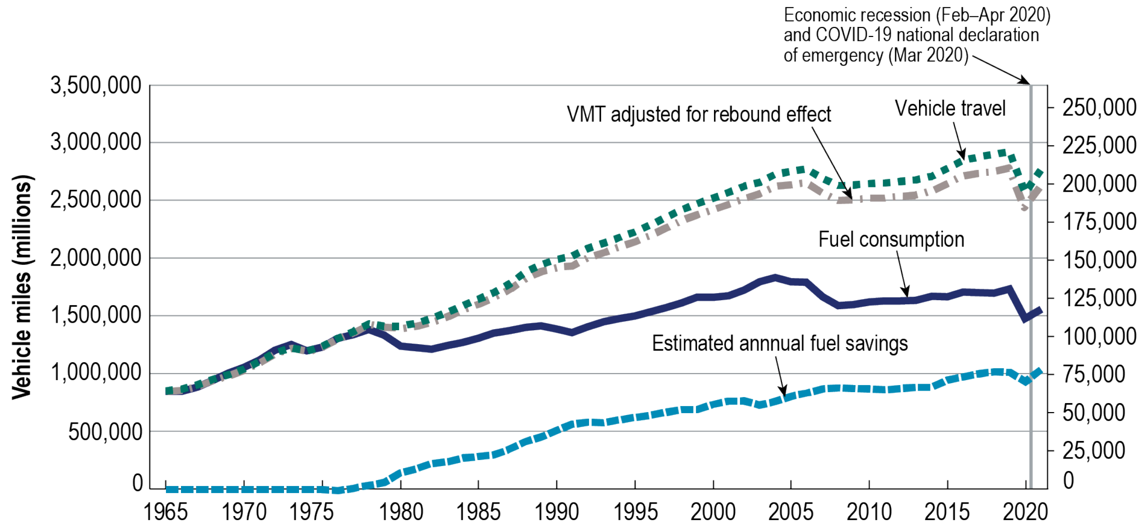
2010–2019, varying by +5.2 to -14.5 percent. Transit bus energy intensity increased by 23.1 percent in 2020 and increased further in 2021, due to the loss of ridership and lower load factors during the COVID-19 pandemic that began in mid-March 2020. From 2019 to 2021, passenger-miles traveled by bus and rail fell by 52.0 and 62.9 percent, respectively [USDOT FTA, 2023]. As a result, heavy rail occupancy rates declined from 48.7 percent to 23.4 percent and bus load factors decreased from 23.1 percent to 13.5 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 6-1. 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 6-1, 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 (Single unit truck Btu/vehicle-mile decreased by almost 60 percent from 1980 to 2021 while combination truck energy intensity decreased by 14 percent).

Fuel economy improvements to cars and light trucks are estimated to have saved over two trillion gallons of gasoline since 1975, enough fuel to power every light-duty vehicle in the United States for more than 15 years. Prior to 1975, vehicle travel and gasoline use increased along the same trajectory [Greene, et al., 2020a]. After the oil price shock of 1973–74 and the enactment of Corporate Average Fuel Economy 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 estimate that for every 10 percent increase in fuel economy, all else equal, vehicle travel increases by about 1 percent. However, the rebound effect also decreases with increases in fuel economy and income per capita (Hymel and Small, 2015; Dimitropoulos et al., 2018). Figure 6-6 shows light-duty vehicle travel as reported by FHWA and adjusted to remove the additional miles attributed to the rebound effect. Fuel savings due to increased miles per gallon (MPG) were estimated using the rebound-adjusted vehicle-miles traveled (VMT) trend and actual on road fuel economy. Fuel savings in 2021 are estimated at just over 75 billion gallons, saving drivers almost $250 billion on fuel that year. The sum of all fuel estimated to have been saved is 2.3 trillion gallons, more than all the fuel used by cars and light trucks from 2005–2021. Traffic volume data indicate a continued increase in highway vehicle travel in 2022 of 1 percent over 2021, and VMT in the first six months of 2023 were 2 percent above the same period in 2022 (USDOT FHWA, 2023). New vehicle fuel economy continued to increase in 2022 (EPA, 2022d).

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

Figure 6-6 Miles of Travel and Fuel Use by Light-Duty Vehicles: 1965–2021



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.

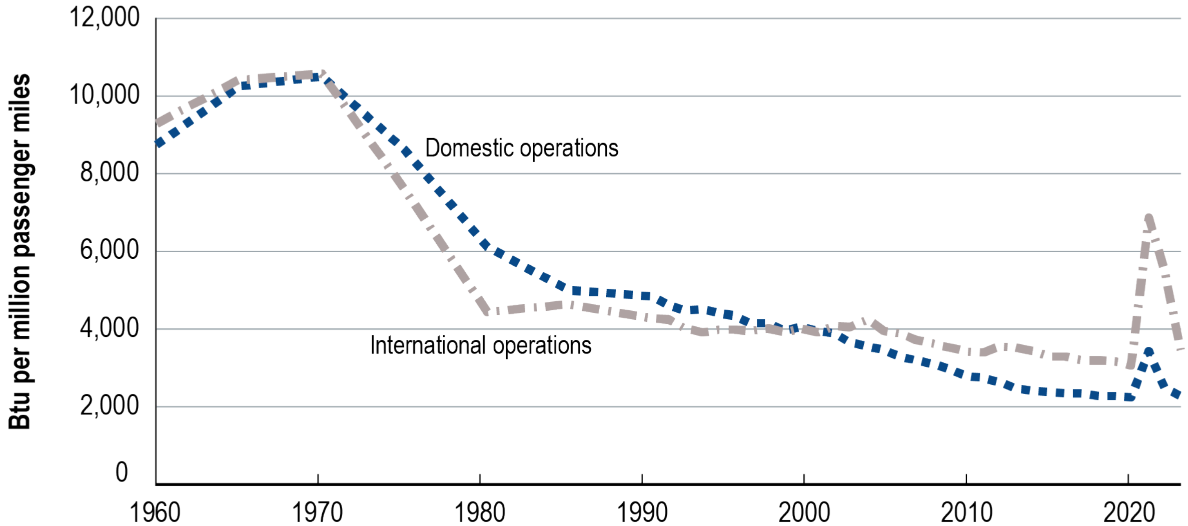
for passenger cars, light trucks, and medium- and heavy-duty motor vehicles [Executive Order, 2021]. Light-duty vehicle fuel economy standards for 2024–26 were finalized in March of 2022 and require that new vehicle MPG increase by 8 percent per year in 2024 and 2025 and by 10 percent in 2026 [USDOT NHTSA, 2022]. In 2023, fuel economy and GHG standards were proposed by the agencies for 2027–32. The proposed GHG standards would require large reductions in emissions and, together with other policies such as the Inflation Reduction Act of 2022, incentivize a large-scale transition to electric vehicles over the coming decade, as discussed below.

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 in hub-and-spoke airline operations. 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 mostly recovered to 953 million passenger miles in 2022, still a 10.2 percent below the level in 2019 [USDOT BTS, 2023b]. As a consequence, the energy intensity of air passenger travel has also recovered to slightly above 2019 levels (Figure 6-7).

Transition to Clean Fuels and Vehicles

In January 2023, the U.S. Departments of Energy, Transportation, Housing and Urban Development and the Environmental Protection

Figure 6-7 Energy Intensity of Certificated Air Carriers, All Services: 1960–2022



KEY: Btu = British thermal unit.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 4-21, available at www.bts.gov as of November 2023.

Agency published the *U.S. National Blueprint for Transportation Decarbonization*. The Blueprint provides a roadmap for an ambitious transformation of the U.S. transportation system that will fundamentally change its use of energy.

"To address the climate crisis, we must eliminate nearly all greenhouse gas (GHG) emissions from the sector by 2050 and implement a holistic strategy to achieve a future mobility system that is clean, safe, secure, accessible, affordable, and equitable, and provides sustainable transportation options for people and goods."

Publication of the Blueprint follows the announcement on August 5, 2021, of Executive Order 14037 that established a national goal that 50 percent of passenger car and light-truck sales in 2030 be zero-emission vehicles (ZEVs): 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. By mid-2023, 12 other states had adopted California's ZEV mandates. Together, the states adopting the ZEV program account for over 30 percent of U.S. light-duty vehicle (LDV) sales [CARB, 2023]. Many other nations, including the European Union and China, have adopted similarly ambitious policies [IEA, 2023], and the world's largest automobile manufacturers have announced plans to transition to electric vehicles over the next few decades [Motavalli, 2021].

Pursuant to Executive Order 14037, in 2023 the Environmental Protection Agency proposed new GHG standards for motor vehicles and the National Highway Traffic Safety Administration proposed CAFE standards for 2027–32 [EPA, 2023a; USDOT NHTSA, 2023]. The proposed carbon dioxide (CO_2) emission standards are estimated to reduce passenger car and light- and medium-duty truck emissions by more than half, and the two combined would reduce light-duty emissions per mile from 186 g/mi in 2026 to 82 g/mi in 2032 and beyond. The proposed standards also require reductions in other pollutant emissions, including methane, nitrous oxide, particulates, carbon monoxide, hydrocarbons, sulfur oxides, and toxic gases. Although there is considerable uncertainty about how the proposed standards would affect electric vehicle sales, the EPA estimated that the EV share of light-duty vehicle (LDV) sales could reach 67 percent in 2032 (Figure 6-8).

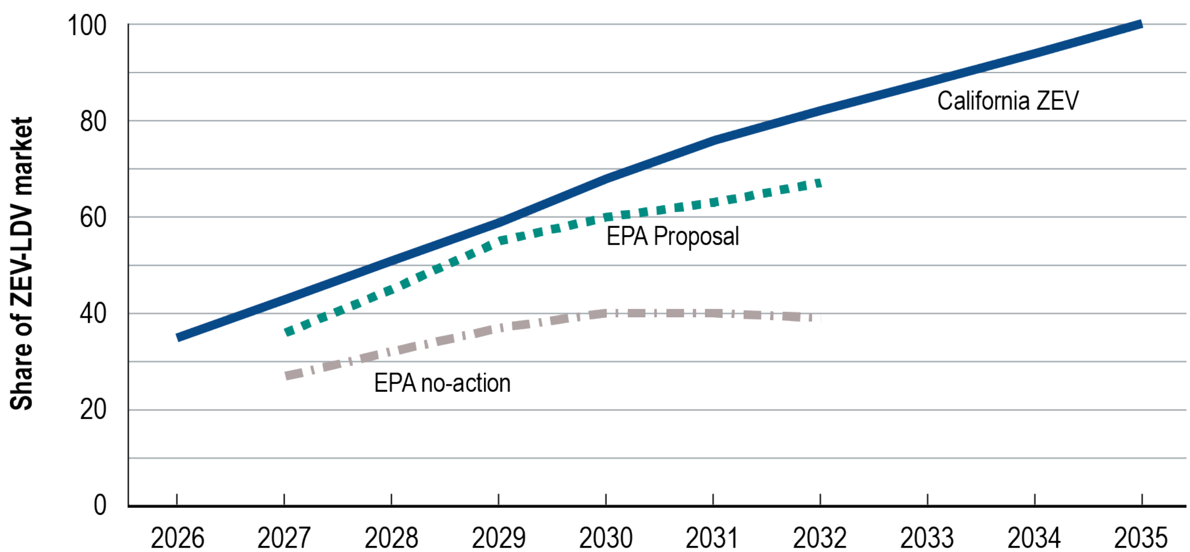
Electricity

Achieving the future electric vehicle goals set in 2021 requires increasing make and model availability, overcoming consumers' lack of familiarity with EVs, reducing vehicle costs, deploying a reliable and economical nationwide charging network, and developing a labor force skilled in EV maintenance and repair. Fully realizing the potential environmental benefits of the transition also requires decarbonizing electricity generation and creating a battery recycling industry. Fortunately, substantial progress has already been made to overcome these barriers.

The numbers of plug-in electric vehicle (PEV) makes and models, have grown rapidly in the United States and worldwide. Worldwide, 500 EV makes and models were on the market in 2022, an 11 percent increase over 2021 [IEA, 2023]. In the United States, 26 carmakers offered 49 battery electric (BEV) car and light truck makes and models in 2023 [Cox Automotive, 2023a]. The number of plug-in hybrids (PHEV) makes and models decreased to fewer than two dozen, consistent with a market shift towards battery electric vehicles [fueleconomy.gov, 2023]. (Refer to Box 6-A for a description of the different types of electric vehicles.)

Although there is a long way to go to reach the goal of a 50 percent EV share of new vehicle sales in 2030 from 9 percent in 2023, EV sales have been growing rapidly in the

Figure 6-8 California ZEV Mandate and EPA Proposed 2027–32 GHG Rule Estimated Electric Vehicle Market Shares



KEY: ZEV = zero-emission vehicle, GHG = greenhouse gas, BEV = battery electric vehicle.

SOURCE: U.S. Environmental Protection Agency, 2023; California Air Resource Board, 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.

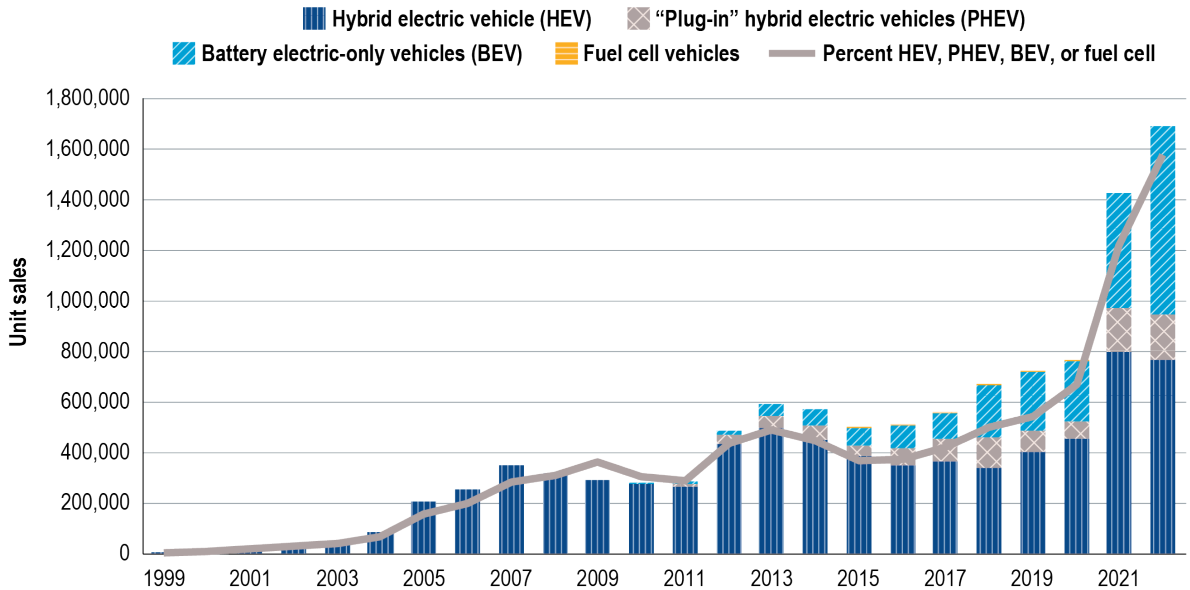
PEV/Electric vehicle (EV): A general term for any on-road licensed vehicle that can plug into an electric power source and uses electric power to move. EVs plug into a source of electricity and store power in a battery pack for all or part of their power needs. Includes Battery Electric Vehicles (BEVs) 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 2023.

U.S. and around the world. U.S. sales of BEVs and PHEVs grew by 47 percent in model year 2022 over 2021 (Figure 6-9) as the economy continued to grow, and manufacturers offered a greater diversity of EV makes and models. BEVs continued to outsell PHEVs and increased their share of the PEV market again in 2022. Sales of BEVs increased by the greatest percentage (62 percent), while PHEV sales were up by only 5 percent), and HEVs declined by 4 percent. Total Plug-in electric vehicle (PEV) sales increased to 930,000 in the model year 2022, approaching 7 percent of total U.S. passenger car and light truck sales. At the end of 2022, there were a total of 3 million PEVs on U.S. roads, of which 70 percent were BEVs [IEA, 2023]. California's new car buyers purchased 345,000 zero-emissions vehicles (ZEV) in 2022, 18.8 percent of total car and light truck sales in the state. In the first three quarters of 2023, ZEVs achieved a market share of 25 percent in California, the highest ZEV market share in the United States. [CEC, 2023]. Eighty-five percent of the ZEVs sold in California were BEVs. Worldwide, 10 million BEVs and PHEVs were sold in 2022, an increase of 55 percent over 2021 [IEA, 2023] bringing the world PEV fleet total to 26 million vehicles. In the first half of 2023, U.S. sales of battery electric vehicles exceeded 7 percent of total U.S. light-duty vehicle sales, an increase of approximately 50 percent over the same period in 2022 (Cox Automotive, 2023a). A 2023 survey found that for the first time, a majority (51 percent) of potential buyers were considering either a new or used EV for their next vehicle purchase (Cox Automotive, 2023b). The large gap between consideration and sales share reflects consumers' lack of familiarity with EVs. The supply of used EVs is still very small, making up only 1 percent of used vehicle sales.

Figure 6-9 Sales of Hybrid, Plug-in Hybrid, and Battery Electric Vehicles: 1999–2022



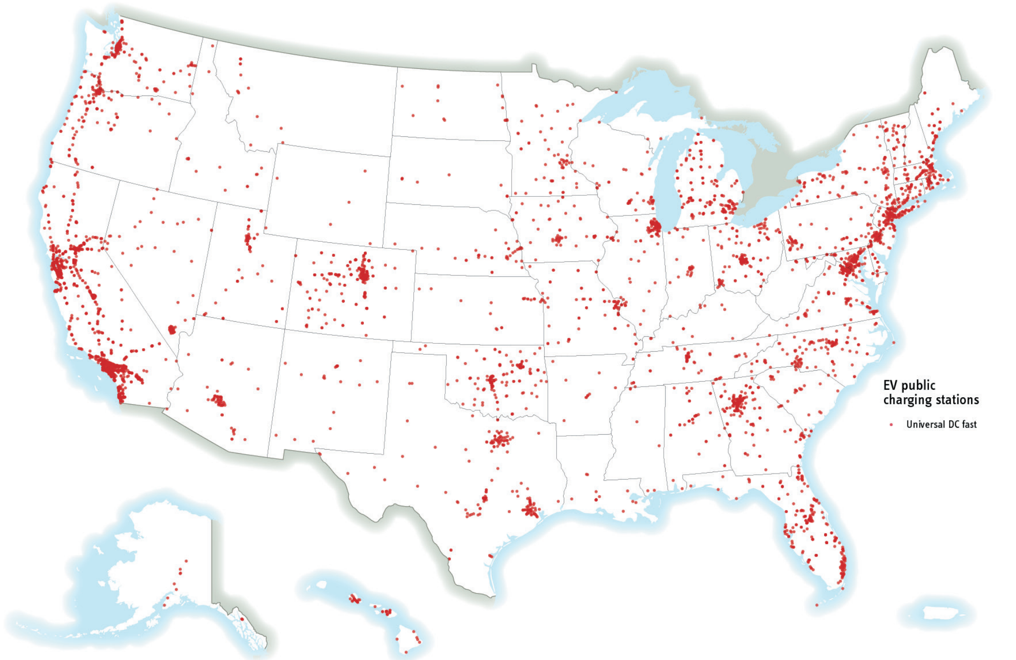
SOURCE: Argonne National Laboratory, Electric Drive Vehicle Sales, available at www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates as of August 2023.

As sales volumes have increased, the cost of EVs has decreased. The cost of lithium-ion batteries, the critical component determining the price of an EV, is approximately 10 percent of the cost 15 years ago [Nykvist and Nilsson, 2015; Mauler et al., 2020; BNEF, 2022]. In addition, scale economies and competition are bringing down the price of an EV. In June 2023, the average price paid for an EV was 20 percent below the price one year earlier [Cox Automotive, 2023a]. The Inflation Reduction Act of 2022 extended EV subsidies of up to $7,500 for new EVs to 2032, added subsidies of up to $4,000 for used EVs, and created additional subsidies for batteries that meet domestic manufacturing requirements of up to $45 per kWh ($2,700 for a typical 60 kWh battery).

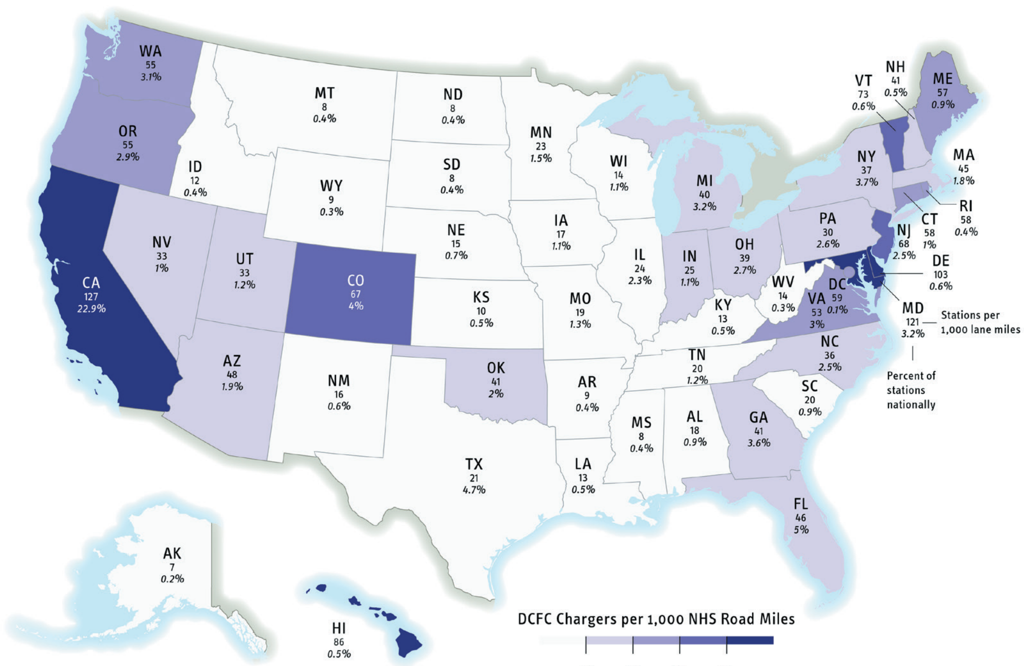
If electric vehicles are to achieve mass-market success consistent with national goals, public charging will have to become as accessible, rapid, and economical as refueling with gasoline. Deploying an effective national charging infrastructure is challenging, chiefly because the EV market is in the early stages of development, and battery and charging technologies are evolving. EV owners do 80 to 90 percent of their charging at home, a major departure from traditional vehicle petroleum refueling [Greene et al., 2020b]. In mid-2023, 55,829 public charging stations with 2–3 charging ports per station were in operation in the U.S. (Figure 6-10A). Of these, 7,908 with a total of 33,375 charging ports, were DC fast charging stations (DCFC), capable of recharging an EV up to 80 percent of capacity in 15 to 45 minutes [USDOE AFDC, 2023]. To date, 1,911 DCFC stations with 21,039 ports are proprietary to one manufacturer's vehicles. However, two other manufacturers have reached agreements that will allow their vehicles to access the proprietary network in the future, and others may follow as demand for reliable charging to support long-distance travel increases. At present, coverage of the National Highway System for intercity EV charging is concentrated in a few states, with large portions of the nation's midsection sparsely covered (Figure 6-10B). This compares with ubiquitous

Figure 6-10 Fast Charging Stations in the U.S.: Mid-2023

A. Electric Vehicle Public Level 2 and Direct Current Fast Charging Stations in the U.S.



B. Electric Vehicle Public DC Fast Charging Stations by State, per 1,000 Miles of the National Highway System



SOURCE: U.S. Department of Energy, Alternative Fuels Data Center, *Electric Vehicle Charging Station Locations* as of August 2023.

coverage by approximately 142,000 gasoline stations, typically with 8 pumps per station, for refueling Internal Combustible Engines (ICEs) in about 6 minutes for a full refill [Davis and Boundy, 2022, table 4.24].

Vehicle use data from the 2017 National Household Travel Survey (NHTS) indicate that 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, a recent MIT study found that BEVs with less than 100 miles of range were driven 2,000 to 5,000 miles per year less than BEVs with longer ranges (Doshi and Metcalf, 2023). The median range of a fully charged BEV sold in the model year 2015 and earlier was 90 miles or less [USDOE, 2023]. In 2016, median range increased to 218 miles and reached 257 miles in 2022. Recent evidence indicates that today's longer range BEVs are used in much the same way as gasoline vehicles [Chakraborty et al., 2021].

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 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.

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. 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, 44.8 percent of U.S. electricity was generated by burning coal and 23.9 by combustion of natural gas while wind power produced 2.3 percent and solar power generation was negligible (Table 6-2). In 2022, coal's share was 19.5, and natural gas which produces fewer emissions increased to 39.8 percent. Generation by renewable energy sources increased, with solar rising to 3.4 percent and wind growing to 10.2 percent. (Table 6-2). Carbon dioxide emissions from electric power generation decreased by 32.2 percent, while electricity production increased by 2.9 percent [USDOE EIA, 2023a, tables 11.6 and 7.2a].

As a result, greenhouse gas (GHG) emissions from U.S. electricity generation have fallen from 2.3 billion metric tons of CO2 to 1.5 billion, reducing CO2 emissions by one-third and substantially diminishing an EV's full fuel cycle GHG emissions [USDOE 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.,

Table 6-2 Electricity Generation by Energy Source: 2010 vs. 2022

Energy source	Billion kWh 2010	Billion kWh 2022	Percentage 2010	Percentage 2022
TOTAL	**4,125**	**4,243**	**100**	**100**
Coal	1,847	829	44.8	19.5
Petroleum	37	23	0.9	0.6
Natural gas	988	1,689	23.9	39.8
Nuclear	807	772	19.6	18.2
Hydropower	260	262	6.3	6.2
Solar	1	146	0.0	3.4
Wind	95	435	2.3	10.2
Other	90	87	2.2	2.1

KEY: kWh = kilowatt hour.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review July 2023*, table 7.2a, available at https://www.eia.gov/totalenergy/data/monthly/ as of August 2023.

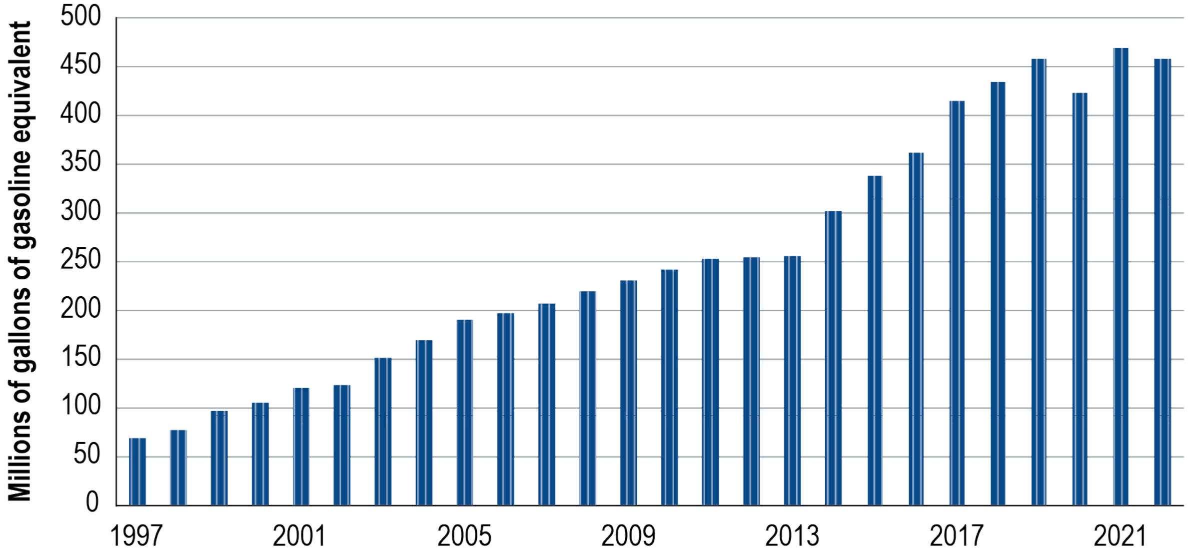
2022, figure ES-1]. The Energy Information Administration estimates that policies in recently enacted legislation such as the Bipartisan Infrastructure Law of 2021 and the Inflation Reduction Act of 2022 will accelerate the decarbonization of electricity and reduce total carbon emissions from electricity generation by almost half by 2030 [USDOE EIA, 2023d, table 18], bringing the life-cycle climate impacts of EVs closer to the ultimate goal of zero.

Natural Gas and Propane

Fossil gases provide a fraction of a percent of transportation's energy needs, and their use in road vehicles has been decreasing in recent years. According to Energy Information Administration (EIA) summary statistics, natural gas vehicles on U.S. roads in 2022 consumed up to 53.2 billion cubic feet of gas, the energy equivalent of 459.3 million gallons of gasoline [USDOE EIA, 2023b], and a 2.4 percent decrease over 2021. Motor vehicle use of natural gas increased at an average annual rate of almost 9 percent per year from 1997 to 2019 (Figure 6-11), encouraged by abundant and economical supplies of domestic gas and lower tailpipe emissions than equivalent vehicles powered by gasoline or diesel fuel. Since then, natural gas use in vehicles has not increased, partly due to the effects of the COVID-19 pandemic but also because of the shift in emphasis from fossil alternative fuels to electric vehicles.

The EIA's summary data does not break down energy use by vehicle type and excludes use by non-highway modes. However, the EIA's Annual Energy Outlook (AEO) provides estimates for 2022 by vehicle type and mode that are roughly but not precisely consistent with the summary totals for highway vehicles (Table 6-3). The detailed AEO estimates indicate approximately 95,000 highway vehicles fueled by natural gas and propane consuming just over 80 trillion Btu, or approximately 640 million gallons of gasoline equivalent energy in 2022. According to the AEO estimates, heavy trucks are the largest consumers (55 percent) of natural gas among highway vehicles, followed by transit buses (33 percent). 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 6,700 gallons of gasoline-equivalent natural gas per year [USDOE EIA, 2023d Table 3].

Figure 6-11 Natural Gas Use by U.S. Vehicles: 1997–2022



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 August 2023.

Table 6-3 Propane and Natural Gas Alternative Fuel Use by Mode: 2022

	Propane			Natural gas		
Mode/vehicle	Energy use (trillion btu)	Miles (billions)	Vehicles (thousands)	Energy Use (trillion btu)	Miles (billions)	Vehicles (thousands)
Passenger transport						
Passenger Car	0.80	0.15	4.30	0.71	0.14	15.67
Light Truck	0.00	NA	11.30	1.10	NA	5.27
Transit Bus	1.48	NA	NA	26.10	NA	NA
School Bus	7.62	NA	NA	0.92	NA	NA
Freight transport						
Light Truck	0.01	0.00	0.12	0.19	0.02	0.81
Medium Truck	0.67	0.04	2.49	0.76	0.04	2.44
Heavy Truck	0.57	0.03	3.21	50.39	2.15	49.81
Domestic Shipping	NA	NA	NA	0.64	NA	NA
International Shipping	NA	NA	NA	26.42	NA	NA
Rail	NA	NA	NA	0.52	NA	NA
Pipeline	NA	NA	NA	1,234.00	NA	NA

KEY: NA = data are not available.

SOURCES: U.S. Department of Transportation, *National Transportation Statistics*, Table 4-6, available at https://www.bts.gov/topics/national-transportation-statistics, pipeline and transit bus energy use. Energy Information, Annual Energy Outlook 2023, Tables 36, 39, 40, 41, and 49 available at https://www.eia.gov/outlooks/aeo/.

Natural gas use to power the pumps of natural gas pipelines is by far the largest use of natural gas, at 1.2 quadrillion Btu. Small amounts of natural gas are used by ships. The 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 liquefied natural gas (LNG). In recent years, increased exports of liquefied natural gas have led to increased use in international shipping. International shipping of liquefied natural gas has ready access to LNG and uses about the same amount of natural gas as transit buses. To date, natural gas has been limited to experimental use in aircraft for much the same reasons [Dubois, 2021].

In the United States, the great majority of natural gas vehicles are powered by compressed natural gas (CNG) stored onboard at approximately 2,000 psi (pound force per square inch). Some of the larger vehicles, locomotives, and ships 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. In mid-2023, CNG refueling is supported by 771 public and 587 private refueling stations, a decrease of about 12 percent for both types. LNG vehicles are refueled at 50 public and 46 private LNG stations, about 6 percent fewer than a year ago.

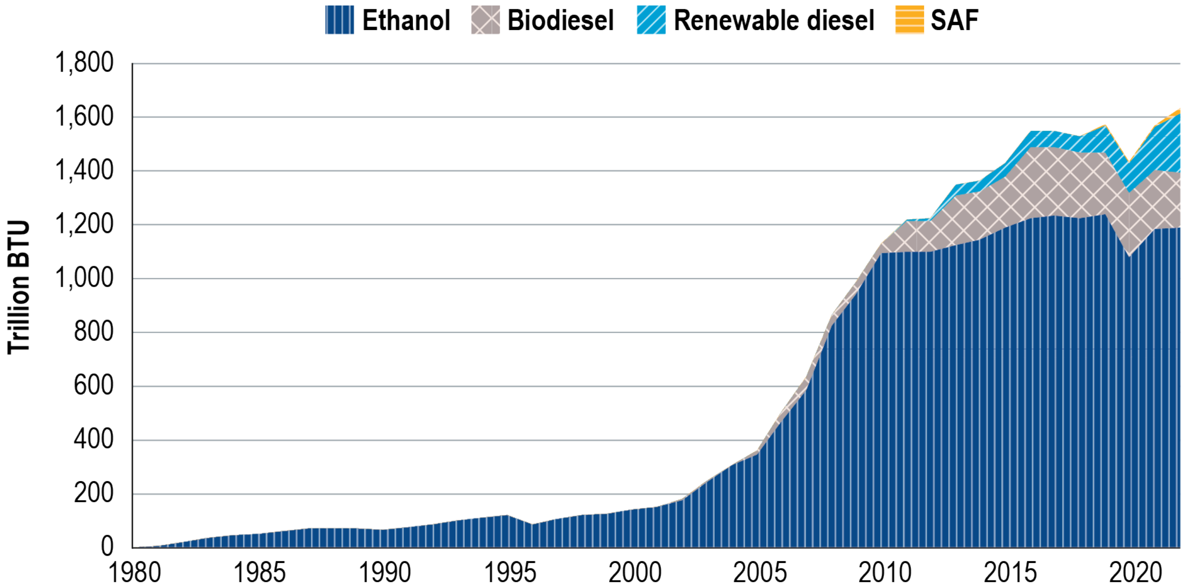
According to DOE estimates there are more than 20,000 vehicles fueled by propane operating on U.S. roads (USDOE AFDC, 2023), more than half (53 percent) of which are light trucks. However, the DOE estimates do not include buses, which use the most propane. School buses account for 68 percent of highway propane use, according to EIA AEO estimates (Table 6-3). Transit buses add another 13 percent, the rest being used by passenger cars and medium and heavy trucks. Consumption of propane by highway vehicles increased to 11 trillion Btu in 2022 from 7 trillion in 2021, due to increased propane use by school buses. Still, 2022 propane use remained well below the 54 trillion Btu used in 2000 (USDOE EIA, 2023d). Propane is stored on-board vehicles in liquid form under moderate pressure of about 150 pounds per square inch. In liquid form, a gallon of propane contains about 73 percent as much energy as a gallon of gasoline.

Biofuels

Ethanol, renewable diesel, and biodiesel are the most widely used biofuels in transportation. Ethanol, which is blended into almost every gallon of gasoline sold in the U.S., accounts for 73 percent of transportation biofuel use, the remaining consists of 13 percent biodiesel, 14 percent renewable diesel and 1 percent other biofuels (Figure 6-12). Other biofuels include renewable jet fuel, renewable gasoline and unspecified amounts of renewable heating oil and naphtha. Most fuel ethanol used in the U.S. is produced from corn via fermentation. Biodiesel is derived chiefly from vegetable oils and animal fats. Biodiesel is blended with petroleum diesel at percentages ranging from 2 to 20. Renewable diesel can be produced from a variety of biomass sources and is chemically similar to petroleum diesel. It can be used alone or blended with petroleum diesel [USDOE EIA, 2023c].

Almost all 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. Small amounts of ethanol are blended with gasoline at percentages up to 83 to produce E85 fuel which can be used by flex-fuel vehicles. 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. Gasoline-powered

Figure 6-12 Transportation Use of Biofuels: 1980–2022



KEY: Btu = British thermal unit, SAF = sustainable aviation fuel.

SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 10.2c, available at https://www.eia.gov/ as of August 2023.

vehicles of model year 2001 and later 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 implemented. 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. The rapid increase in biofuels use was primarily driven by the U.S. Renewable Fuels Standards and California's Low Carbon Fuels Standard. In recent years, most of the growth in biofuel use is due to renewable diesel. 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 6.4 percent of transportation's energy use in 2021 (1.6 quadrillion Btu), approximately the same quantity as all biofuels used in transportation (Figure 6-2 and Figure 6-12). 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, 2020. 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 has been limited, however, with only about 2 million gallons of SAF produced annually in the U.S. in 2016–2019, 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]. However, because of the airline industry's interest in reducing GHG emissions and federal and California state policy initiatives, the supply of SAF reached 15.8 million gallons in 2022, a three-fold increase over 2021 [GAO, 2023].

Greenhouse Gas Emissions and Air Quality

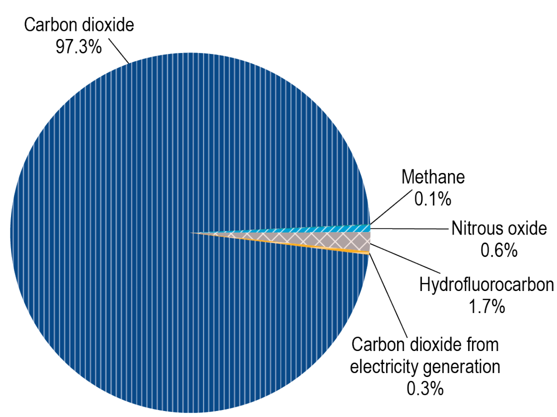
While pollutant emissions affecting local and regional air quality continue to decline, contributing to cleaner air in metropolitan areas, emissions of greenhouse gases appear to be returning to pre-COVID levels and transportation remains the largest source of carbon dioxide emissions. Transportation's other effects on the environment include surface and groundwater pollution, impacts on wildlife, solid 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]. 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.

Carbon dioxide dominates transportation's greenhouse gas emissions (Figure 6-13). Emissions of hydrofluorocarbons (HFC), the second largest component, are not a result of fuel combustion but leakage from vehicle air conditioners. HFCs, a GHG 1,430 times more potent than CO_2, continued to decrease, from 2.1 percent in 2020 to 1.7 percent in 2021. Starting with model year 2012 vehicles, manufacturers began to replace HFCs with less polluting alternatives, and by 2021 no new vehicles were allowed to use HFCs in their air conditioning systems [EPA, 2023b].

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 6-14). 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 but did not return to the level of 2019. Among all sectors, electricity generation has achieved the greatest reduction in CO_2 emissions by transitioning from coal to much less carbon-intensive natural gas, and to zero-emission renewable wind and solar power. As noted above, this trend is expected to continue through at least 2030. As electric vehicles increasingly displace petroleum-fueled internal combustion vehicles, decarbonizing the grid ensures that direct and indirect GHG emissions from motor vehicles will decrease towards zero [Leard and Greene, 2023].

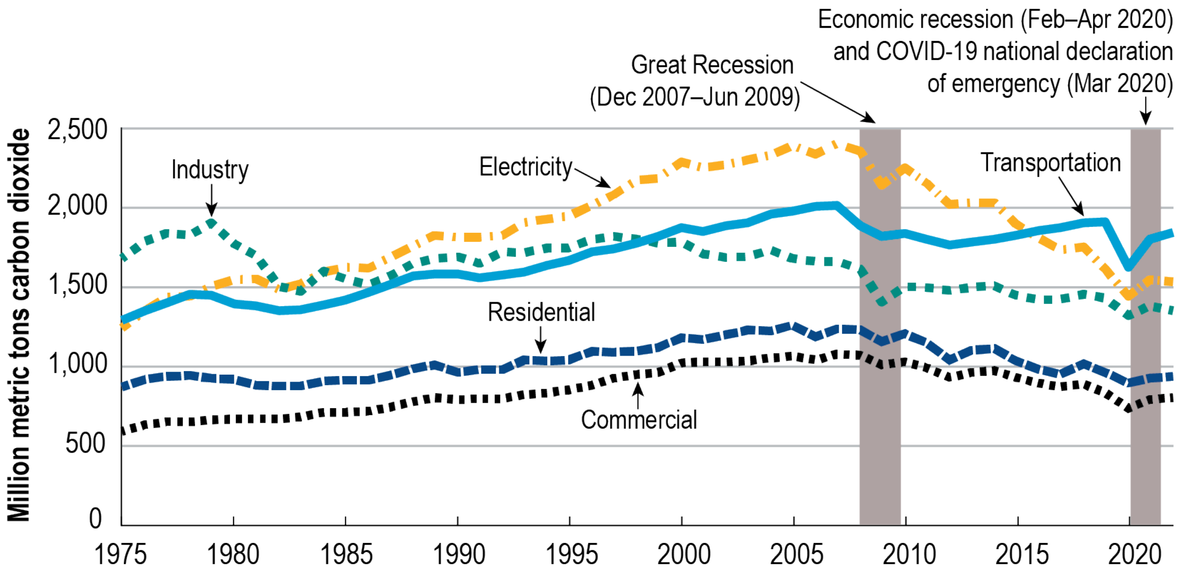
Figure 6-13 Transportation's Greenhouse Gas Emissions by Gas: 2021



KEY: Methane = CH_4; Carbon dioxide = CO_2; Carbon dioxide from electricity generation = eCO_2; Hydrofluorocarbon = HFCs; Nitrous oxide = N_2O.

SOURCE: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021*, table 2-12, available at www.epa.gov/ghgemissions/ as of August 2023.

Figure 6-14 U.S. Carbon Dioxide Emissions from Energy Consumption: 1975–2022



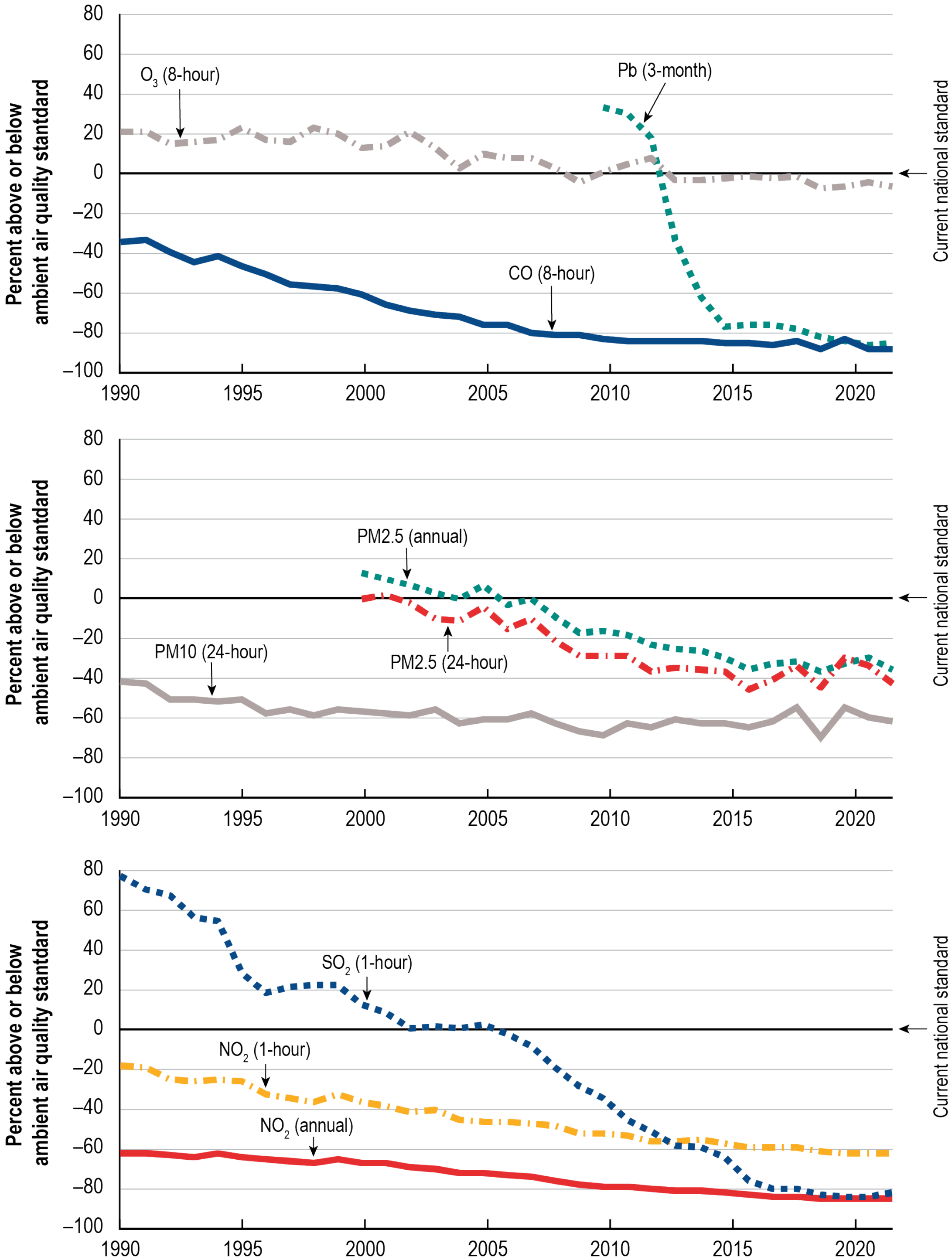
SOURCE: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, table 11.2-11.6, available at www.eia.gov/ as of November 2023.

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 6-15). Average 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, 2023c]. 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, air quality was unhealthy for sensitive groups in the 35 cities on 16 percent of the total days. The frequency of unhealthy days fell to 8.6 percent in 2010, 5.1 percent in 2021 and decreased again in 2022 to 4.7 percent of total days.

Transportation is a major source of air pollution. In previous years, transportation's share of air pollutant emissions was calculated excluding miscellaneous sources that include pollution from wildfires. Due to the growing importance of pollution from wildfires, their emissions are included in Table 6-4. Still transportation accounts for 41.7 percent of carbon monoxide emissions and 49.3 percent of emissions of nitrogen oxides. Although miscellaneous sources dominate particulate emissions, transportation emissions are still important because they occur mainly in populated areas. Electricity generation is a major source of sulfur dioxide and nitrogen oxides emissions, which makes transitioning electricity generation from fossil fuel combustion to renewable energy important for minimizing the upstream emissions attributable to electric 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

Figure 6-15 National Average Air Pollutant Concentrations: 1990–2022



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, 2023. *Our Nation's Air: Trends Through 2022*, https://gispub.epa.gov/air/trendsreport/2023/#introduction as of November 2023.

Table 6-4 Sources of U.S. Air Pollutant Emissions Including Wildfires: 2022 (Percentages)

Air Pollutant	Stationary Fuel Combustion	Industrial and Other Processes	Transportation	Miscellaneous Including Wildfires
Carbon Monoxide	7.5	4.9	41.7	45.8
Ammonia	1.9	2.8	1.9	93.4
Nitrogen Oxides	31.1	14.0	49.3	5.6
PM2.5	14.6	11.3	3.2	70.9
PM10	5.5	6.7	1.9	85.9
Sulfur Dioxide	61.9	25.0	1.5	11.6
Volatile Organic Compounds	3.8	40.5	12.4	43.4

KEY: kWh = kilowatt hour.

SOURCE: U.S. Environmental Protection Agency, 2023. *Our Nation's Air: Trends Through 2022*, available at https://www.epa.gov/air-trends as of November 2023.

Table 6-5 Emission Rates of Gasoline and Diesel Vehicles: 2022

	Light-duty Trucks			Heavy-duty Vehicles		
Emission	Gasoline (g/mi)	Diesel (g/mi)	Difference (%)	Gasoline (g/mi)	Diesel (g/mi)	Difference (%)
Total HC	0.312	0.325	4%	1.051	0.224	–79%
Exhaust CO	3.93	2.296	-42%	7.616	1.674	–78%
Exhaust NOx	0.251	1.783	610%	0.418	3.252	678%
Exhaust PM2.5	0.003	0.08	2567%	0.015	0.075	400%
Brakewear PM2.5	0.003	0.003	0%	0.005	0.008	60%
Tirewear PM2.5	0.001	0.002	100%	0.002	0.003	50%

KEY: CO = carbon monoxide; HC = hydrocarbons; NOx = nitrogen oxides; PM2.5 = particulate matter with diameter less than or equal to 2.5 micrometers; g/mi = grams per mile.

SOURCE: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, personal communication, as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-43, available at www.bts.gov as of November 2023.

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]. Despite this, vehicle emissions of all types have decreased over time as emissions standards have tightened.

Transportation vehicles continue to emit fewer pollutant emissions as new gasoline and diesel vehicles meeting stricter emissions standards replace older, more polluting vehicles. From 2000 to 2022, the rate of emissions per vehicle-mile of every pollutant for which transportation vehicles are a major source decreased by more than 85 percent (Figure 6-16). Exceptions are the PM2.5 emissions from tirewear and brakewear, which were reduced by 50 percent and 0 percent, respectively. As increasing numbers of electric and hybrid electric vehicles enter the on-road fleet, PM2.5 emissions from brakewear are likely to decrease due to the beneficial effect of regenerative braking (EPA, 2022b) but emissions from tirewear may increase due to increased vehicle weight. Current and future standards are projected to continue reducing vehicle emissions per mile through 2032.

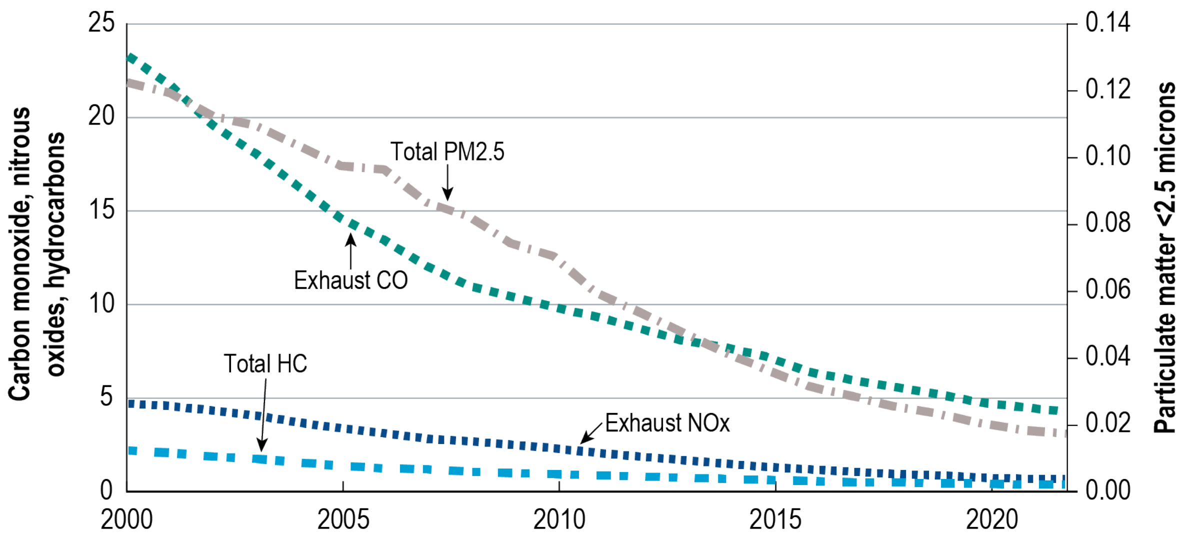
Additional Effects On The Environment And Sustainability

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. 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

Figure 6-16 Estimated National Average Emissions per Vehicle: 2000–2022



KEY: CO = carbon monoxide; HC = hydrocarbons, NOx = nitrogen oxides; PM2.5 = particulate matter with diameter ≤ 2.5 micrometers; g/mi = grams per mile.

SOURCE: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, personal communication, April 30, 2021.

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 contribute to water pollution, but they reduce vehicle accident 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 [Usman et al., 2010]. 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, wetlands, and groundwater 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. The USGS estimates that road salt use in 2022 was approximately the same as in 2021 [Bolen, 2023].

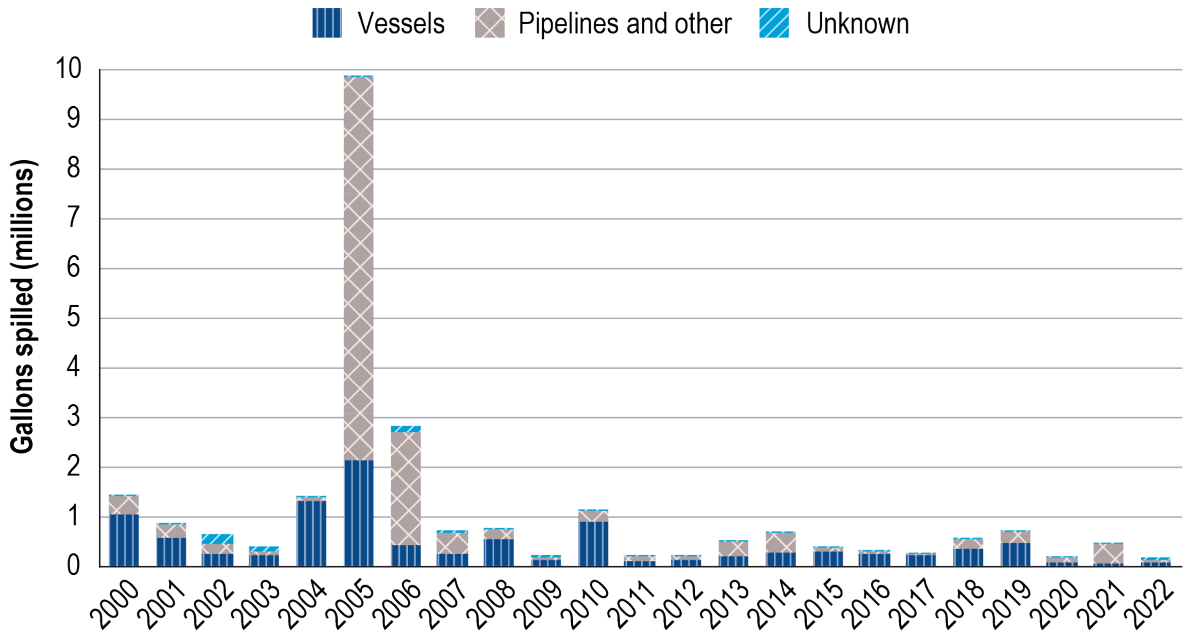
Thousands of oil spills occur in U.S. waters each year, but most involve less than a barrel (42 gallons) and occur, for example, when ships are refueled (Figure 6-17). Major spills that occur when pipelines break, oil tankers leak or sink, and drilling operations catastrophically fail cause extensive 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, there were three large (>700 metric tons) oil tanker spills and four spills between 7 and 700 metric tons, releasing a total of 15,000 metric tons in 2022 [ITOPF, 2023]. Oil spills in U.S. navigable waterways decreased in 2022 to 167 thousand gallons, the lowest level in recent decades.

Petroleum fuels are also released into the ground (Figure 6-18), potentially contaminating ground water, when underground fuel storage tanks leak. The EPA tracks cumulative cleanups and active releases not yet cleaned up from petroleum and chemical underground storage tanks. However, about 98 percent are petroleum storage tanks. From 1990 to 1995, the number of confirmed releases increased by an average of 43,000 new releases per year. Since 2015, there have been fewer than 6,000 new releases per year, and fewer than 4,500 during 2022. As of 2021, 509,091 of the 568,981 confirmed releases to date had been cleaned up. The number not cleaned up decreased from 61,981 in 2020 to 59,890 in 2021 [USDOT BTS, 2023c, 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 [AAI, 2023]. 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 6-17 Petroleum Spills Into Navigable Waterways: 2000–2022



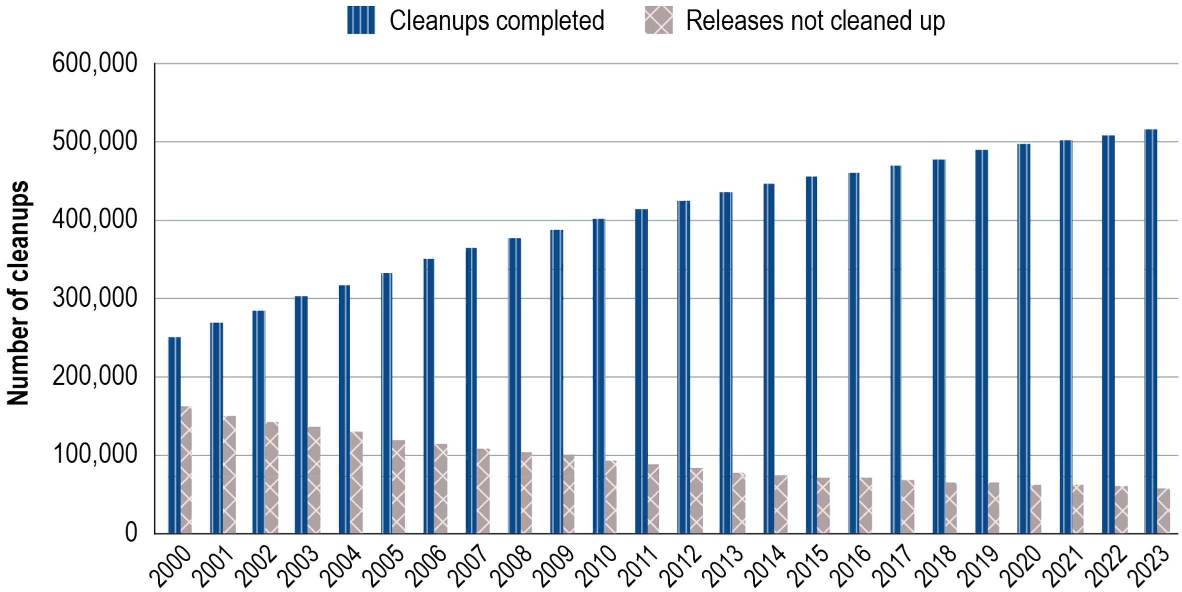
NOTES: The spike in gallons spilled for 2005 can be attributed to the passage of Hurricane Katrina in Louisiana and Mississippi on Aug. 29, 2005, which caused numerous spills of approximating 8 million gallons of oil in U.S. waters. The largest spill in U.S. waters began on Apr. 20, 2010, with an explosion 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 Homeland Security, U.S. Coast Guard, Office of Investigations and Analysis, as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-54, available at http://www.bts.gov as of October 2023.

2018). Lead-acid batteries appear to be the most recycled consumer product, with 100 percent of the 12 billion pounds of lead recovered from 99 percent of batteries from all types of transportation vehicles recycled from 2017 to 2021 [Vault, 2023]. 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 in its early stages because very few EVs have been scrapped, and recycling methods are still being developed [Wilkerson, 2022; Baum et al., 2022]; 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]. However, battery recycling facilities are now operating, and the European Commission has announced new regulations that will require collection of at least 61 percent of used EV batteries by 2031, recycling of all collected batteries and a lithium recovery rate of 80 percent [EC, 2023].

Transportation infrastructure is also extensively recycled and asphalt reclaimed from road paving may be the most recycled infrastructure material. In 2021, 101.3 million tons of asphalt paving was reclaimed, an increase of 5 million tons over 2020. Nearly all (94.7 tons) was mixed with new asphalt and reused as paving, 4.2 tons was used as aggregate or for other purposes, and only 0.1 ton went to landfill, the rest being stored for future use [Williams, et al., 2022]. Recycling asphalt pavement reduced greenhouse gas emissions by an estimated 2.3 million metric tons in 2021 [Williams et al., 2022, table 19]. Other recycled products used in asphalt pavements

Figure 6-18 Releases and Cleanups from Leaking Underground Storage Tanks: 2000–2023



SOURCE: U.S. Environmental Protection Agency, Office of Underground Storage Tanks, UST Performance Measures, as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 4-55, available http://www.bts.gov as of November 2023.

include 1.3 million tons of steel and blast furnace slag, 0.6 million tons of asphalt shingles, and 140,000 tons of ground tire rubber.

Collisions with Wildlife

In animal involved roadway collisions, there were an estimated 164 human fatalities in 2021, down from 202 in 2020 [IIHS, 2023]. Collision with the animal was considered the most harmful event in 63 percent of the collisions. There were 1.9 million fatalities to animals in collisions between July 2021 and June 2022, a 5.5 percent decrease over the same period a year earlier [State Farm, 2022]. Over 70 percent of the reported wildlife fatalities were collisions with deer, while 101,000 were with rodents, 60,000 with dogs, 56,000 with raccoons, and 236,000 with other unidentified animals. These statistics are based on insurance claims and 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 [PL 117-58, 2022] 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.

The FAA reported 17,190 occurrences of U.S. civil aircraft striking animals in 2022, an increase of 10 percent over 2021, but still just below the number in 2019 before the COVID-19 pandemic [FAA, 2023]. Of these strikes, only 4 percent caused damage to the aircraft. Civil aircraft operating in the U.S. reported 16,960 strikes, of which 16,099 were with birds, 513 with bats, 282 with terrestrial mammals and 66 with reptiles.

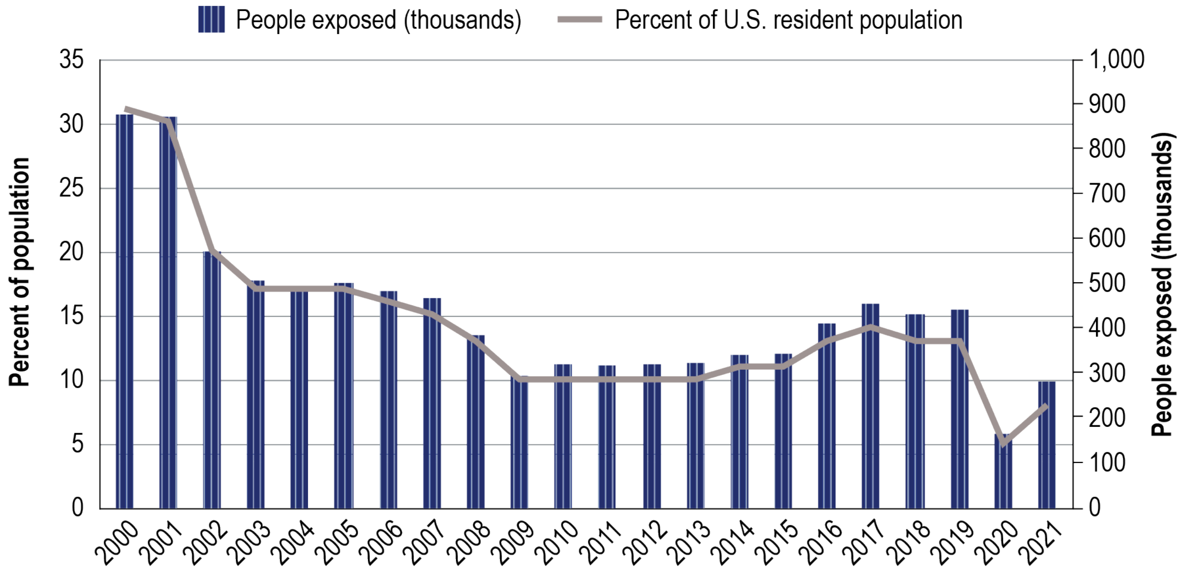
Transportation Noise

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 [USDOT BTS, 2022c].

In 2021, an estimated 281,000 people living in the vicinity of airports were exposed to noise exceeding 65 decibels. The FAA has identified DNL 65 dB as the highest threshold of airport noise exposure that is normally compatible with indoor and outdoor activity associated with a variety of land uses, including residential, recreational, schools, and hospitals. Noise levels are based on an aggregated measure of 24-hour noise levels, with nighttime noise weighted more than daytime noise [Tang, 2021]. 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 (Figure 6-19). In 1980, 5.2 million people were exposed to aircraft noise that exceeded the 65 db threshold. Improvements to aircraft and airport operations reduced the number to 874,000 in 2000. After further declines, exposure to excessive aircraft noise leveled off, but increased from 2015 to 2017. The decline in 2020 reflects the impact of the COVID-19 pandemic on air travel, and 2021 reflects the beginning of its recovery. Aircraft noise is mitigated by managing operations to avoid populated areas during take-off and landing, by soundproofing affected buildings and by improvements to aircraft technology. The correlation between operations at the San Francisco Bay Area's three largest airports and average noise exposure is illustrated in

Figure 6-19 Numbers of People in Areas of Significant Noise Exposure Around U.S. Airports: 2000–2021



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 4-57. Available at www.bts.gov as of November 2023.

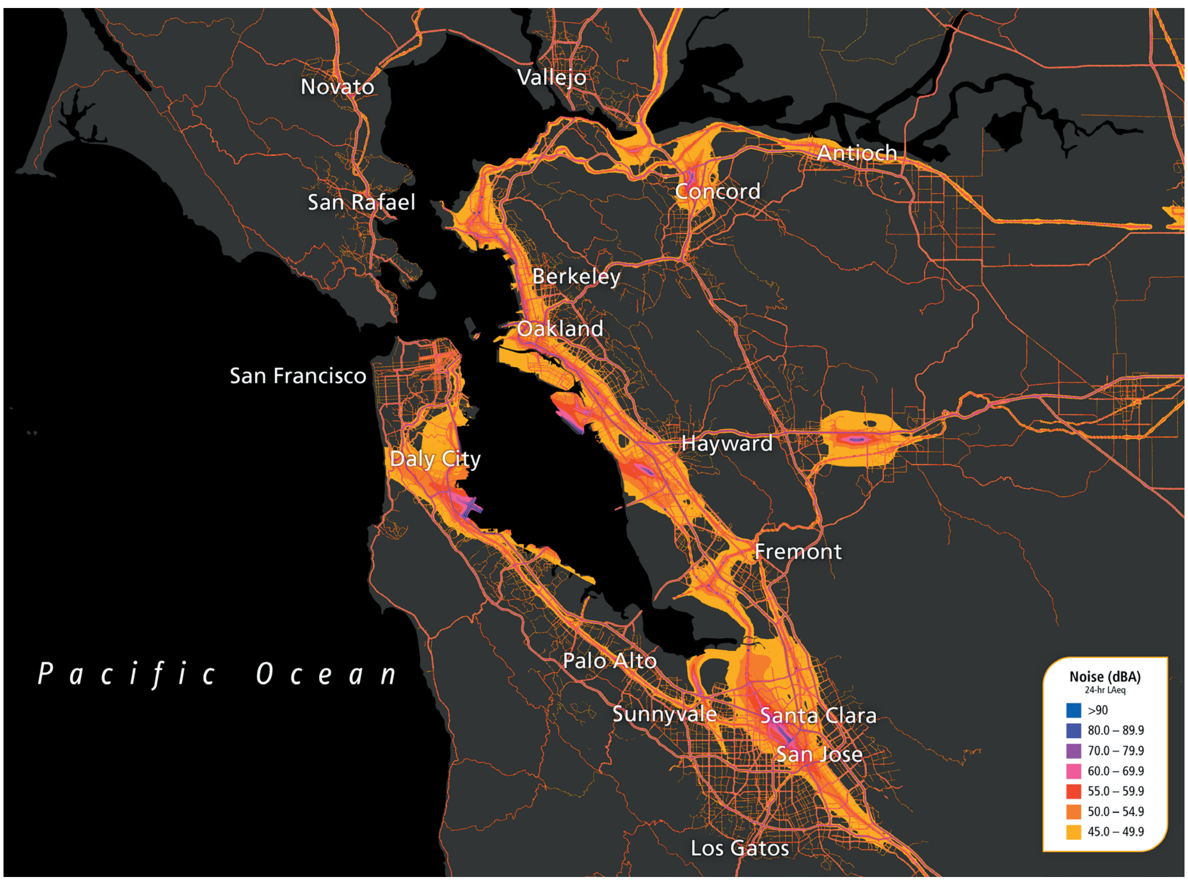
Figure 6-20, but major highways and regional airports at Livermore and near Concord are also noise hot spots.

Emerging Issues: Transition to new energy sources for transportation

Electrifying Public Transportation

Zero emission vehicles have additional environmental benefits in urban areas where the greatest numbers of people are exposed to harmful air pollution. Over the past decade, new electrified micromobility modes of public transport have emerged and traditional transit modes have increasingly adopted zero-emission electric vehicles. Federal funding for electric buses, battery and fuel cell, authorized by the Infrastructure Investment and Jobs Act of 2021 was six times greater than the funds dispersed over the previous five years by the Federal Transit Administration's Low and No-Emission Bus Program (CALSTART, 2023). In the two years following the Act, the FTA made grants totaling $2.3 billion to 150 projects across the U.S., nearly four times the cumulative funding allocated in the previous six years (USDOT FTA, 2023). In 2022, the number of full-sized zero-emission buses in U.S. cities increased by 66 percent to 5,480 and the number of smaller

Figure 6-20 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 2023.

electric buses increased by 42 percent to 876 (Table 6-6).

Electrically assisted micromobility modes are an emerging transportation services, such as non-motorized and electric pedal-assisted (e-bike) bike-sharing, electric scooters, and electric skateboards. Patterns 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 1.1 million e-bikes were sold in the United States in 2022, up from 880,000 in 2021 [Levin, 2023]. U.S. shared mobility systems provided 71,000 docked and 13,000 dockless e-bikes and 166,000 e-scooters in 2022 [NABSA, 2022]. The e-bikes were ridden on 58.7 million trips and the e-scooters on 69 million (Table 6-7). In 2015, there were 3,372 bike-sharing docking stations open to the public in U.S. cities; since then, the number more than doubled to 8,796 in 2022 [USDOT BTS, 2023b]. The number of cities with dockless bike- or scooter-share systems increased from 159 in 2021 to 172 in 2022. E-scooter systems grew from 135 systems when they first appeared in 2018, to 315 systems in 2021, but decreased to 284 systems in 2022 [USDOT BTS, 2023b].

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, 2022]. Since the average trip length for shared e-bikes and e-scooters is 1.3 miles, frequent re-charging is not necessary. 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

Table 6-6 U.S. Zero Emission Bus Fleets: 2021–2022

Bus Type	2021	2022	Increase	Percent Increase
Battery Electric	3,168	5,269	2,101	66
Fuel Cell Electric	129	211	82	64
Full Size Total	3,297	5,480	2,183	66
Small Total	615	876	261	42

SOURCE: CALSTART, Reports and Analyses, Buses: Zeroing in on ZEBs, tables 1 and 4, available at https://calstart.org/resources/#busesresources as of October 2023.

Table 6-7 Estimates of Energy Use by e-Bikes and e-Scooters in the U.S.: 2022

E-bike/e-scooter	Vehicles (thousands)	Trips (millions)	Annual Trips per Vehicle	Miles per Trip	Annual Miles per Vehicle	kWh per Mile	kWh per Vehicle per Year	Total Electricity (1,000 kWh)
e-bikes	84	58.7	699	1.3	908	8	7	610
e-scooters	166	69	416	1.3	540	15	8	1,346
Total Electricity (10^6 kWh)								2.0

KEY: Wh = watt hour, kWh= kilowatt hour.

SOURCE: Bureau of Transportation Statistics' calculations NACTO 2019; NABSA 2022.

assisted e-bike because the scooter rider provides little or no power.

Data Gaps

Data gaps on three major areas are identified:

1. Transition to Electrified Transportation

At present, there is no accurate and reliable source of data on electric vehicle energy use. As sales of electric vehicles and their presence on U.S. highways increase, accurate geographically and temporally specific measurement of their electricity use is needed to understand their impacts on electricity generation and transmission, and requirements for charging infrastructure. Currently 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. Data on the usage and energy efficiency of electric vehicles, and their rates of survival and scrappage are needed to project future electricity supply and recharging requirements. Better data on EV use and energy consumption are also needed to determine their cost responsibility for highway infrastructure. The great majority of EV charging by U.S. households is done at residences using private chargers that are not metered. As a result, most of their electricity use is attributed to residential electricity consumption.

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.

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 ensure 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

The transportation community is embracing data-based decision making, embodied in the Foundations for Evidence-Based Policymaking Act (Evidence Act) [Pub. L. 115-435], as it confronts the rapidly evolving issues and challenges described in the preceding sections of this report. The Bureau of Transportation Statistics (BTS) and its partners are increasingly called on to provide decision makers with objective, accurate, and timely information. This information includes the changing logistical demands of the economy and of households—demands that are altering traditional patterns of freight movement and passenger travel. Increased concerns with equity, reflected in the Infrastructure Investment and Jobs Act [Pub. L. 117-58], place a renewed emphasis on statistics about transportation users and about the effects of transportation on surrounding communities. Disruptions related to climate change underscore long-standing concerns with transportation system condition and performance. Needs for statistics on traditional concerns, such as safety, continue. BTS and its partners are mobilizing new analytical methods and both traditional and new data sources to understand these issues and inform decision makers and the public in a rapidly changing world.

The Transportation System and Sustainability

The state of the transportation system includes the connectivity provided by transportation facilities, equipment, and services; the condition of facilities and equipment, which will affect the future connectivity of the transportation system; and the use of the transportation system for moving freight and passengers throughout the Nation. The state of the transportation system also includes the environmental effects of its uses and whether the system can provide sustainable mobility and geographic accessibility in the future.

BTS compiles data from many sources in the National Transportation Atlas Database (NTAD) to geographically characterize the extent, use, and physical condition of transportation facilities and to identify areas affected by those facilities [USDOT BTS 2023l]. Examples of NTAD data sources include the Federal Highway Administration's Highway Performance Monitoring System, the Federal Railroad Administration's North American Rail Network, the Army Corps of Engineers' National Waterway Network, and the Federal Aviation Administration's runways dataset for airports. Using environmental data layers in the NTAD, BTS combines data from several sources to create the National Transportation Noise Map [USDOT BTS 2023m].

While NTAD data provide a comprehensive set of spatial information on the transportation system and the system's effects on neighboring locations, several statistical shortcomings that must be addressed to properly inform investments in transportation infrastructure, equipment, and services remain:

- Limited nationwide data on the deployment of traffic control devices and connected vehicle infrastructure reduce our understanding of how these technologies affect the capacity of highway infrastructure.
- Data on infrastructure to support motor vehicles, from parking capacity to availability of refueling and recharging stations, are essential for understanding whether vehicles can make full use of the Nation's extensive highway network.
- Data on geographic coverage and usage of local public transit, intercity bus, and charter bus services are incomplete, hindering analysis of alternatives to private vehicles for the general population and for disadvantaged groups.
- Limited data on the availability of bike-share and eScooter facilities and on protected routes for bicycles and other forms of active transportation reduce the understanding of how micromobility alternatives can serve local travel.
- Lack of data on accessibility of passenger terminals and equipment limits analyses of available transportation for the disabled population.
- Data on water pollution from transportation infrastructure, impacts on wildlife and wildlife habitats, and components of waste from scrapped vehicles and infrastructure are needed to supplement existing data on emissions and noise related to transportation for a complete accounting of transportation's consequences for the environment.

The operation of autonomous vehicles will require high definition (HD) mapping with a level of precision far greater than that provided by the current digital representations of the highway network. Current digital representations include the U.S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing (TIGER) files, the Federal Highway Administration's ARNOLD program,[1] and various commercial products used by consumers and businesses for routing. BTS is initiating a discussion with stakeholders in HD mapping to explore different collaborations between the public and private sectors that achieve desirable standards and avoid duplicative investments.

Until recently, the biggest deficiency in understanding the use and consequences of the transportation system was a lack of fresh data on the operational characteristics of the Nation's motor vehicles. For example, emission models used to estimate the impacts of transportation investments on air quality were calibrated with on-road fuel economy data and other vehicle characteristics that were over two decades old. BTS responded to this deficiency by working with the Census Bureau, the Federal Highway Administration, and the Department of Energy to restore the Vehicle Inventory and Use Survey (VIUS), which had not been conducted since 2002 [USDOT BTS 2023s]. In 2021 the reconstituted VIUS collected data on vehicle size and weight, miles traveled and typical range of operation, operating weights, fuel type and fuel economy, personal versus business use, economic activities served, commodities carried, safety equipment installed, and other characteristics for a sample of more than 100,000 vehicles ranging from sport utility vehicles and pickups to 18-wheelers. VIUS

[1] All Roads Network of Linear Referenced Data.

data serve a wide range of analytical needs and are especially critical to understanding the potential impacts on the infrastructure of vehicles by vehicle size and weight. Stable funding to conduct VIUS is critical for capturing trends in the electrification of transportation. BTS is conducting a version of the VIUS that will target on electric vehicles in 2024. The Electric Vehicle Inventory and Use Survey (eVIUS) will ask questions specific to electric vehicles (such as charging patterns) as well as questions similar to those in the VIUS to a national sample of electric vehicle owners.

Vehicle registration files maintained by the states contain some of the characteristics measured in the VIUS and eVIUS and provide the sample frames for the surveys. BTS is exploring ways to access these files for statistical purposes under the confidentiality protections provided by the Evidence Act.

In collaboration with its partners, BTS continues to respond to the other shortcomings in data on infrastructure extent, condition, usage, and environmental consequences. For example, the Federal Transit Administration is requiring all operators of fixed-route public transit to share data on routes, stops, and schedules with BTS to supplement the National Transit Map. In addition, BTS is recruiting intercity bus operators to share their network data as well. Geographic data on bike lanes, transportation facilities that meet architectural standards of the Americans with Disabilities Act, and electric vehicle recharging stations are among the enhancements currently under development.

Passenger Transportation and Equity

To guide and support investments in passenger transportation and management of passenger transportation services, decision-makers and the public need statistics to answer three basic questions—questions that parallel those asked of freight transportation:

1. Is the transportation system equitably supporting personal fulfillment and healthy communities across all spectrums of society by delivering people to where they want to go and supplying households with goods and services in a timely, reliable manner and at a reasonable cost?
2. Is the transportation system delivering workers and tourists to support the national, regional, and local economies?
3. Is passenger travel impeding freight movement, affecting safety, contributing to climate change, or causing environmental or societal disruption at the national, regional, and local levels?

To answer these questions, BTS publishes the following:

- An extensive set of statistics on passenger travel via commercial aviation, including monthly numbers of passengers by flight and airport, costs of airline tickets, and flight delay and cancellations by cause [BTS 2023].
- Estimates of trips by county and distance range based on anonymized location-based services data gleaned from mobile devices [USDOT BTS 2023e].
- Numbers of passenger crossings at the Canadian and Mexican borders [USDOT BTS 2023b].
- Travel on ferries [USDOT BTS 2023n].

Parallelly, the Federal Highway Administration collects national data on household travel patterns, the Census Bureau on commuting, and the Bureau of Labor Statistics for data on household expenditures for personal travel. BTS is combining data from several sources to estimate the cost burden of transportation on households and especially on disadvantaged groups.

Current statistics do not provide the following:

- Comprehensive measures of the volume of passenger movement, especially involving long-distance travel, which are essential to understand the demand for intercity and local transportation facilities and services.
- The demographic and economic characteristics of travelers and the purposes of their travel with geographic specificity, which are essential to understanding the social and economic value of travel, the cost burden and equity aspects of travel, and the current and future markets for transportation facilities and services.
- Statistics on workers who work at multiple locations or who telework for portions of the week, potentially causing significant changes in daily travel that affect recurring peak period congestion and transit usage.
- Estimates of local passenger movement by travelers from outside the region who place demands on the local transportation system and who bring tourism dollars to the local economy, including recreational travel involving national parks, other tourist attractions, and cruise ships.
- Estimates of trips not taken because of the availability, safety, personal security, costs, or other aspects of transportation, and the value of that "latent demand" to both the affected individuals and the providers of goods and services that forgone by the reduced travel.
- Estimates of travel affected by disruptions to the transportation system, which are central to ascertaining consumer satisfaction and assessing system vulnerability and resilience.

BTS and its partners have been tapping new types of data, such as anonymized location-based services data gleaned from mobile devices, to monitor travel but recognize that such data have several major weaknesses. The relationship between mobile devices and travelers is not clear because some individuals carry more than one smart device, the geographic precision of the data vary by type of location-based services, and the demographic and economic characteristics of the travelers must be imputed from characteristics of residents in the presumed home of the traveler. Access to data from mobile devices may be barred in the future by privacy legislation and social concerns, even when statistical agencies invoke strong assurances that the data will be used only for statistical purposes. Traditional surveys may remain the most reliable source of data on the demographic and economic characteristics of travelers, even with declining response rates.

Freight Transportation and Supply Chains

To guide and support investments in freight transportation and management of freight transportation services, decision-makers and the public need statistics to answer three basic questions analogous to those asked of passenger transportation, as previously discussed:

1. Is the transportation system supporting national, regional, and local economies by delivering goods in a timely, reliable manner and at a reasonable cost?
2. What markets for obtaining supplies and selling goods can be reached with the transportation system?
3. Is freight movement impeding passenger travel, threatening safety, or causing environmental or societal disruption at the national, regional, and local levels such as exposing disadvantaged communities to traffic and pollution next to major ports?

BTS is the preeminent source of statistics to answer these questions. Major BTS freight programs include the following:

- The Freight Analysis Framework (FAF), which integrates data from the Commodity Flow Survey and other sources to provide an annually updated comprehensive picture of the value and weight of commodity movements to, from, and within the United States by all modes of freight transportation [USDOT BTS 2023i].
- The Commodity Flow Survey (CFS), conducted every 5 years for BTS by the Census Bureau to measure the value and weight of shipments by commodity, mode, origin, and destination for shippers in mining, manufacturing, wholesale, and selected other parts of the economy, with additional information on hazardous materials shipments and shipments requiring temperature control [USDOT BTS 2023d].
- The Transborder Freight Data Program, which provides a detailed picture of freight movement at border crossings with Canada and Mexico [USDOT BTS 2023p].
- Monthly air cargo tonnage by flight and airport for commercial airlines [USDOT BTS 2023a].
- The Transportation Services Index, which provides monthly estimates of total for-hire freight activity that can potentially serve as a leading indicator of economic activity [USDOT BTS 2023r].
- The Transportation Satellite Account, which tracks the purchase of goods and services among sectors of the economy to estimate the contribution of for-hire and shipper-provided transportation to Gross Domestic Product and identifies supply chain interactions among sectors of the national economy that generate the commodity movements to be served by the freight system [USDOT BTS 2023q].
- Freight Supply Chain Indicators, a monthly compilation of over 40 measures from multiple public sources covering freight movement, port congestion inside and outside the gate, and transportation labor [USDOT BTS 2023j].
- The Port Performance Freight Statistics program, which provides information on the throughput and capacity of the Nation's top ports by value and volume of goods moved [USDOT BTS 2023o].
- The Freight Logistics Optimization Works (FLOW) [USDOT BTS 2023h] initiative in which shippers, carriers, terminal operators, and other players in supply chains are sharing their confidential data on container volumes and capacities with BTS under the Confidential Information Protection and Statistical Efficiency Act (CIPSEA). The intent is to improve supply chain efficiency [Pub. L. 115-435].
- The Freight Mobility Initiative to develop statistics on freight travel times from anonymized location-based services information from over 500,000 trucks.

In addition to BTS programs, other federal sources of freight statistics include rail waybill statistics collected by the Surface Transportation Board, Waterborne Commerce Statistics collected by the Army Corps of Engineers, container statistics collected by the Federal Maritime Commission, statistics from the Department of Agriculture on transportation of farm products, statistics on the production of goods to be moved and on the revenues and employment of for-hire transportation establishments from the Census Bureau, and producer prices and occupational statistics for for-hire transportation from the Bureau of Labor Statistics.

Shortcomings in data limit the understanding of decision makers to guide freight transportation investments and services:

- Lack of FAF estimates for geographic granularity smaller than metropolitan regions.
- Little data on the domestic transportation of U.S. foreign trade.
- Partial data on freight shipping costs.
- Little data on last-mile freight movements.
- Little data on freight system performance.
- Partial data on the availability of transportation equipment and labor to move freight.
- The lack of comprehensive national statistics on freight energy efficiency is evident in Table 6-1 in Chapter 6–Energy and Sustainability.

Planned improvements to the FAF will increase the geographic granularity 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 interactions between freight movement and passenger travel, identification of regional market areas to guide economic development, and estimates of freight movement that is passing through a region and affecting local infrastructure needs.

Experience with the FLOW initiative should provide opportunities to create comprehensive statistics on timeliness, reliability, or cost of freight movement beyond ports to the entire freight system.

While planned improvements and new data collections provide a useful picture of freight movements and the performance of the freight transportation system, frequently requested information on the economic cost of freight transportation, the domestic transportation of international trade, and the last-mile delivery of freight remain largely underdeveloped. BTS will explore potential collaborations with private industry and other federal statistical agencies to seek cost-effective solutions to these data shortcomings and to 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 in the Department of Transportation has major safety data programs or supports safety data programs in the states. For example, the National Highway Traffic Safety Administration has a National Center for Statistics and Analysis dedicated to measuring highway fatalities, injuries, the causes of crashes, and the effectiveness of safety countermeasures [USDOT NHTSA 2023]. Other major safety analysis activities in the Department are illustrated by the large-truck crash causation study by the Federal Motor Carrier Safety Administration [USDOT FMCSA 2023].

While extensive data exist on most transportation crashes and their consequences, data are lacking on:

- Fatal and injury crashes that occur on private roads, which represent a significant portion of the highway network.
- Exposure data, especially for travel by population groups with a higher propensity for involvement in crashes, for travel during unsafe conditions around sunrise, sunset, and bad weather, and for travel on new micromobility options and by pedestrians.
- Precursor (close calls) data for all modes.
- Data on the effectiveness of driver assistance and autonomous vehicle technology.

BTS provides a comprehensive compilation of safety statistics that removes overlaps, such as rail-highway grade crossing crashes appearing in both highway and rail statistics [USDOT BTS 2023k]. BTS also collects data on the conversion of the railroad tank car fleet to safer equipment standards [USDOT BTS 2023g]. Most importantly, BTS deploys its special capabilities to protect respondent confidentiality to obtain sensitive information on precursor safety, including close calls and near misses [USDOT BTS 2023c].

The Confidential Information Protection and Statistical Efficiency Act (CIPSEA) authorizes BTS and its agents to protect respondents to BTS data collections from direct or indirect identification [Pub. L. 115-435]. CIPSEA exempts data collected by BTS and other federal agencies from the Freedom of Information Act (FOIA) and from 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 agents analyze individual reports and summarize them into statistical assessments that inform sponsoring organizations of problems while protecting the confidentiality of the respondent.[2] In fact, many BTS programs collect and protect data under CIPSEA.

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, has sponsored the program since 2012, and BSEE has sponsored the program for offshore petroleum extraction since 2013. Both programs have identified safety problems that prompted corrective actions by the sponsors. BTS continues to work with the Massachusetts Bay Transit Authority to implement a version of the WMATA safety precursor data program in Boston. These precursor safety data programs instigated another similar program in partnership with the Maritime Administration on the maritime industry. A pilot effort on maritime safety is underway and should have initial results in 2024.

Transportation Economics and Financial Statistics

BTS is a major source of statistics on the contribution of transportation to the economy and inflation, household and business expenditures on transportation, transportation workforce, and government finance of transportation facilities and services [USDOT BTS 2023f]. A cornerstone of the economic statistics is, the Transportation Satellite Account which extends the national accounts produced by the Bureau of Economic Analysis to include the contribution by in-house freight activity, such as the trucking operations of grocery chains; and by household transportation to create a more complete picture of transportation's role in the economy.

Major shortcomings in current statistics include:

- The economic contribution of shared transportation services, such as ride-hailing and bikeshare;
- Characteristics of emerging and nontraditional forms of transportation employment, such as drivers for ridesharing services and food delivery arrangement services;
- Government revenues and expenditures related to transportation; and
- Innovative finance in transportation, such as public–private partnerships.

To address some of these shortcomings, BTS embarked on an initiative to improve financial statistics. Traditional sources of data on public

[2] While any federal agency can invoke CIPSEA, only BTS and the other principal federal statistical agencies can deputize external subject matter experts to act as statistical agency staff in processing and analyzing confidential data.

investment in transportation reported by the Federal Highway Administration take years to become available; require complicated reconciliations of fiscal and calendar years and of authorizations versus obligations versus final spending; and assume a clear distinction between public and private investment. That distinction is less clear with the increasing use of innovative financial instruments and public–private partnerships. BTS is working with state partners and others to develop methods for producing more robust, timely statistics that more accurately account for public and private spending on transportation from capital projects to operations and maintenance.

Meeting State and Local Data and Analytics Needs

Section 25003 of the Infrastructure Investment and Jobs Act [Pub. L. 117-58] 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 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 is meeting with stakeholders to identify the next steps in developing data sources, analytical tools, and technical assistance programs. Together with other federal statistical agencies, BTS is exploring privacy and confidentiality issues that limit access to key information that is needed to inform decisions by local decision makers. BTS is implementing the Standard Application Process required by the Evidence Act to give researchers controlled access to confidential data for the development of evidence that does not reveal information on individuals.

Meeting Data Needs of Departmental Priorities

The Department of Transportation has published the following four priorities:

- Reduce inequities across our transportation systems and the communities they affect.
- Reduce greenhouse gas emissions and transportation-related pollution and build a more resilient and sustainable transportation systems to benefit communities;
- Make our transportation safe for all people.
- 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 [USDOT 2023].

In addition to the infrastructure, passenger travel, and safety data that support analyses of resilience, sustainability, and equity, the Office of the Assistant Secretary for Transportation Research (OST-R) is creating additional data resources to support continued innovation and evidence building by requiring that data collected as part of research grant programs be preserved and made available. Under BTS leadership, the OST-R is adopting principles to improve the Findability, Accessibility, Interoperability, and Reuse (FAIR) of digital assets that were developed as part of research grants. By cataloging research data and methods for accessing that data, OST-R will encourage learning from experience to improve transportation in the future.

Evidence Building: Challenges and Opportunities

Title III of the Evidence Act defines evidence as "information produced as a result of statistical activities conducted for a statistical purpose" [U.S.C. 44 § 3561(6)]. At least three elements are crucial to evidence building: data, statistical methods, and workforce capacity.

The traditional focus of statistical agencies on surveys and long-established analytical methods is undergoing a period of dramatic change. BTS and other statistical agencies are exploring alternatives and supplements to surveys in response to demands for faster reporting of statistics, increased survey costs and declining survey response rates, the growth in electronic administrative records and sensor-based data, and the need to inform decisions with statistical evidence. The new data sources typically involve massive amounts of data that require new approaches and infrastructures for data processing and analysis. Data science and data engineering join traditional disciplines of statistics, economics, geography, and library science as necessary skills for evidence building.

New data sources and new analytical methods are not free of the potential for bias and error that statisticians have managed in survey data for decades. BTS and the entire Federal Statistical System are considering the accuracy, timeliness, relevance, and other aspects of data quality to develop the best possible statistics from traditional surveys, new data sources, artificial intelligence, and other new analytical methods, and to understand the fitness of use for those statistics.[3]

Many of the new methods for understanding patterns, trends, and insights from massive or unstructured data fall under the label of Artificial Intelligence (AI). BTS and its partners are applying AI and other data science techniques including but not limited, to improve data quality and website content search, reduce reporting burden of various surveys, and extract insights from the vast flow of messages streaming through the air traffic control system. BTS foresees many challenges in developing safe and reliable AI applications and understands the quality of those applications.

The expanded skills required to meet these challenges is reflected in the Department's capacity assessment, which recognizes a need to "increase staff capacity on statistical science …[and] train staff to have a combination of statistical competencies and transportation subject matter expertise" [USDOT 2022, p. 9]. The Department notes further: "Statistical methodologies and data sciences are rapidly evolving ... BTS will focus its recruitment and training efforts on cutting-edge methodologies to improve its capacity in this area" [USDOT 2022, p.11].

Conclusion

When BTS was created 3 decades ago, statistics were used primarily as an input to transportation planning and to justify investments and regulations. During the early years of BTS, an 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 and supply chain disruptions placed even greater demands for

[3] Data quality and fitness for use are outlined in Federal Committee on Statistical Methodology, A Framework for Data Quality, September 2020, available at https://www.fcsm.gov/assets/files/docs/FCSM.20.04_A_Framework_for_Data_Quality.pdf.

timely data to identify large, rapid changes in transportation. Now the Evidence 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-implement-learn-do better,” statistics are no longer a static input to forecasts that are used for plans and shelved; statistics are now a key part of continuous learning and decision making.

The COVID-19 pandemic encouraged the evolution of BTS from a focus on annual statistics published through printed reports to a focus on monthly and weekly statistics continuously updated on the web. The evolution of BTS continues under encouragement by the Evidence Act and the Section 25003 study to focus on decisions hindered by lack of available data as a basis for identifying data relevance and needs.

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 in goals of the Department of Transportation. BTS and its partners across the department endeavor to produce statistics that are relevant and useful throughout the Nation and to fulfill Abraham Lincoln’s vision that: “Statistics will save us from doing what we do, in wrong places” [Lincoln 1848].

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APPENDIX A
Legislative Responsibilities

BTS compiles these and other statistics as required by 49 U.S. Code § 6302 - *Bureau of Transportation Statistics*, which requires information on 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.

Confidential Close Call Reporting Program: Administered by BTS, provides employees of the Washington Metropolitan Area Transit Authority (WMATA) with a confidential platform to report precursor safety events voluntarily without fear of disciplinary action. Information from the program is used by the sponsor to inform preventive safety actions and avoid future adverse events. The program completed its tenth year in 2023.

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.

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.

Gross domestic product (GDP): 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.

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.

Lock: An enclosure or basin located in the course of a canal or a river (or in the vicinity of a dock) with gates at each end, within which the water level may be varied to raise or lower boats.

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.

Producer Price Index (PPI): A family of indexes that measures the average change over time in selling prices received by domestic producers of goods and services. PPIs measure price change from the perspective of the seller.

Real dollars: Value adjusted for changes in prices over time due to inflation.

SafeMTS (Maritime Transportation System): A voluntary program for confidential reporting of near-miss events occurring on vessels within the Maritime Transportation System. The program is intended to provide a trusted, proactive means for the maritime industry to report sensitive and proprietary information, for the purpose of identifying early warnings of safety problems and potential safety issues.

SafeOCS (Outer Continental Shelf): Administered by BTS and sponsored by the Department of the Interior's Bureau of Safety and Environmental Enforcement (BSEE), is a precursor safety event reporting program for the offshore oil and gas industry. It includes both mandatory reporting of equipment failure events and voluntary reporting of near-miss and other safety events

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-ft by 8-ft by 8-ft 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. Refer to 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: Refer to 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.

Vessel: In maritime context, a vessel usually refers to a ship, boat, watercraft, or other artificial contrivance used as a means of transportation on water.

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 U.S. public roadways as in FARS. The differences might seem to be substantial: using NCHS data, for example, the National Safety Council (NCS) found that there were 46,020 motor vehicle related deaths in 2021. This compares to 42,939 public trafficway deaths in FARS—a difference of about 3,100. Please note that neither estimate is wrong but reflects the different definitions of geographic coverage and time period after a crash to ascribe a death to the crash. (The FARS total fatality count used in Figure 5-1 and Table 5-1 in this TSAR does not include the 3,100 motor vehicle deaths that occur outside public roadways (such as on residential 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 nonfatal 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. Because the total number of crashes is so high—there were 6.1 million police-reported motor vehicle crashes in 2021—NHTSA estimates the number of nonfatal 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. For more information, refer to U.S. Department of Transportation, National Highway Traffic Safety Administration, Overview of the 2022 Crash Investigation Sampling System, November 2023, DOT HS 813 526, available at NHTSA.gov as of December 2023.

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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