TRANSPORTATION STATISTICS

ANNUAL REPORT 2024

30th Anniversary

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

Bureau of Transportation Statistics

TRANSPORTATION STATISTICS ANNUAL REPORT 2024

ABOUT THE BUREAU OF TRANSPORTATION STATISTICS

Leadership
Patricia Hu, *Director, Office of Director*
Rolf R. Schmitt, *Deputy Director, Office of Director*

Publication Management
Ramond Robinson, Director, *Office of Transportation Analysis*

ABOUT THIS PUBLICATION

Project Manager
Long Nguyen

Major Contributors
Stacey Bricka*, Michael Bronzini*, Julie Edmonds, Bingsong Fang*, Theresa Firestine, Wendell Fletcher*, David Greene*, Paul Kent*, Alan Pisarski*, Christopher Rick*, Qingshue Xie*

Editor
William H. Moore*

Visual Information Specialists
Hannah Hocevar* and Sari Kimmel*

Other Contributors
Justina Beard*, Patricia DiJoseph, Allison Fischman, Sean Jahanmir, Gummada Murthy, Robert Nazareth, Daniel Palumbo, Mikki Stacey*, Monique Stinson, Xiaoyuan Sun, Hoa Thai, and Miles Weule-Chandler

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.

Report DOI
https://doi.org/10.21949/e0kq-gf72

Publication Date
December 2024

Key Words
Transportation Statistics Annual Report; TSAR; transportation statistics; Bureau of Transportation Statistics; BTS; state of the transportation system; passenger travel and equity; freight and supply chain; transportation economics; transportation safety; energy and sustainability; state of transportation statistics

Title
Transportation Statistics Annual Report 2024

Performing Organization*
MacroSys, LLC
522 21st Street NW, Suite 120A
Washington, DC 20006

Recommended Citation
U.S. Department of Transportation, Bureau of Transportation Statistics. *Transportation Statistics Annual Report 2024*. Washington, DC: 2024. https://doi.org/10.21949/e0kq-gf72.

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

BTS Publications

To obtain free copies of the *Transportation Statistics Annual Report 2024* and other BTS publications, please refer to the following resources:

Mail

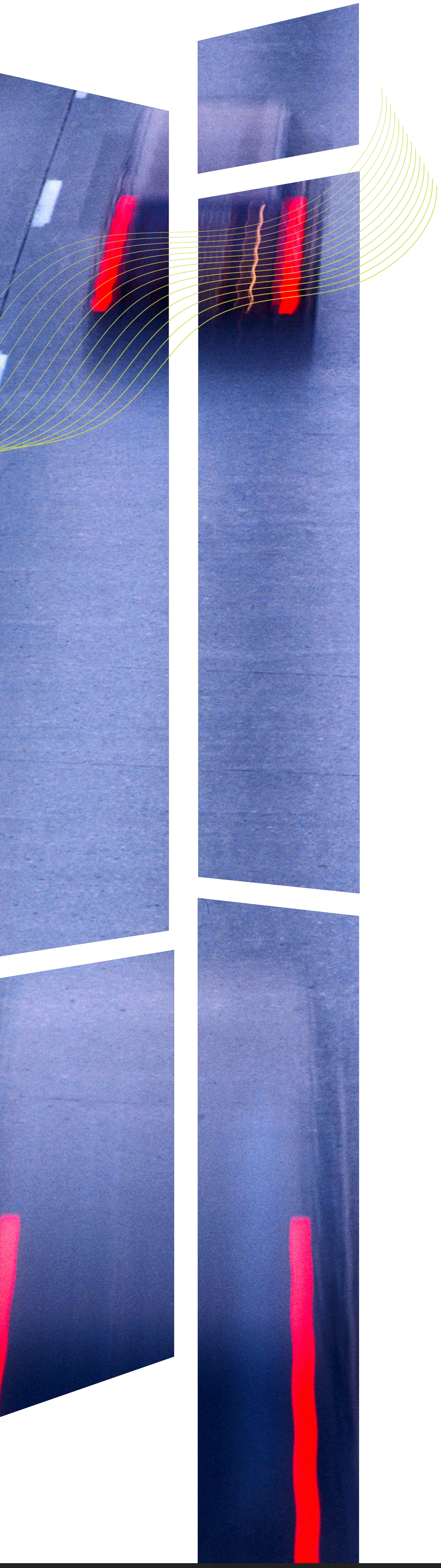
U.S. Department of Transportation
Bureau of Transportation Statistics
Attn: Product Orders
1200 New Jersey Avenue
Washington, DC 20590

Internet https://www.bts.gov/tsar

BTS Information Service

Ask-A-Librarian http://transportation.libanswers.com/

Phone 202-366-DATA (3282)



INTRODUCTION

Transportation is fundamental to the vibrancy of the Nation and facilitates economic prosperity and quality of life. It enables people to engage in productive pursuits and experience the social interactions that take full advantage of geographic specialization and diffusion. 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.

The first TSAR covered the same topics as the current edition in a slightly different order and without the benefit of many major statistical products. For example, freight statistics were based on data from carriers and trade associations rather than the comprehensive, public statistical information in today's Freight Analysis Framework. Economic statistics lacked the complete enumeration of transportation's role in the economy provided by today's Transportation Satellite Account. The environmental section discussed transportation noise in general without today's National Transportation Noise Map. The State of Transportation Statistics chapter included extensive discussions of transportation in the Decennial Census, economic classification, the forthcoming Commodity Flow Survey, and the need for a large survey of long-distance travel.

While TSARs in the last 3 decades have followed a similar format, three editions were much shorter than the traditional format. The 20th-anniversary edition focused on a look back and a look ahead in *Two Decades of Change in Transportation: Reflections from Transportation Statistics Annual Reports: 1994-2014*. The 2019 edition focused on the effects of recent legislation on the state of transportation statistics. The 2021 edition focused on the effects of the COVID-19 pandemic on transportation. All editions of the TSAR can be downloaded from the National Transportation Library,[2] a major part of BTS that was not anticipated in the first edition of the annual report.

This 30th-anniversary edition of TSAR documents how the transportation system has changed through economic booms, a major recession, and the shock of a pandemic. This report is organized into 7 chapters on the State of the System, Passenger Travel and Equity, Freight and Supply Chains, Transportation Economics, Transportation Safety, Energy and Sustainability, and the State of Transportation Statistics. The concluding chapter provides specific information required in the mandate for this report.[1]

BTS welcomes comments on 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.

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

1 Title 49 U.S.C. § 6312, Transportation Statistics Annual Report. Available at https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title49-section6312&num=0&edition=prelim.

2 USDOT. n.d. National Transportation Library, Transportation Statistics Annual Report Series. Available at https://rosap.ntl.bts.gov/gsearch?ref=docDetails&related_series=Transportation%20Statistics%20Annual%20Report%20%28TSAR%29.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

STATE OF THE TRANSPORTATION SYSTEM

In 2023, the U.S. transportation system served 335 million U.S. residents residing in 145 million households, including people who may not own a vehicle or rarely travel, plus 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 8.3 million business establishments with customers, suppliers, and workers [Census Bureau 2024].

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 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 (refer to Chapter 4 Transportation Economics). 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 2022. A point of emphasis is the changes in the transportation system brought about during the COVID-19 pandemic.

Highways, Bridges, and Vehicles

Expansive Infrastructure Is Required to Meet Demand and Resiliency Needs

The U.S. road system had about 4.2 million centerline-miles and 8.8 million lane-miles[1] in 2022, remaining virtually the same since the pre-COVID-19 year of 2018. The number of bridges increased by 0.7 percent from 616,096 in 2018 to 620,669 in 2022 (621,581 in 2023). The mileage of

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.

HIGHLIGHTS

COVID-19 Effects:

Recovery from the COVID-19 pandemic continues with some transportation modes nearly reaching or exceeding prepandemic traffic levels, while others continue to lag.

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 2022, erasing about 80 percent of the 2020 drop.

Public Transit: While 2020 saw little change in public transit infrastructure, transit ridership plummeted during the COVID-19 pandemic. Passenger trips dropped from 9.9 billion in 2019 to 5.9 billion in 2020, a 40 percent reduction. While transit ridership is slowly increasing, it has yet to recover to prepandemic levels. In 2023, passenger trips were 70.7 percent of those in 2020.

Air freight was a bright spot during the pandemic, with enplaned tons increasing 17.1 percent from 2019 to 2021 but dropped 11.4 percent from 2021 to 2023.

Freight Railroads: The COVID-19 pandemic severely impacted freight railroad traffic and operations, but traffic has since rebounded to near-normal levels. Total rail revenue ton-miles in 2022 were back to 95 percent of the total for 2019.

Passenger Rail: In fiscal year 2023, Amtrak recovered more than 80 percent of the lost ridership during COVID-19 and carried more than three times as many riders between Washington and New York City as did all airlines combined and more than all airlines combined between New York City and Boston and several other city-pair markets.

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 enplanements reported 2 decades earlier. Enplanements rebounded in 2023 to the 2019 level and were on pace to exceed that level through the first half of 2024.

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 2022, waterborne commerce had recovered to the same level as in 2019.

Petroleum Pipelines: The crude petroleum and products pipeline systems carried 3.3 billion barrels across the United States in the pandemic year of 2020, down 10 percent from 3.7 billion in 2019. Pipeline shipments recovered to 3.9 billion barrels in 2023, a 5 percent increase over 2019.

Conditions on Roads, Bridges, and Vehicles:

Between 2011 and 2022, 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 poor ride quality compared to about 19 percent of such roads in urban areas. This is generally attributed to more activity and wear on urban than on rural roads.

Between 2010 and 2024, the number of the Nation's bridges in poor condition declined by 17,225, from about 10 to about 7 percent of all bridges.

New passenger car and light truck sales and leases in the United States declined from 17.3 million vehicles in 2018 to 14.6 million in 2020 and remained at that level through 2022 due to reduced vehicle production and increased vehicle prices.

Highlights Continued »

HIGHLIGHTS CONTINUED

Aviation: 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

Urban Roads: Urban roads have a larger share of VMT on roads with poor pavement condition (13 percent of VMT) than rural roads (2 percent).

Disruptions to the U.S. Transportation System: In 2023, there were 28 weather and climate disaster events, each with losses exceeding $1 billion across the United States—the highest number on record. While hurricanes and other severe storms brought disruption from too much water, drought left the lower Mississippi River with too little water for normal navigation in 2022, 2023, and 2024.

nonexpressway principal arterial streets and collector streets were also up by 0.8 percent 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 2022 (Table 1-1). However, interstate highways, which accounted for about 48,600 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 2022 [FHWA 2023]. Rural highways comprise 70.2 percent of the centerline-miles and 68.2 percent of the lane-miles and carry 32.14 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.

Table 1-1 Public Roads, Streets, and Bridges: 2010 and 2018–2022

Road/street/bridge	2010	2018	2019	2020	2021	2022
Public road and street mileage by functional type (miles)	4,067,076	4,176,915	4,171,125	4,172,562	4,187,440	4,197,446
Interstate	46,900	48,440	48,481	48,472	48,519	48,605
Other freeway and expressways	14,619	18,603	18,631	18,656	18,712	18,804
Other principal arterial	157,194	156,614	156,680	157,210	157,398	157,844
Minor arterial	242,815	246,214	246,831	246,539	246,303	246,314
Collectors	799,226	814,585	815,118	819,025	820,343	821,283
Local	2,806,322	2,892,459	2,885,384	2,882,660	2,896,165	2,904,596
TOTAL lane-miles	**8,582,261**	**8,794,569**	**8,785,398**	**8,790,746**	**8,823,515**	**8,844,304**
TOTAL bridges	**604,460**	**616,096**	**617,084**	**618,456**	**619,622**	**620,669**
TOTAL registered vehicles	**250,070,048**	**273,602,100**	**276,491,174**	**275,936,367**	**282,214,578**	**283,400,986**
Vehicle-miles of travel (millions)	2,967,266	3,240,327	3,261,772	2,903,622	3,132,411	3,196,191

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 October 2024.

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

Condition of Roads and Highways

Interstate Highways Have the Best Pavement Condition

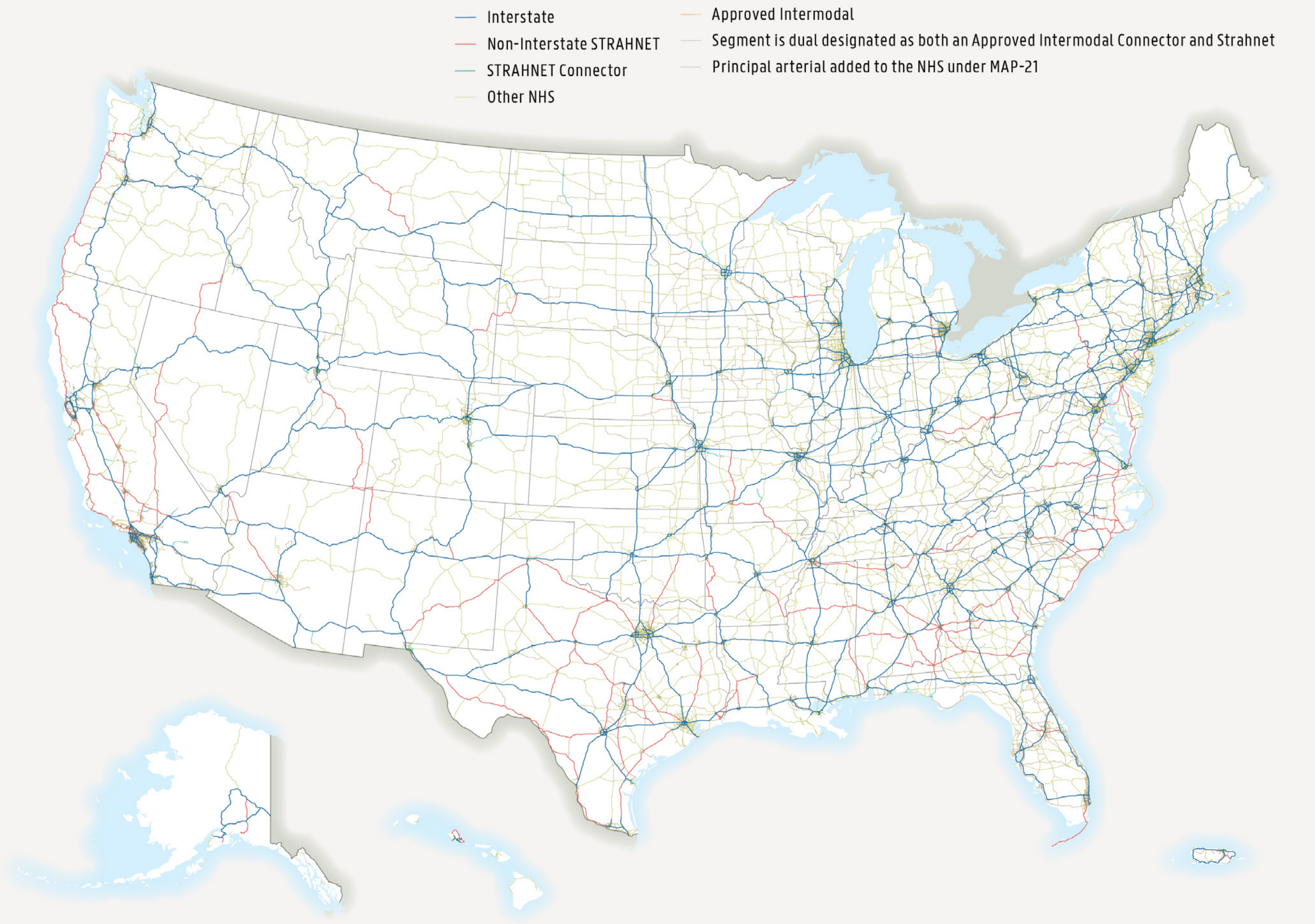
The International Roughness Index (IRI) indicates the smoothness of pavement for three major categories:

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 (only 2.1 percent of mileage rated poor) of all NHS roads (Figure 1-2). The percentage of urban NHS interstate highways with poor pavement improved from 5.4 percent in 2011 to 4.9 percent in 2022. From 2011 to 2022, the portion of the NHS with the poorest pavement has consistently been the urban noninterstate portion of the system, with a percentage about 6 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

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 1-1 NHS, Intermodal Connectors, and Principal Arterials: 2022



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 2024.

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.

Puerto Rico. Poor condition is defined as any pavement with an IRI value greater than 170 inch/miles.

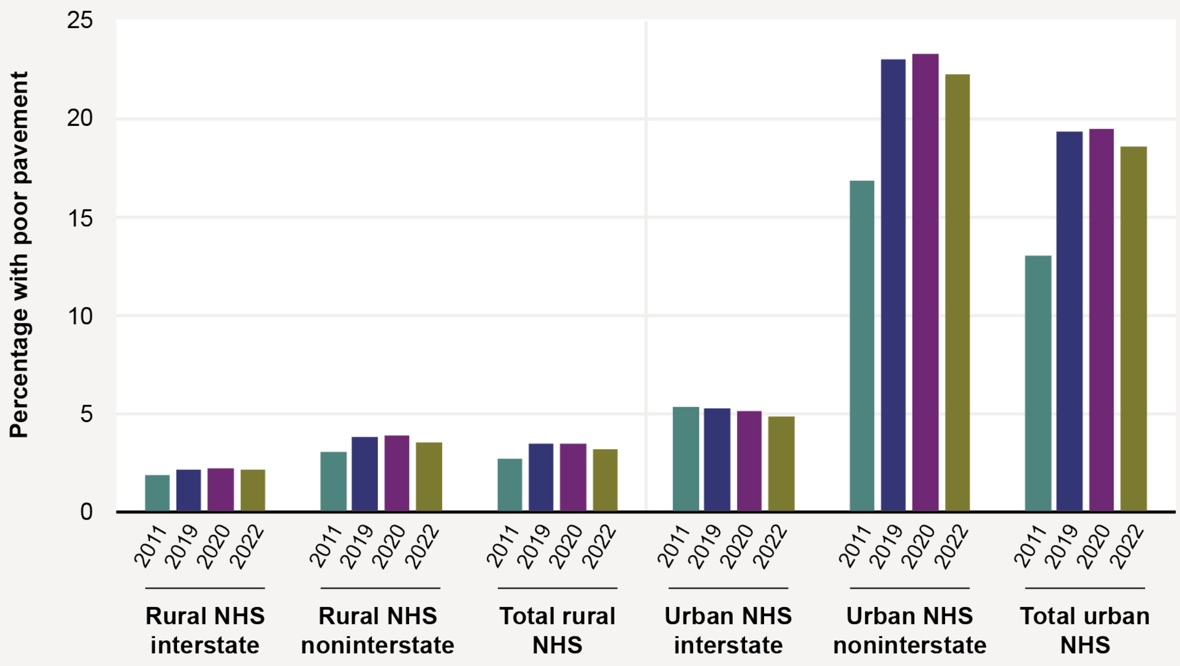
Looking at the pavement condition for all high function roads, including non-NHS federal and state roads that have high traffic volumes and densities, yields a broader and slightly different view of overall road condition than just examining the NHS (Figure 1-3). The mileage of rural higher function roads with poor pavement conditions increased from 4.8 percent in 2011 to 5.7 percent in 2017, and has since dropped to 5.0 percent in 2022. The mileage of urban higher function roads with poor pavement conditions improved for all roadway classes, decreasing from 21.4 percent in 2011 to 18.8 percent in 2022.

Daily travel on the NHS reached about 4.8 billion VMT in 2022, with 9.63 percent of this travel over roads in poor condition, down from 10.3 percent in 2020. 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 at 2.4 percent from 2011 to 2022; for urban NHS travel on poor pavement, the percentage increased from about 11 to 13 percent in 2022 (Figure 1-4). There has been little or no change in these results since 2018.

Bridges

A total of 623,218 highway bridges were in use in 2024, 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 69.6 percent of the total bridge network [FHWA 2024a]. While the interstate highway bridges accounted for 9.4 percent of all bridges, they carried 45.3 percent of motor vehicle bridge traffic.

Figure 1-2 Percent Miles of the NHS With Poor Pavement: 2011, 2019, 2020, and 2022

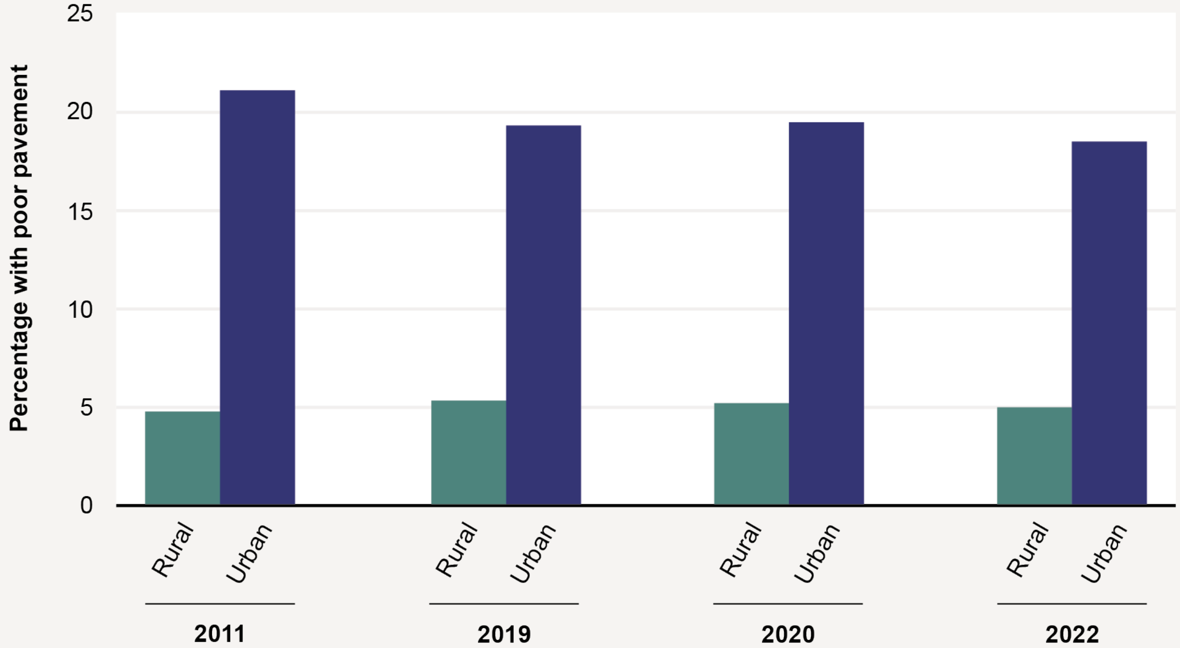


Source: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics, Table HM-47, available at www.fhwa.dot.gov/policyinformation/statistics.cfm as of August 2024.

Note: 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. No data were reported for 2010 due to a change in the data model, so the data reported for 2011 were used. Poor condition is defined as any pavement with an IRI value greater than 170 inch/miles. No data were reported for 2021.

NHS = National Highway System or the interstate highway system.

Figure 1-3 High-Function Roads with Poor Pavement Condition, Rural vs. Urban: 2011, 2019, 2020, and 2022



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 July 2024.

Note: The higher functionally classified roads in the urban category include interstates, other freeways and expressways, other principal arterials, and minor arterials for the entire road network. For the rural classified roads, the functional classification includes interstates and other principal arterials including those for Puerto Rico. No data were reported for 2010 due to a change in the data model, so the data reported for 2011 were used for this period. No data were reported for 2021. Poor condition is defined as any pavement with an IRI value greater than 170 inch/miles.

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 42,080 in 2024 (6.7 percent) [FHWA 2024a]. 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 in rural and urban areas are on local roads as determined by the lowest rating of the National Bridge Inventory condition ratings for the bridge deck, superstructure, substructure, or culverts (Figure 1-5). Bridges in poor condition on rural roads in 2024 accounted for about 7.7 percent of the total number of rural bridges and 3.2 percent of the throughput (average daily traffic[8]) on rural bridges.

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

4 Closed bridges are not open to public traffic.

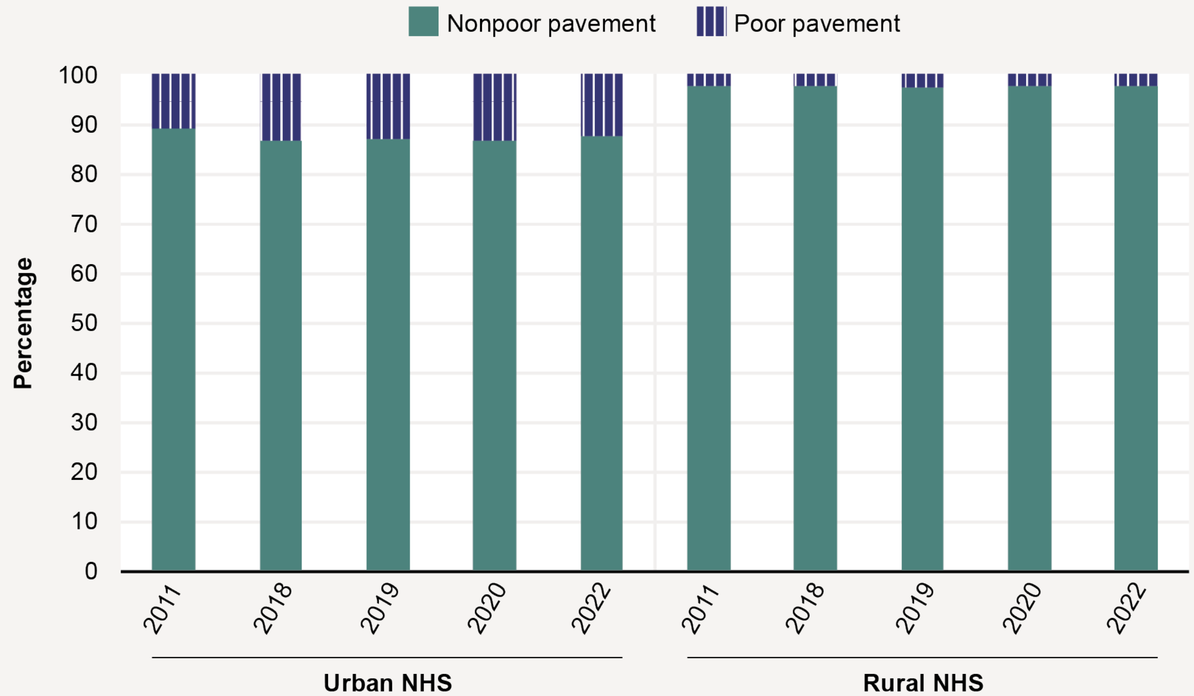
5 A weight-restricted bridge cannot safely support the weight of any vehicles that exceed the posted weight limit even if they are otherwise legal on the adjacent roadways.

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."

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.

Figure 1-4 Daily VMT on NHS Roads With Poor Pavement Condition, Urban vs. Rural: 2011, 2018–2020, and 2022 (Daily VMT = 4.8 Billion in 2022)



Source: U.S. Department of Transportation, Federal Highway Administration, National Highway System Length, Daily Travel by Measured Pavement Roughness – Urban and Rural. table HM-47A, available at www.fhwa.dot.gov/policyinformation/statistics/2022 as of August 2024.

Note: the higher functionally classified roads in the urban category include interstates, other freeways and expressways, and other principal arterials for the entire road network. For the rural classified roads, the functional classification includes interstates and other principal arterials including those for Puerto Rico. No data were reported for 2010 due to a change in the data model, so the data reported for 2011 were used for this period. Poor condition is defined as any pavement with an IRI value greater than 170 inch/miles. No data were reported for 2021.

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

In comparison, bridges in poor condition on urban roads comprised approximately 4.7 percent of urban bridges and 3.5 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 42,080 bridges considered to be in poor condition nationwide in 2024,[9] about 79 percent of them are in rural areas [FHWA 2024a]. Bridges in poor condition are concentrated in rural areas in the Midwest and Northeast (Figure 1-6). Moreover, 4 of 5 closed bridges and 9 of 10 bridges 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 [USDOT 2023].

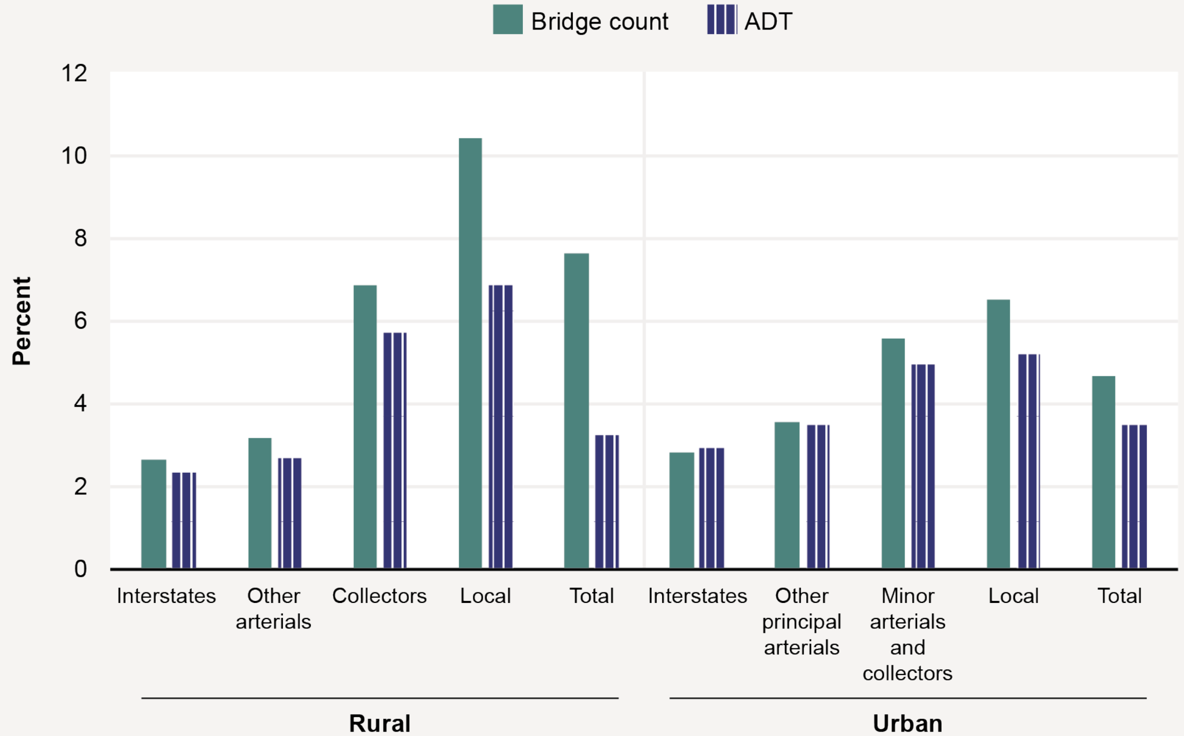
Concerning who owns and is responsible for the upkeep of the 42,080 bridges in poor condition in 2024, about 31 percent of these bridges were owned by States, 50 percent by counties, 7.5 percent by towns, 7.8 percent by cities, and 1.9 percent (773) by the Federal Government. The remaining 1.9 percent of bridges in poor condition are owned by park agencies, tollways, railroads, and other entities [FHWA 2024b].

In 2024, 65,116 out of the 619,388 bridges open to traffic[10] had some type of load restriction posting in place, comprising about 10.5 percent of all open bridges [FHWA 2024c]. The percentage of bridges with load restrictions posted was about

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).

10 This is lower than the total number of bridges since the latter includes closed bridges and new bridges not yet opened to traffic.

Figure 1-5 Bridges in Poor Condition and Average Daily Traffic on Bridges: 2024



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 2024.

Note: A “poor” bridge condition rating is determined by the lowest rating of the National Bridge Inventory condition ratings for bridge deck, superstructure, substructure, or culverts. Roads are usually classified by the volumes carried and travel speeds designed for. Thus, interstate highways are considered the highest functional classification whereas local streets are considered the lowest.

ADT = average daily traffic.

11 percent in 2010, so there has been a modest reduction from then to 2024. Of the bridges having some form of posted restriction in 2024, about 28 percent (18,389 bridges) were in poor condition.

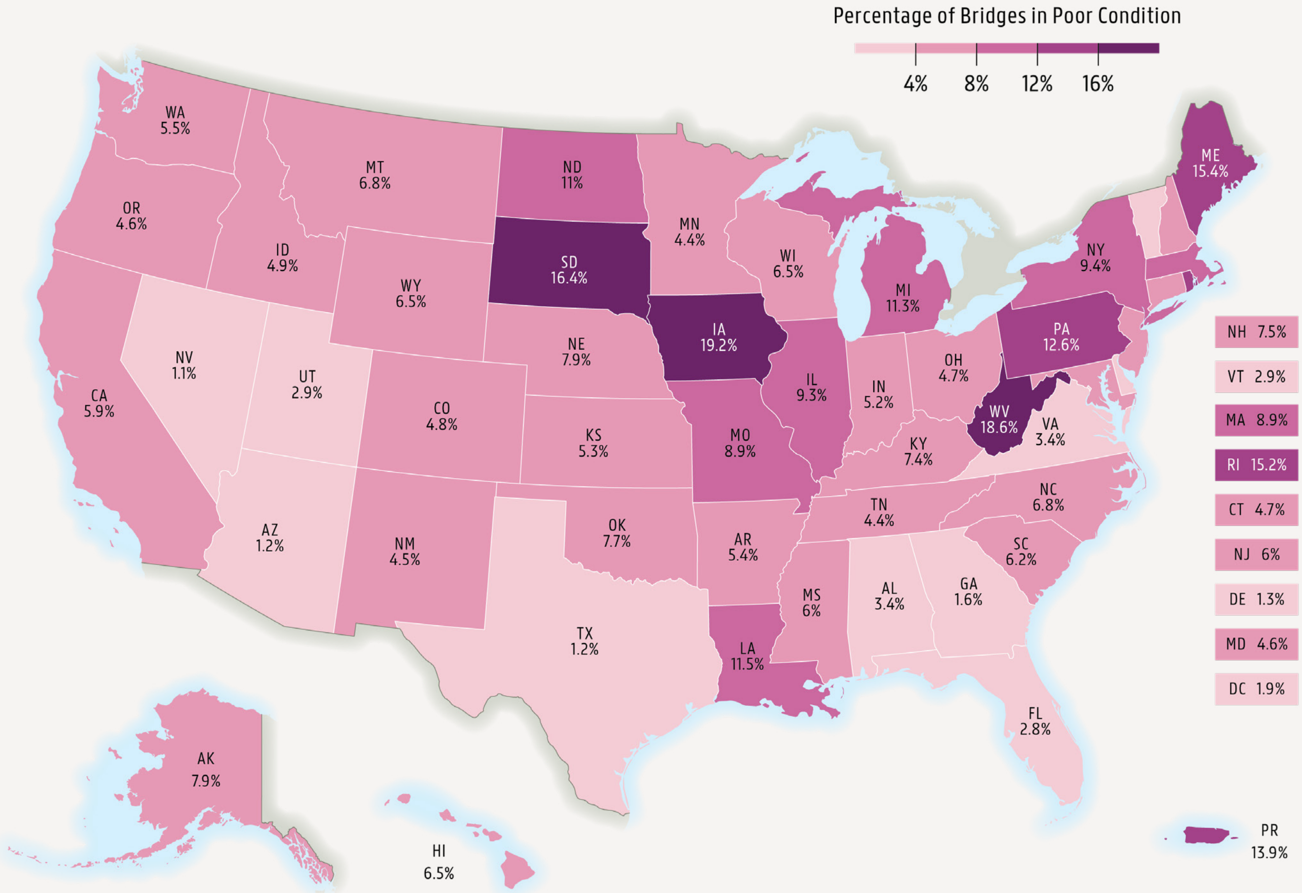
Vehicles

Government, businesses, private individuals, and nongovernmental organizations owned and operated about 283.4 million motor vehicles in 2022 and drove a total of 3.2 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 [FHWA 2023].

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 2022, to about 3 percent above their values in 2019; and VMT increased sharply from 2020 to 2022, erasing about 80 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.

Vehicle registrations were anemic during the pandemic (0.8 percent) from 2018 to 2020. Registrations include both new and old vehicles, so they can increase even if new car sales decrease as older vehicles remain in use longer. Over that period, new passenger car and light truck sales and leases in the United States declined from 17.3 million to 14.6 million vehicles, and have stayed at about that level through 2022 [BTS 2023g]. Shortages of labor and vehicle

Figure 1-6 Rural Bridges in Poor Condition: 2024



Source: U.S. Department of Transportation, Federal Highway Administration, National Bridge Inventory, available at www.transportation.gov as of September 2024.

components (especially electronics) resulted in reduced vehicle production and increased vehicle prices.

Most daily personal travel, particularly work commutes, is in privately owned vehicles. According to the National Household Travel Survey [FHWA 2024d], the average passenger vehicle was driven 7,937 miles in 2022, which was down about 21 percent from 2017.This decline in average annual miles per household vehicle is likely due to the lingering effects of the COVID-19 pandemic.

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 [BTS 2024e]. 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. Some key data points from both the 2002 and 2021 VIUS datasets include the following:

- In 2021, the total number of trucks operated on U.S. roadways was 169.8 million, versus 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 VMT was 9,800 per truck, versus 12,200 in 2002.

- Heavy-duty trucks, which have a GVWR heavier than 26,000 pounds, had a fuel efficiency of 6.34 MPG in 2021, versus 6.23 MPG in 2002. In 2021, the average annual VMT for these trucks was 36,000 per truck, versus 41,000 in 2002.

The VIUS details light-duty vehicles that weigh less than 10,000 pounds, mostly SUVs, which are 34 percent of vehicles.

Condition of the Vehicle Fleet

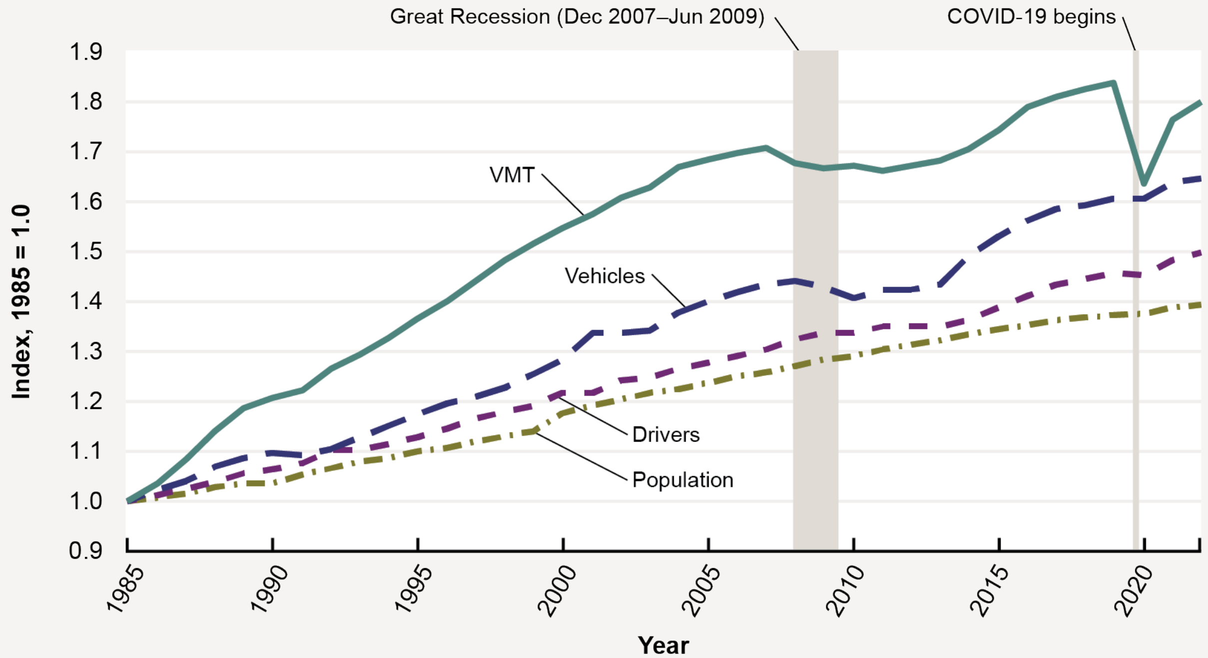
Age of Vehicles Is Increasing

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 increased the average vehicle age even further, reaching 12.5 years in 2023 [BTS 2024f]. Vehicle condition usually declines with use and age. Some additional key data points from the 2021 VIUS datasets include the following:

- 41 percent of VIUS vehicles below 10,000 pounds were more than 10 years old and averaged 7,100 miles per year, while newer light-duty vehicles averaged more than 10,000 miles per year.
- 47 percent of trucks heavier than 26,000 pounds were more than 10 years old and averaged 20,000 miles per year.
- 10 percent of trucks heavier than 26,000 pounds were from model years 2020 and 2021 and averaged more than 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 [BTS 2024f]. In comparison, the vehicle fleet has aged 6.8 percent from 2018 to 2023, which spans the COVID-19 pandemic years.

Figure 1-7 Licensed Drivers, Vehicle Registrations, VMT, and Population: 1985–2022



Source: Vehicles, Drivers, and Population: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2022. Tables DL-1C and MV-1. Available at http://www.fhwa.dot.gov/policyinformation/statistics/2022 as of July 2024. VMT: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 1-35, available at www.bts.gov as of July 2024.

VMT = vehicle-miles traveled.

Highway Congestion

Urban Highway Congestion Was Lower During the Pandemic But Has Increased

Congestion measures are reported for the 52 largest metropolitan statistical areas (MSAs)—those with a population larger than 500,000—in the FHWA Urban Congestion Report [FHWA 2021b] based on vehicle probe data.[11] Three measures are used to gauge congestion—the excess of vehicles on the roadway 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).

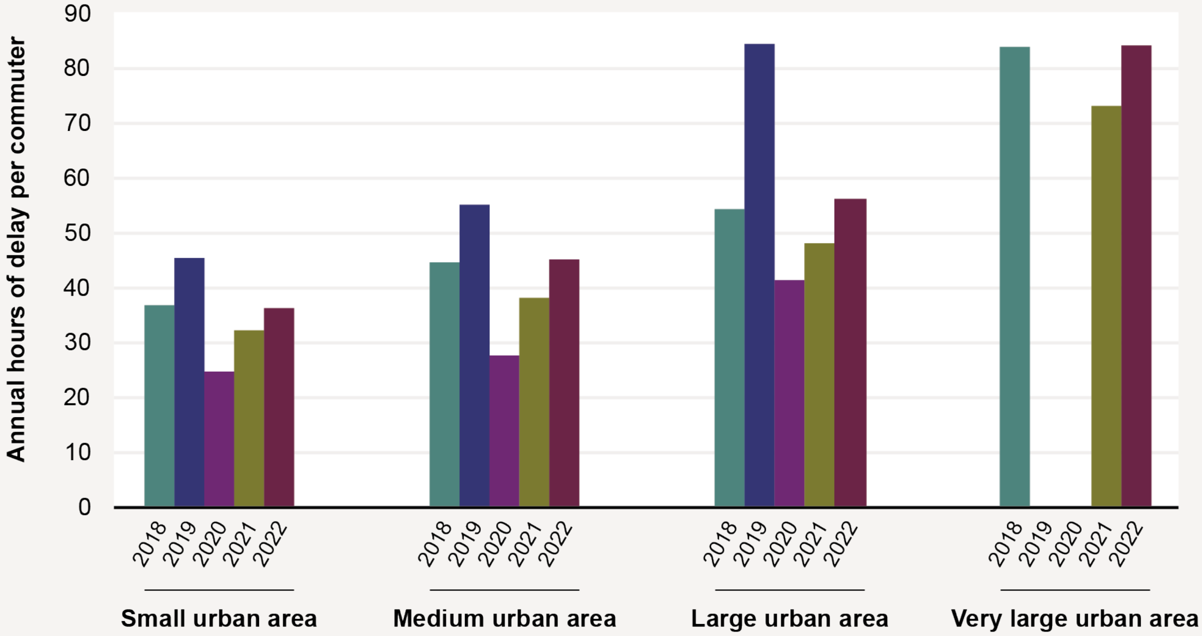
Each of these measures represents a different aspect of congestion. The effects of reduced driving during the pandemic were evident in recent results. From 2019 to 2020, on average for the 52 urban areas studied, congested hours were down 39 percent, TTI was down 14 percent, and PTI dropped 24 percent [FHWA 2021b]. Since then, all three of these measures have trended toward (but not yet reached) their prepandemic values. From 2020 to 2023, congested hours (2.75) were up 20 percent, TTI (1.24) was up 10 percent, and PTI (1.88) increased 20 percent [FHWA 2024e].

The Texas A&M Transportation Institute's Urban Mobility Report provides a comprehensive look at highway congestion [Schrank et al. 2024]. This biennial report, which relies on INRIX[12] data, includes both NHS and non-NHS freeways and arterial roads. The Urban Mobility Report reports show metrics for 101 MSAs with additional data for another 393. The 2021 Urban Mobility Report showed that there were unprecedented reductions in highway congestion in urban areas in the initial COVID-19-pandemic year of 2020.

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

12 INRIX data are 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: 2018–2022



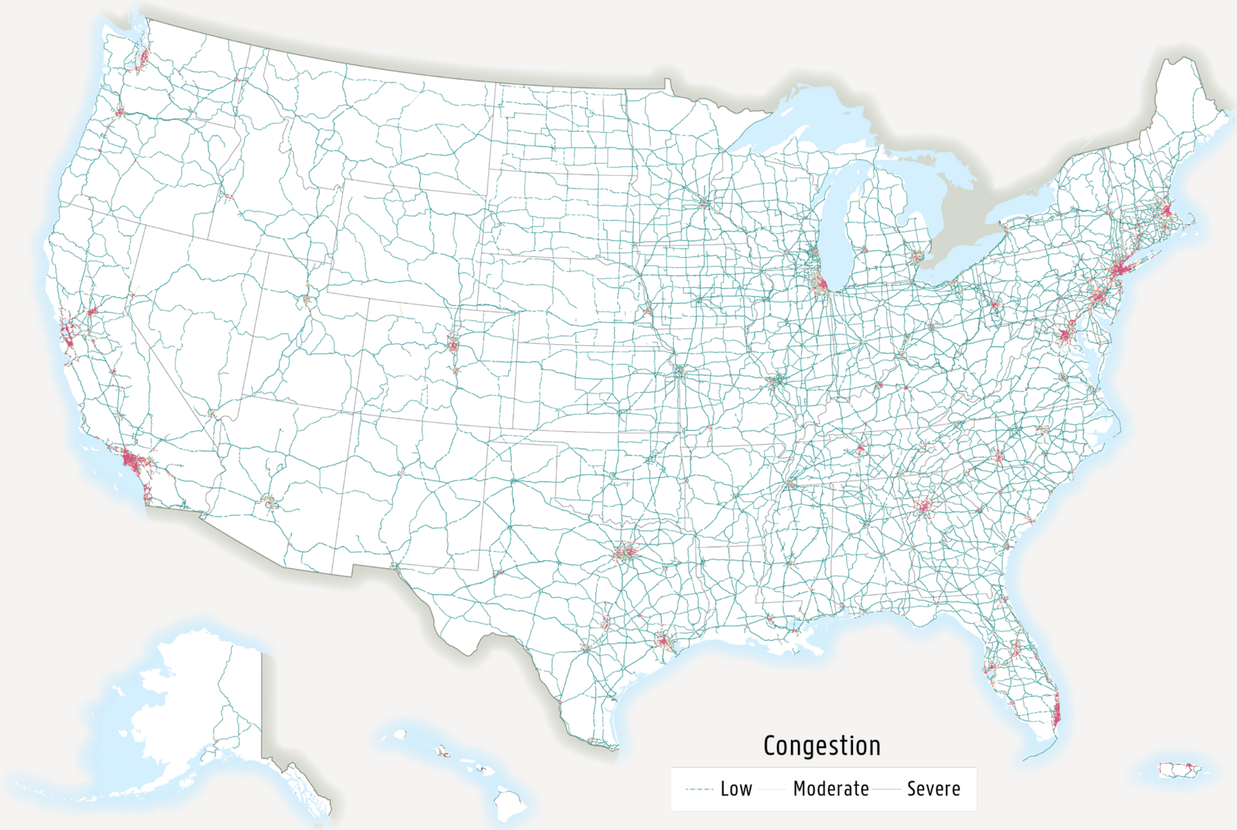
Source: Schrank and Eisele. Texas A&M Transportation Institute, Urban Mobility Report 2023, available at https://mobility.tamu.edu/umr/ as of July 2024, as reported in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, Table 1-69, available at www.bts.gov as of July 2024.

Overall, annual hours of delay per commuter in urban areas (Figure 1-8) dropped from 54 hours in 2019 to 27 hours in 2020, a value not seen since 1989, more than 3 decades ago. Other congestion measures also recorded drops of historic proportions from 2019 to 2020. The average TTI 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). These measures all increased to at or near the 2019 levels in 2022, with annual delay hours back up to 54, TTI at 1.21, delay cost at $1,259, and wasted fuel due to congestion at 3.3 billion gallons. Underlying these results are some changes in congestion dynamics since 2019. For example, due partially to an increase in working from home, congestion is more spread out among hours of the day and days of the week [Schrank et al. 2024]. More research is needed to understand the relationship between the increase in working from home and the congestion measures.

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 $13 billion (2022 dollars) in 2020, down from $23 billion in 2019, but more than doubled to $27 billion in 2022. The truck share of total congestion cost increased from 11 percent of the total in 2019 to 12 percent in 2022 [Schrank et al. 2024].

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; Chicago; Houston; Atlanta; Los Angeles; and Nashville) in the Nation have stayed about the same over the past 10 years, although some locations

Figure 1-9 Peak-Period Congestion on National Highway System's High-Volume Truck Routes: 2023



Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.5, special tabulation as of November 2024.

have shown minor movements up or down the list [ATRI 2024]. In 2023, the average peak-hour truck speed for the top 100 truck bottlenecks was 34.4 mph, down 3.8 percent from 2022. 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). Truck speeds at these bottlenecks were up during the 2020 pandemic year, but have since settled in at about 3 to 5 mph higher than in 2019.

Public Transit

Transit Ridership Is Slowly Recovering From COVID-19

In 2022, nearly 3,000 urban, rural, and tribal government transit agencies offered a range of travel options, including commuter rail, subway, and light rail; transit and trolley bus; demand-response services; and ferryboat. In 2022, these transit agencies operated more than 6,000 stations.[13] There were 13,950 fixed-rail transit track-miles and 4,666 fully controlled or limited-access bus roadway miles in 2022 [FTA 2024a].

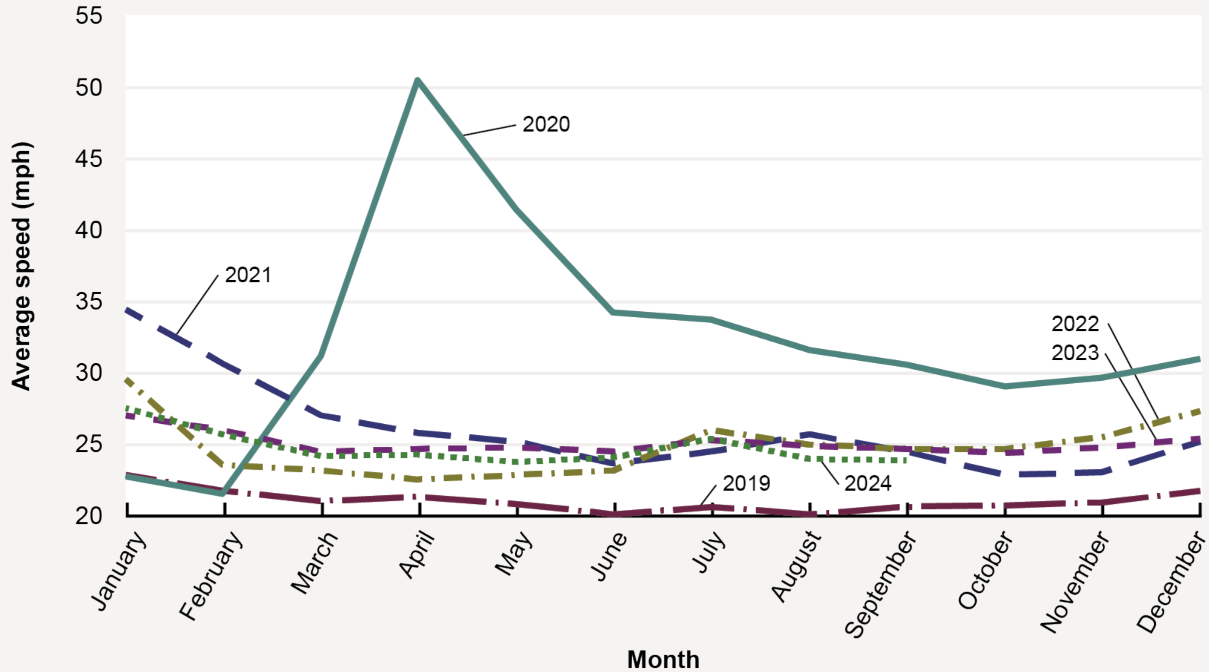
Transit agencies vary widely in size, ranging from social service agencies operating a single vehicle to the 12,000 vehicles[14] operated by the New York City Metropolitan Transportation Authority. While recent years have seen little change in public transit infrastructure, transit ridership plummeted during the COVID-19 pandemic. Passenger trips dropped from 9.9 billion in 2019 to 4.5 billion in 2021, a reduction of 55 percent (Table 1-2), before recovering to 7.0 billion in 2023. Monthly ridership losses during the onset of the pandemic were even more striking. April 2020 had 158.5 million unlinked passenger trips (UPT)—the lowest ridership on record since 2002—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 62 percent from 2019 [FTA 2024a]. While transit ridership is slowly increasing, the pace has yet to recover to prepandemic levels. In 2022, passenger trips were 68 percent of those in 2019. Figure 1-11 shows transit ridership in the top 50 urbanized areas in 2023, which collectively accounted for 91 percent of total transit rides.

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

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

Figure 1-10 Average Truck Speed in mph at Bottleneck Locations: 2019–2024



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 September 2024.

mph = miles per hour.

Table 1-2 Transit Vehicles and Ridership: Revenue Years 2010, and 2018–2023

Transit vehicle	2010	2018	2019	2020	2021	2022	2023
TOTAL, transit vehicle	**135,674**	**134,855**	**137,257**	**137,434**	**129,483**	**129,974**	**129,970**
TOTAL, rail transit vehicles	**20,374**	**20,515**	**21,153**	**21,387**	**21,346**	**21,417**	**21,636**
Heavy rail cars	11,510	10,763	11,198	11,064	10,942	10,880	11,069
Commuter rail cars and locomotives	6,768	7,023	7,144	7,524	7,545	7,645	7,603
Light rail cars	2,096	2,729	2,811	2,799	2,859	2,892	2,964
TOTAL, nonrail transit vehicles	**115,300**	**114,340**	**116,104**	**116,047**	**108,137**	**107,994**	**107,799**
Motor bus	63,679	63,284	64,000	63,903	62,836	62,766	61,131
Demand response	33,555	33,253	34,613	34,633	31,553	31,777	32,423
Ferry boat	134	171	183	204	209	226	224
Other	17,932	17,632	17,308	17,307	13,539	13,225	14,021
Rail transit stations	3,124	3,448	3,630	3,663	3,801	3,792	3,837
Person-miles (millions)	52,627	53,830	54,097	31,547	22,371	29,947	35,018
Unlinked passenger trips (UPT) (in billions)	9.30	9.87	9.88	5.94	4.47	5.96	6.99
Rail transit UPT	3.92	4.77	4.84	2.41	1.95	2.82	3.27
Nonrail transit UPT	5.38	5.09	5.05	3.53	2.52	3.14	3.72

Source: Transit vehicles: U.S. Department of Transportation (USDOT). Federal Transit Administration (FTA). National Transit Database (NTD) as cited in USDOT. Bureau of Transportation Statistics (BTS). National Transportation Statistics (NTS). Tables 1-11. Available at http://www.bts.gov/ as of November 2024. Person-miles traveled: USDOT/FTA/NTD as cited in USDOT/BTS/NTS. Table 1-40. Available at http://www.bts.gov/ as of November 2024. Transit Stations and UPT: USDOT/FTA/NTD. Available at https://www.transit.dot.gov/ntd/ntd-data as of November 2024.

Note: Motor bus includes bus, commuter bus, bus rapid transit, and trolley bus. Light Rail includes light rail, streetcar rail, and hybrid rail. Demand response includes demand response and demand response taxi. Other includes Alaska railroad, automated guideway transit, cable car, inclined plane, monorail, and vanpool. UPT is the number of passengers who board public transportation vehicles. Passengers are counted each time they board vehicles no matter how many vehicles they use to travel from origin to destination. 2019, 2020, and 2021 data are revised.

UPT = unlinked passenger trips.

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 48 percent of transit trips and 58 percent of person-miles traveled (PMT) in 2022 [FTA 2024a]. Buses recorded 47 percent of transit trips but only 37 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 25 percent of transit vehicles in 2022 but carried only 2 percent of the trips and passenger miles. Demand-response and paratransit systems, which operate mostly in urban areas but also sometimes in rural areas, tend to service those with a disability or those who do not own a car.

Two rapidly growing travel services that affect both driving and transit usage in urban areas are ride-hailing and vehicle-sharing. These on-demand services have created new business models, including transportation network companies (i.e., TNCs), mobility on demand (i.e., MOD), and mobility-as-a-service (i.e., MaaS), which rely on a digital platform that integrates various forms of transport services into a single on-demand service.

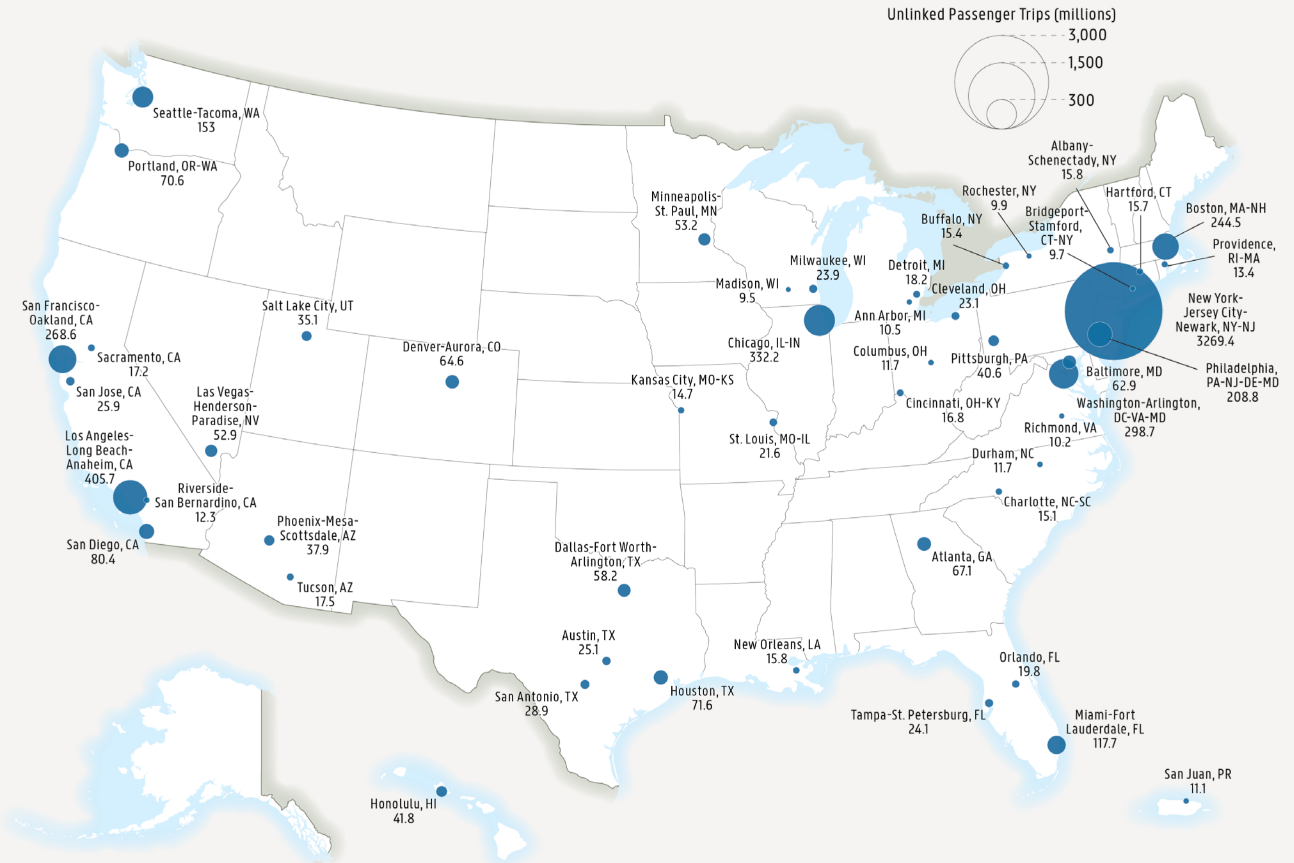
Transit System Condition

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[15] reflecting the respective conditions of different transit modes, with older transit vehicles more likely to break down than newer ones.

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

Figure 1-11 Top 50 Urbanized Areas of Transit Ridership: 2023



Source: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, available at www.transit.dot.gov/ntd as of September 2024.

Note: Urban areas (shaded) are built-up areas or urban agglomeration with a high population density and significant infrastructure.

For the most part, the average age of the Nation's transit fleet increased between 2010 and 2022 (Figure 1-12). Reduced transit ridership and revenue during the COVID-19 pandemic had a negative effect on vehicle replacements, as all vehicle types except commuter rail locomotives saw an increase in average age from 0.5 to 4 years from 2020 to 2022. In 2023 the average ages of heavy rail passenger cars, light rail vehicles, and ferry boats are all at about 22 to 23 years, making them the oldest vehicles in the Nation's transit system [BTS 2024f]. In general, the 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 175,000 in 2022, a 29 percent decrease [FTA 2024a].

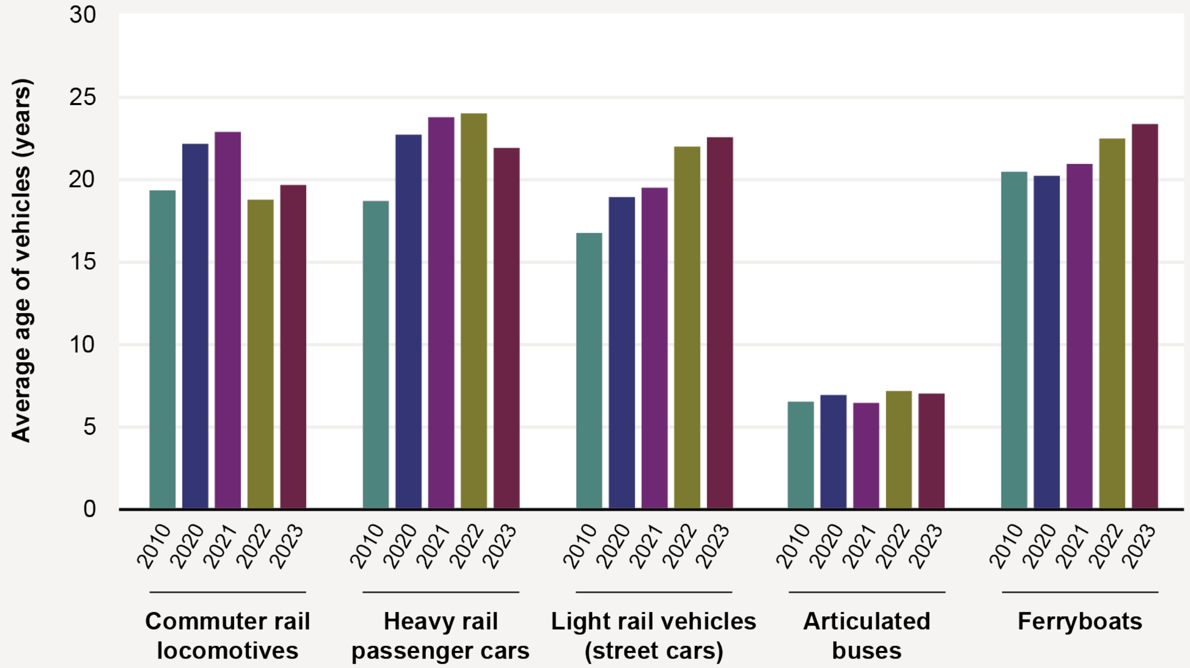
Aviation

Air Travel Plummeted Due to the Pandemic but Now Exceeds the Prepandemic High

The main elements of aviation system infrastructure include airport runways and terminals, aircraft, and air traffic control systems. In 2023, the United States had about 20,000 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 2 decades,

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 is compromised.

Figure 1-12 Average Age of Urban Transit Vehicles: 2010 and 2020–2023



Source: U.S. Department of Transportation, Federal Transit Administration, Vehicles, available at www.transit.dot.gov/ntd/ntd-data as of October 2024; 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 October 2024.

the exception being a 3.5 percent increase in the number of private airports since 2010.

Major reductions in air travel occurred during the COVID-19 pandemic in 2020 (Table 1-3). Total passenger enplanements at U.S. airports were down from 1.06 billion in 2019 to 403 million in 2020, a drop of 62 percent, and there were fewer enplanements than the total reported 2 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 58 percent in 2020 and nearly 83 percent in 2023, as compared with 85 percent in 2019. The recovery in air passenger traffic continued into 2023, when enplanements were back up to 1.06 billion and load factor exceeded 83 percent. For the first 5 months of 2024, total enplanements were 441 million—6.7 percent higher than the total for the same period in 2023 [BTS 2024c]. If this growth continues for the remainder of the year, air passenger traffic is on pace to exceed that in 2019. Air freight tonnage was down 11.4 percent from 2021 to 2023 (Table 1-3), which has erased two-thirds of its 17 percent increase during the pandemic.

Figure 1-13 shows the U.S. airports with the most revenue passenger enplanements on scheduled flights of U.S. carriers in 2023. Hartsfield-Jackson Atlanta International (50.9 million), Dallas/Fort Worth International (39.2 million), and Denver International (37.9 million) continued to be the top three airports in 2023. The top 50 airports accounted for 84 percent (about 785 million) of the U.S. airport passenger enplanements[17] in 2023.

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 8.7 million in 2022 and 9.3 million in 2023. Total prepandemic commercial flights have varied between 9.5 and 10.0 million since 2010 but remained below the high point of 11.3 million in 2005 [BTS 2024c]. At least some of this reduction is due to the trend for airlines to use larger aircraft and reduce the number of flights.

17 There were 940 million revenue passenger enplanements on U.S. air carriers at U.S. airports in 2023. This is less than the total enplanement cited earlier because those include foreign air carriers and nonrevenue 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.

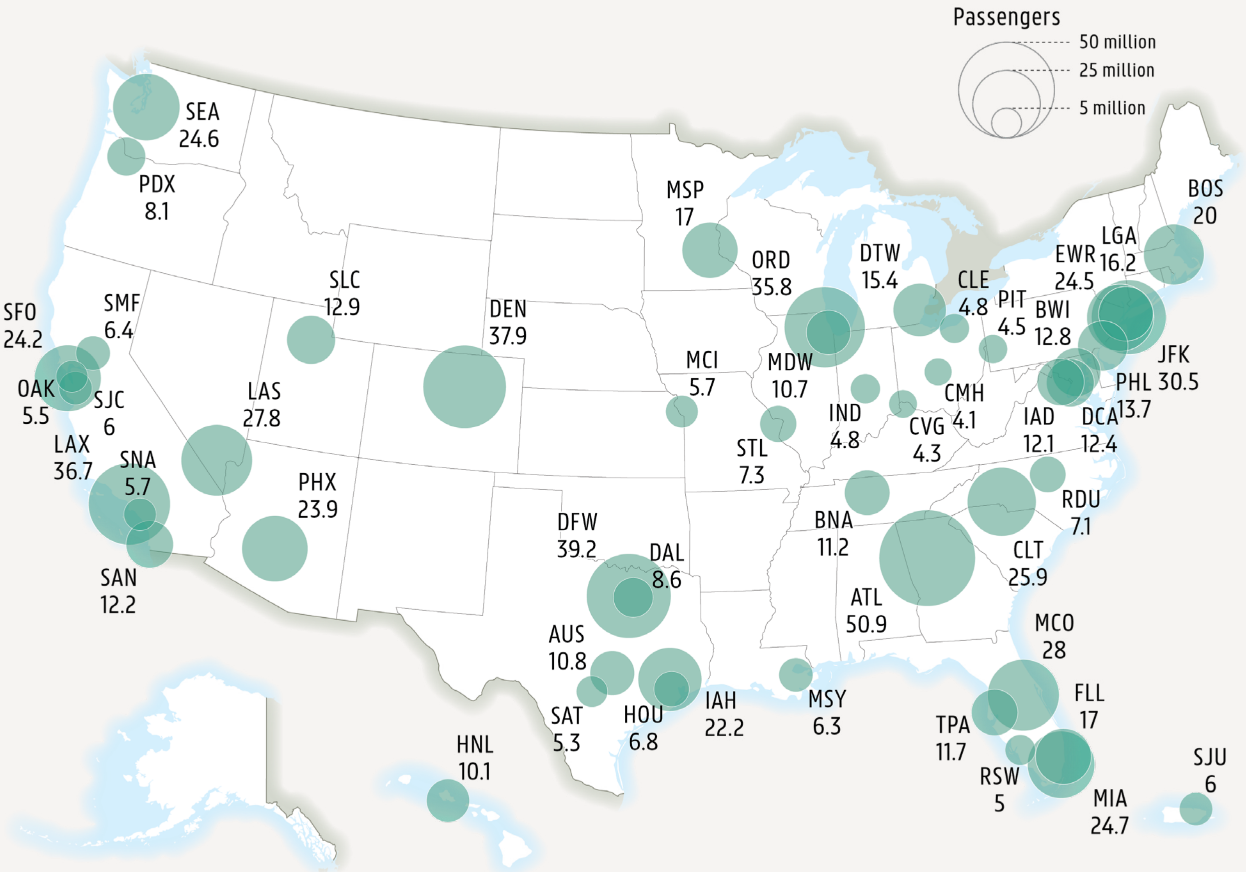
Table 1-3 U.S. Air Transportation System: 2010 and 2018–2023

Category	System	2010	2018	2019	2020	2021	2022	2023
U.S. airports	**TOTAL**	**19,802**	**19,627**	**19,636**	**19,919**	**20,061**	**19,969**	**20,031**
	Public use	5,175	5,099	5,080	5,217	5,211	5,193	5,179
	Private use	14,353	14,528	14,556	14,702	14,850	14,776	14,852
	Military	274	305	308	312	313	313	312
Aircraft	**TOTAL**	**230,555**	**219,224**	**218,609**	**210,024**	**215,009**	**216,392**	**217,275**
	General aviation aircraft	223,370	211,749	210,981	204,140	209,194	209,540	209,703
	Commercial aircraft	7,185	7,475	7,628	5,884	5,815	6,852	7,572
Pilots	Pilots (excluding student pilots)	508,469	465,513	466,900	469,062	470,408	476,346	490,470
Load factors	**TOTAL**	**81.92**	**83.57**	**84.53**	**58.42**	**73.53**	**82.85**	**83.17**
	Domestic flights	82.10	84.34	85.00	58.49	77.45	84.06	83.33
	International flights	81.52	81.71	83.38	58.15	58.86	79.49	82.77
Passenger enplanements	**TOTAL (thousands)**	791,804	1,016,814	1,056,118	402,670	703,453	941,278	1,057,407
	Enplanements on domestic flights	632,129	780,014	813,805	338,809	608,193	753,288	822,219
	Enplanements on international flights of U.S. carriers	108,270	111,910	115,552	34,800	60,773	103,083	122,904
	Enplanements on international flights of foreign carriers	51,405	124,890	126,761	29,062	34,487	84,907	112,284
Revenue passenger-miles	**TOTAL, U.S. carriers (millions)**	**809,068**	**1,017,000**	**1,061,006**	**383,920**	**692,557**	**953,019**	**1,083,059**
	Domestic (millions)	564,695	730,423	762,836	307,688	573,382	711,853	780,429
	International on U.S. carriers (millions)	244,373	286,577	298,170	76,232	119,175	241,166	302,630
Freight enplanements	**TOTAL (thousand tons)**	**14,733**	**17,652**	**17,788**	**19,110**	**20,836**	**19,939**	**18,457**
	Domestic (thousand tons)	10,422	12,494	12,828	14,081	14,899	14,112	12,948
	International on U.S. carriers (thousand tons)	4,311	5,158	4,960	5,028	5,937	5,826	5,509

Source: 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/data_research/aviation/aerospace_forecasts as of September 2024. RPM: USDOT, Bureau of Transportation Statistics (BTS), Office of Airline Information (OAI), T1/DB20 (Green Book). Available at www.transtats.bts.gov/ as of September 2024. Passengers and Freight Enplaned: USDOT, BTS, OAI, T-100 Market and Segment. Available at www.transtats.bts.gov/ as of September 2024.

Note: The number of airports changed from year to year due to the changes in the number of private airports. 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. The 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. Student pilots are excluded from the totals because of an FAA rule change that student pilot licenses never expire. Passenger enplanements are revised because of airline data corrections.

Figure 1-13 Enplanements at the Top 50 U.S. Airports: 2023



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 July 2024.

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 pavement condition is classified by the Federal Aviation Administration (FAA) as follows [BTS 2024f]

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

Over the last decade runway pavement conditions have been nearly constant. In 2022, 80 percent of pavements were 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 [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 [FAA 2022].

19 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.

The average age of U.S. commercial airline aircraft increased nearly 26 percent between 2020 and 2023, going from 14.0 to 17.7 years [BTS 2024j]. In 2023, the average aircraft age for the largest airlines (called majors[20]) was 17.4 years, up from 13.6 years in 2020. For the next level of airlines (called nationals[21]), the average aircraft age increased from 14.1 years in 2020 to 18.3 years in 2023. Regional airlines[22] also recorded an increase in average aircraft age, from 25.3 years in 2020 to 29.5 years in 2023. These increases in aircraft age across all airlines were largely due to reduced carrier revenues during the pandemic which greatly slowed expenditures on new equipment. No public data are currently available to indicate the condition of the aircraft fleet.

Performance

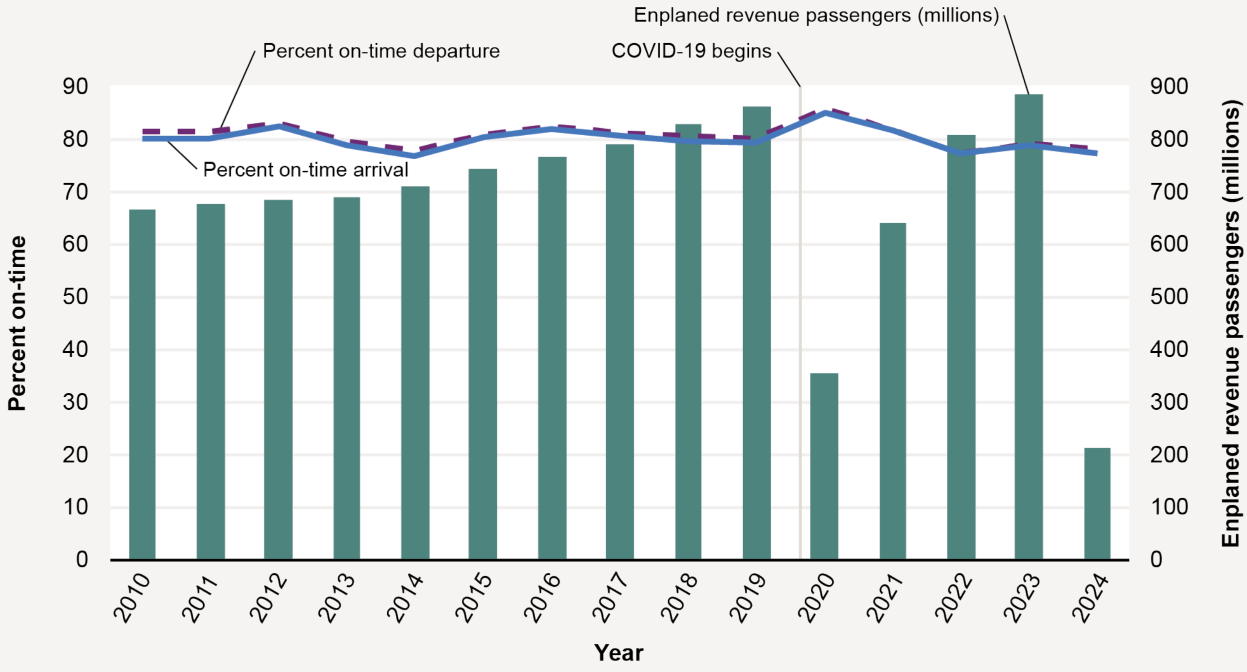
Aircraft Delays Exceed Prepandemic Levels

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 85 percent in 2020. As air traffic began to recover, on-time arrivals and departure values dropped, to 81 percent in 2021 and 77 percent in 2022, and have stayed at about that level through 2024.

In 2020, the U.S. Department of Transportation (USDOT) received 102,560 complaints about airline service from consumers, which was more than 6.5 times greater than the 15,342 complaints received in prepandemic 2019. Complaints dropped to 49,991 in 2021 but then increased to 86,240 in 2022 and 96,853 in 2023 [BTS 2024a]. The nature of the complaints ranges from flight problems, fares, ticketing, refunds and customer service, and disabilities (i.e., civil rights complaints by air travelers with disabilities).

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



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, On-Time Percent Arrivals and Departures and T-100 Market Data, available at www.transtats.bts.gov as of September 2024.

Note: 2024 data is through June. A flight is considered delayed when it arrived 15 or more minutes later than the scheduled arrival or departed 15 or more minutes later than the scheduled departure.

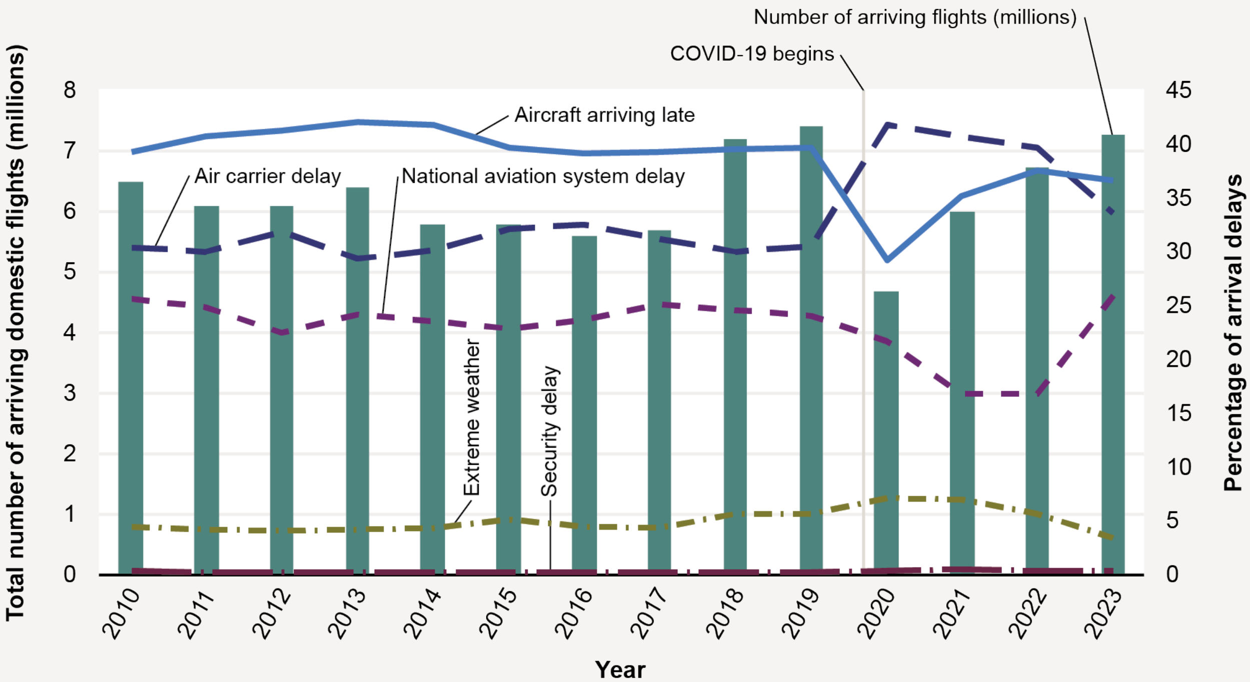
In 2022, the top-ranked complaints were as follows:

1. Flight Problems (Cancellations, Delay and Misconnection)
2. Baggage (Lost or Damage)
3. Refunds
4. Reservations
5. Fares

The causes of 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 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 37 percent in 2023 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 34 percent in 2023. 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, but was back up to 26 percent in 2023. Extreme weather as a cause of delay edged up from 4 percent in 2010 to 6–7 percent in recent years. Security issues have accounted for 0.1 to 0.3 percent of delays since 2010. In 2023, the flight cancellation rate in the U.S. was a record low at under 1.2%—the lowest rate of flight cancellations in over 10 years despite a record amount of air travel. These flight cancellations impacted an estimated 12.5 million passengers.

In 2023, more than 858 million people and 1.9 billion carry-on items passed through the Nation's airport security check points, and Transportation Security Administration (TSA) inspectors prevented 6,737 firearms (93 percent loaded) from being brought aboard aircraft [TSA 2024]. After the COVID-19 pandemic spread in 2020, TSA people screenings 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 (Figure 1-16). Passenger

Figure 1-15 Percent of Flight Delay by Delay Cause: 2010–2023



Source: U.S. 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 July 2024.

Note: 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). Aircraft Arriving Late—previous flight with same aircraft arrived late which caused the present flight to depart late. Security Delay—delays caused by evacuation of terminal or concourse, reboarding of aircraft because of security breech, inoperative screening equipment and long lines in excess of 29 minutes at screening areas. National Aviation System Delay—delays and cancellations attributable to the national aviation system refer to a board 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 judgement of the carrier, delays or prevents the operation of a flight.

screenings have steadily increased since 2020, and those in 2023 tracked closely the pattern of screenings in 2019. Passenger screenings through the first 6 months of 2024 exceed those for the first 6 months of prepandemic 2019. The 4-year recovery of air traffic is clearly shown in Figure 1-16.

Passenger Rail

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

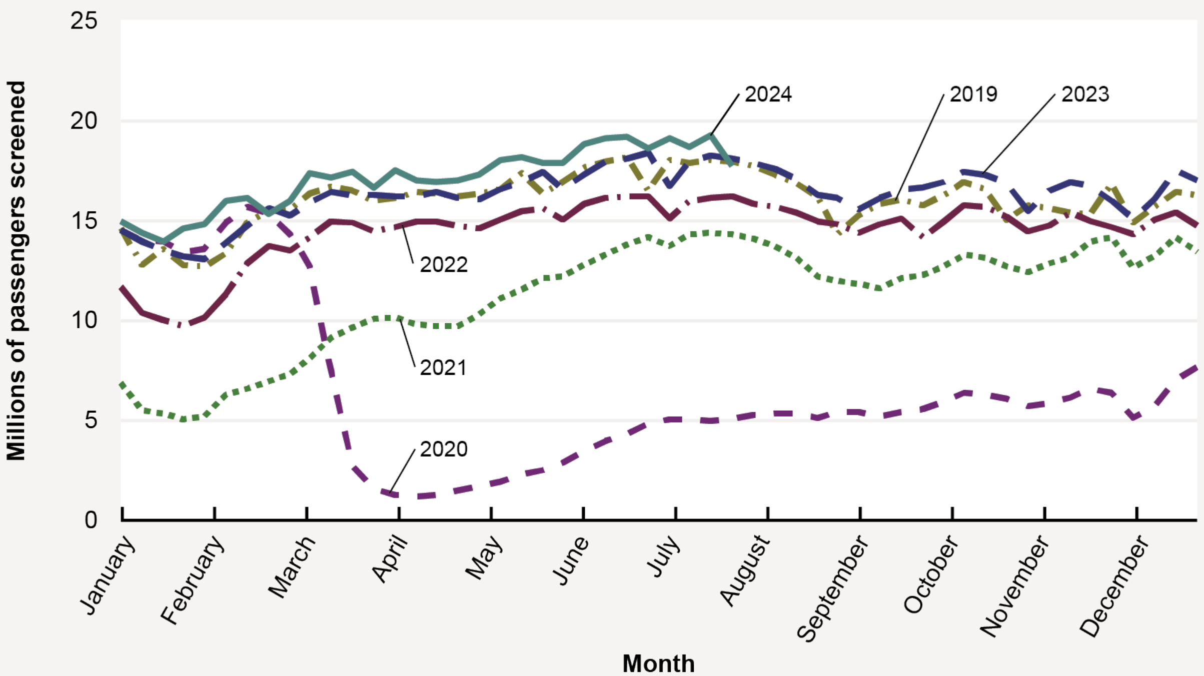
The National Railroad Passenger Corp. (Amtrak) is the primary operator of intercity passenger rail service in the United States. Amtrak operates 21,220 route-miles serving more than 500 destinations stations in 46 states, Washington, DC, and two Canadian provinces. The number of passengers went from 23 million in 2022 to 29 million in 2023, a significant increase but still below the prepandemic level of 32 million in 2019 (Table 1-4). In December 2024, Amtrak reported that its fiscal year 2024 ridership was at a record high with 32.8 million passengers.

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 fiscal year 2023, Amtrak carried more than three times as many riders between Washington and New York City as all the airlines combined for the same route, and more than all the airlines combined between New York City and Boston. Other city-pair markets where Amtrak carried more passengers than the airlines included Seattle–Portland, St. Louis–Kansas City, Los Angeles–San Diego, and Chicago–Milwaukee [Amtrak 2024].

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 fiscal year 2019 totaled 32 million, which reflects a downward adjustment by the corporation from an earlier estimate, compared to 12.2 million in fiscal year 2021. This was a 62 percent reduction in total ridership between 2019 and 2021. More than 28 million people rode Amtrak nationwide during fiscal year 2023, a 24.6 percent increase over the same period in 2022. However, it is still short of prepandemic number of 32 million annual riders set in 2019 [Amtrak 2024]. As noted previously, fiscal year 2024 ridership was nearly 33 million passengers, which did exceed the ridership in 2019.

Figure 1-17 depicts where people ride Amtrak in the United States. The heaviest ridership is in the NEC between Boston

Figure 1-16 Average Daily Number of People Screened at TSA Checkpoints by Week: 2019–2024



Source: U.S. Department of Transportation, Bureau of Transportation Statistics Administration, COVID-19 Transportation Statistics, as of August 2024.

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

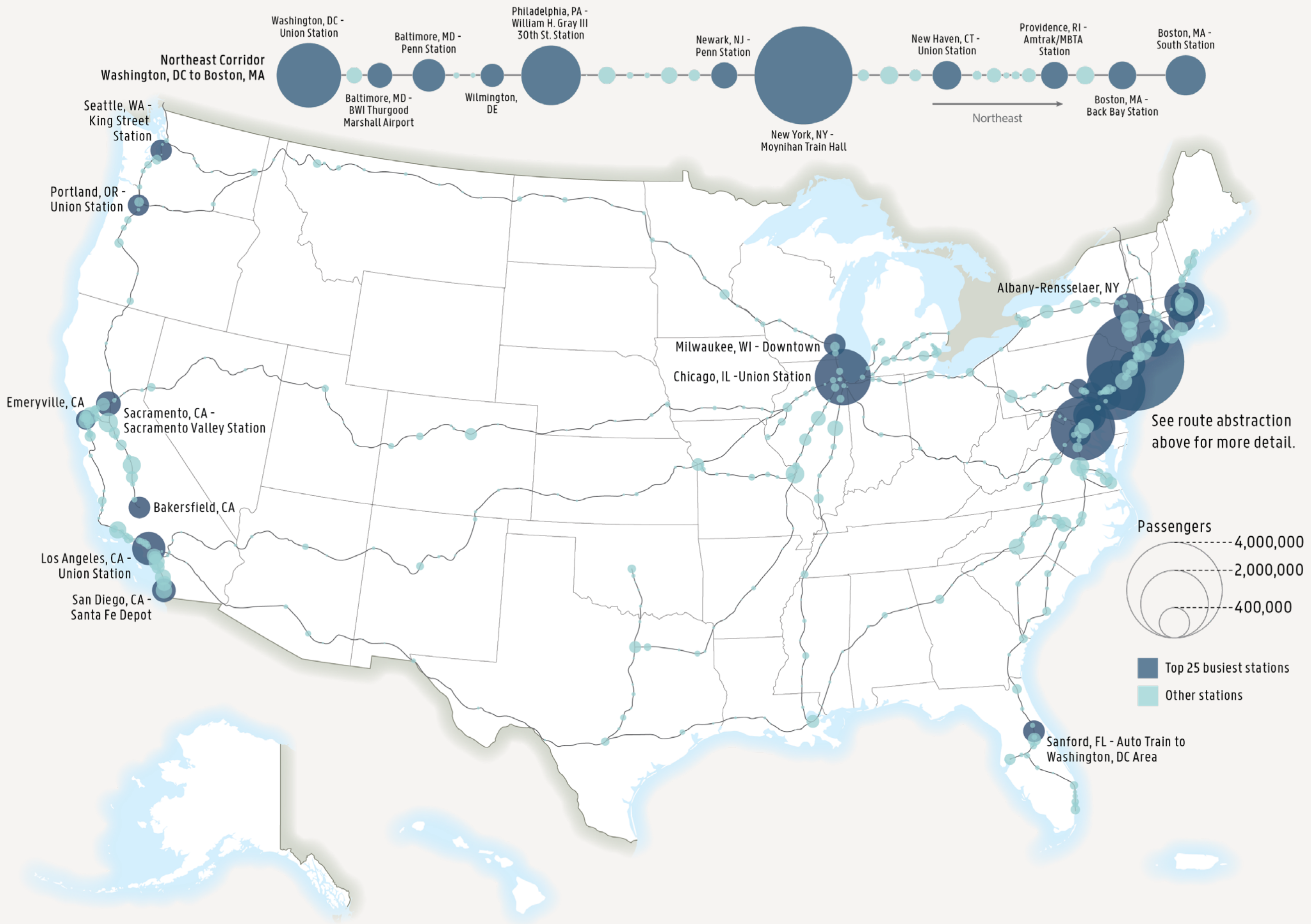
Equipment and mileage operated by Amtrak	2010	2018	2019	2020	2021	2022	2023
Locomotives	282	431	403	384	395	391	—
Passenger cars	1,274	1,403	1,415	1,313	1,529	1,449	—
System mileage	21,178	21,407	21,407	20,787	21,124	21,220	—
Stations	512	526	526	526	526	528	528
Passengers (millions)	28.7	31.7	32.0	16.8	12.2	22.9	28.5
Passenger-miles traveled (millions)	6,420	6,361	6,487	3,450	2,860	4,888	5,826

Source: 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 August 2024.

Note: 2023 data are estimated. Fiscal year ending in September.

— Data not available at time of publication.

Figure 1-17 Busiest Amtrak Stations: 2023



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 September 2024.

and Washington, DC. Ridership is also high around Chicago as well as at several locations in California and the Pacific Northwest. In fiscal year 2023, the busiest Amtrak Station was Penn Station in New York City (10.2 million passengers) followed by Union Station in Washington, DC (4.8 million passengers), and Philadelphia's 30th Street Station (4.2 million passengers).

Amtrak Condition

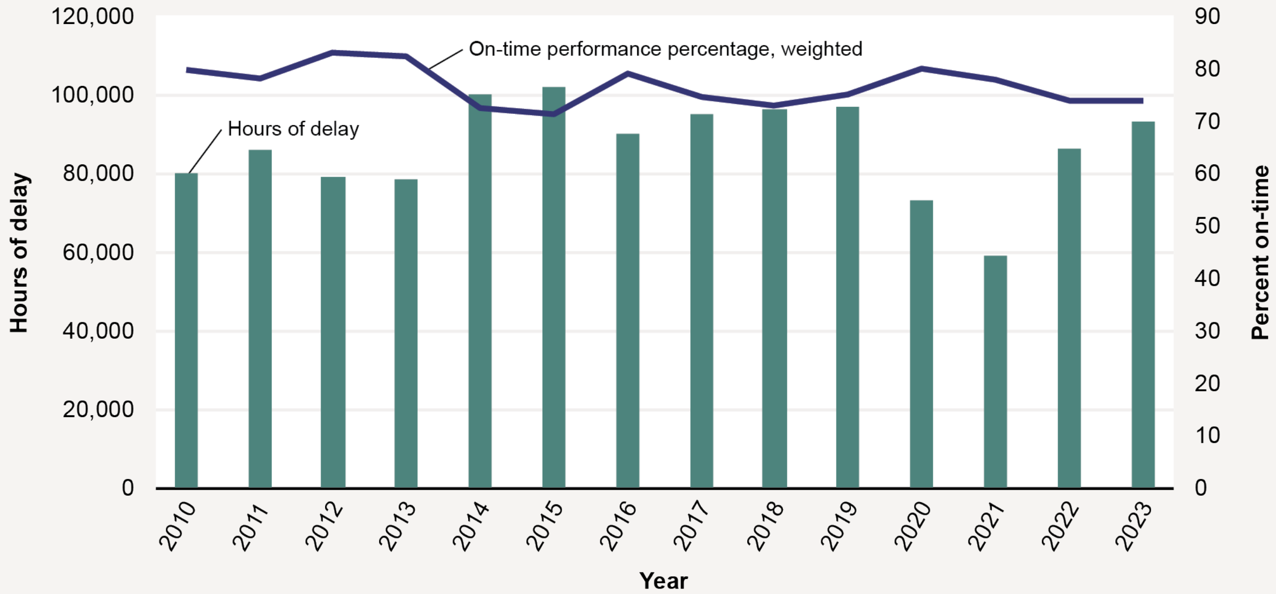
Amtrak owns 363 route-miles in the NEC plus three other shorter segments in the following corridors: New Haven, CT–Springfield, MA; Harrisburg, PA–Philadelphia, PA; and Porter, IN–Kalamazoo, MI [Amtrak 2023]. Most passenger train services outside the NEC are provided over tracks owned by and shared with Class I (the Nation's largest) freight railroads—about 71 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 fiscal year 2023 was 18.4 years, which is 0.8 years lower than in the previous year due to deliveries of new diesel locomotives. The average age for Amtrak passenger cars was 33.3 years, 1 year less than in fiscal year 2022 but 7.7 years more than in 2010 [BTS 2024f]. The increasing average age of the fleet has had an impact on fleet availability and vehicle reliability. The Federal Infrastructure Investment and Jobs Act 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 (FRA) 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 2024].

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 previously (Figure 1-18). Delay dropped again in 2021, to 59,000 hours, in line with the continued decline in ridership. In 2023, delays rose to 93,000 hours as rail passenger traffic increased. The percentage of systemwide on-time arrivals improved from 73 percent in 2018 to 80 percent in 2020, but declined to 74 percent in 2022 and 2023. 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, but then dropped to 78 percent in 2023. On-time arrivals on routes longer than

Figure 1-18 Hours of Delay and On-Time Performance of Amtrak: 2010–2023



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 August 2024.

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.

750 miles have ranged from 44 to 59 percent since 2019, and were 53 percent in 2023 [BTS 2024f].

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 [BTS 2024f].

Freight Railroads

New Efficiencies Help Railroads Carry More Cargo in Fewer Cars

The United States had 136,429 railroad route-miles in 2022, including 91,285 miles owned and operated by the six Class I freight railroads [AAR 2023].[24] About 620 local and regional railroads operated the remaining 45,144 miles. In 2022, Class I railroads provided freight transportation using 23,184 locomotives (Table 1-5) and 1.63 million railcars [AAR 2023]. Average freight car capacity was about 102 tons in 2010 and gradually increased over the decade to 105 tons in 2022 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 2023]. As compared with 2019, rail carloads were down 13 percent, revenue ton-miles down 10.8 percent, and total operating revenue down 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 through 2023 (Figure 1-19) were at about 92 percent of the totals for the same months in 2019. For the first 6 months of 2024 carloads were quite a bit lower, but appear to be reverting to that same pattern for the second half of the year.

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 of 2020 through the 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. In 2023, intermodal was again about 10 percent below traffic in 2019 for most of the year, but is tracking 2019 again through the first 8 months of 2024 [BTS 2024g].

Over the past 60 years, Class I railroads and connecting facilities have developed increasingly efficient ways to carry

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 $1.03 billion in 2022 (the latest year for which data are available). It includes BNSF Railway, CSX Transportation, Grand Trunk Corp. (Canadian National operations in the United States), Canadian Pacific Kansas City, Norfolk Southern, and Union Pacific. Amtrak is also classified as a Class I railroad.

Table 1-5 Rail Transportation System: Fiscal Years 2010 and 2018–2022

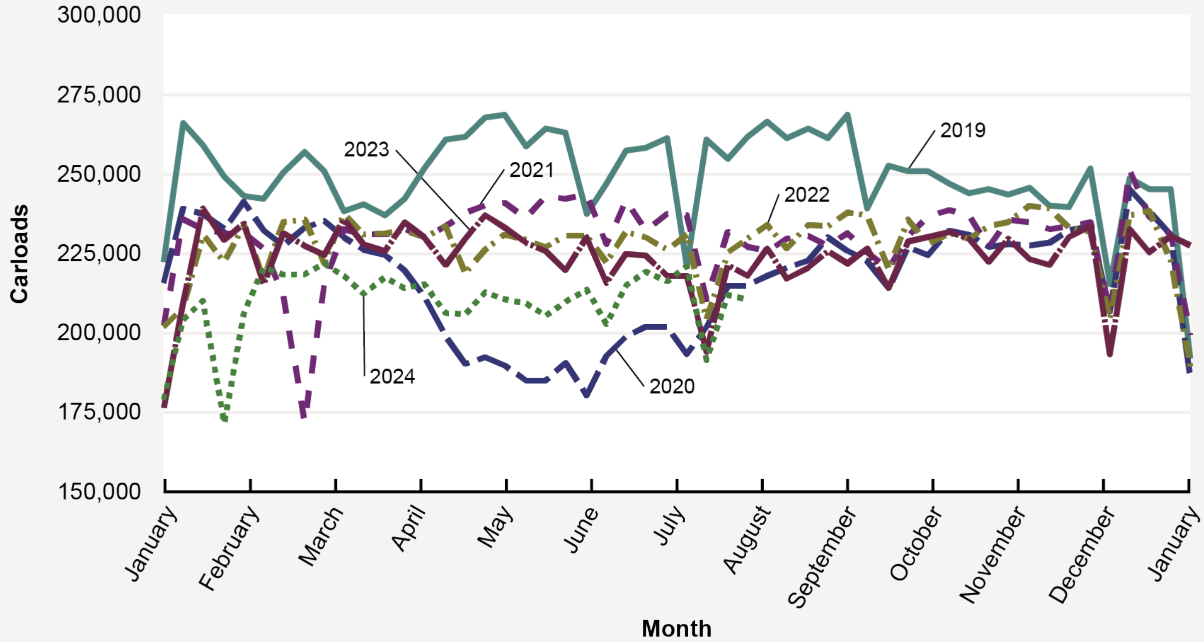
Category	System	2010	2018	2019	2020	2021	2022
Equipment and milage operated by Class I	Locomotives	23,893	26,086	24,597	23,544	23,264	23,184
	Freight cars in service (million)[a]	1.57	1.66	1.67	1.68	1.66	1.63
	Average freight car capacity (tons)	101.7	104.6	103.3	105.1	104.9	105.3
	System mileage	95,700	92,837	92,282	91,773	91,651	91,285
	Revenue ton-miles (trillion)	1.69	1.73	1.61	1.44	1.53	1.53
Capital expenditures (billion dollars)	Roadway and structures	7.86	9.33	9.09	8.35	7.93	8.86
	Equipment	1.91	3.08	3.88	2.46	2.31	2.57
TOTAL		**9.77**	**12.41**	**12.97**	**10.81**	**10.24**	**11.43**

Source: Class I railroads-Locomotives 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 August 2024. Freight cars in service and Capital expenditures: Association of American Railroads, Railroad Facts (Annual issues), as of August 2024.

Note: Fiscal years end in September.

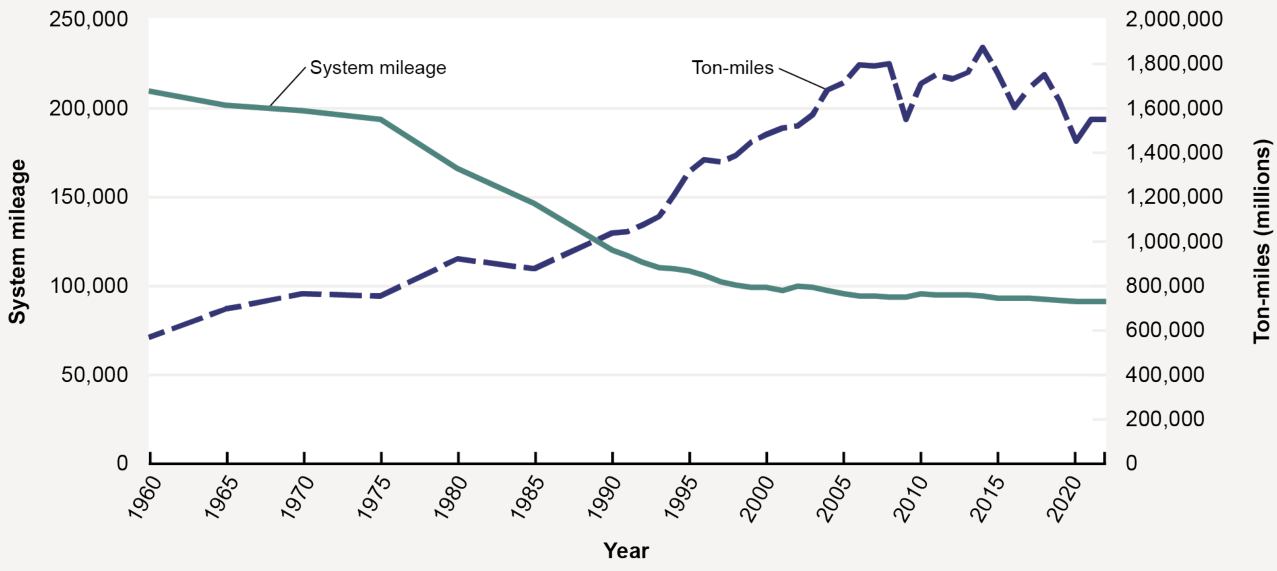
[a] Includes totals for Canada and Mexico.

Figure 1-19 U.S. Total Rail Nonintermodal Carloads by Week: 2019–2024



Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Supply Chain Indicator, available at https://www.bts.gov/freight-indicators#carloads as of December 2024.

Figure 1-20 Class I Railroad System Mileage and Ton-Miles of Freight: 1960–2022



Source: Association of American Railroads, Railroad Facts, Statistical Highlights (Washington, DC; annual issues), available at www.aar.org as of August 2024.

Note: Data include every 5 years until 1970. Data are yearly thereafter.

and transfer cargo (e.g., larger cars as noted previously, double-stack container railcars, longer trains, and on-dock rail), allowing more cargo to be carried with fewer railcars and locomotives. 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 previously, but railroads continue to carry more ton-miles per system mile than they did 30 years ago.

The railroads, which are private companies, invested more than $11 billion in 2022 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 tracks and perform necessary repairs to ensure safety. FRA regulations require railroads to maintain track inspection records and make them available to FRA or state inspectors on request. The FRA's rail safety audits focus on regulatory compliance, prevention, and correction of track defects.

FRA publishes an annual enforcement report, summarizing the civil penalty claims for violations. In fiscal year 2023, FRA inspectors or other railroad regulators reported 307 track safety standards violations, down 28 percent from 2022—about half the number in 2021 and one-quarter of the number in 2018 [FRA 2023].

Ports and Waterways

About 8,500 water transportation facilities existed in the United States in 2022 (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 2022, there were more than 45,500 U.S.-flagged maritime vessels operating on the waterways, an increase of 6.7 percent since 2010 (Table 1-6). Registered recreational boats have numbered about 12 million since 2010.

From 2010 to 2022, waterborne commerce (Table 1-6) increased by only 1.2 percent. Domestic tonnage decreased by 15 percent over that period, and foreign tonnage increased by 11 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 2022 waterborne commerce had recovered to the same level as 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 and 2024 (refer to Chapter 3 Freight and Supply Chain).

Waterway Condition and Performance

Time Delays at Navigation Locks Increase Three-Fold

The U.S. Army Corps 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 233 million cubic yards in fiscal year 2022. Seventy-nine percent of this removal was done for navigational maintenance purposes [USACE 2024].

Table 1-7 shows performance metrics for the 237 lock chambers at 192 lock sites for which the 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].

25 While some line segments have been abandoned, many former Class I miles have been sold or leased to non-Class I railroads [AAR 2023].
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: 2010 and 2018–2022

Category	System	2010	2018	2019	2020	2021	2022
Infrastructure	Waterway facilities (including cargo handling docks)	8,060	8,237	8,250	8,334	8,276	8,471
	Ports (handling over 250,000 tons)	178	181	185	192	208	204
	Miles of navigable waterways	25,000	25,000	25,000	25,000	25,000	25,000
	Lock chambers	239	239	237	237	237	237
	Lock sites	193	193	192	192	192	192
U.S. flag vessels	**TOTAL, commercial vessels**	**42,681**	**43,170**	**43,752**	**44,548**	**44,756**	**45,527**
	Barge/nonself-propelled vessels	31,906	33,266	33,600	34,209	34,364	35,004
	Self-propelled vessels	10,775	9,904	10,152	10,339	10,392	10,523
	Recreational boats, millions	12.4	11.9	11.9	11.8	12.0	11.8
Waterborne commerce	**TOTAL (million tons)**	**2,335**	**2,438**	**2,364**	**2,226**	**2,347**	**2,363**
	Domestic	894	849	818	743	760	760
	Foreign	1,441	1,589	1,545	1,483	1,587	1,603

Source: 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 https://www.iwr.usace.army.mil/About/Technical-Centers/WCSC-Waterborne-Commerce-Statistics-Center-2/ as of August 2024. Recreational boats: U.S. Department of Homeland Security, U.S. Coast Guard, Recreational Boating Statistics as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, Table 1-11, available at http://www.bts.gov/ as of August 2024. Waterways Locks, Facilities, and Vessels: U.S. Army Corps of Engineers, Institute for Water Resources, available at https://ndclibrary.sec.usace.army.mil/searchResults?series=Fact%20Cards as of August 2024. The U. S. Coastal and Inland Navigation System - 2022 Transportation Facts & Information (Annual issues), as cited in U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, tables 1-1 and 1-11, available at http://www.bts.gov/ as of August 2024.

Note: 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.

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

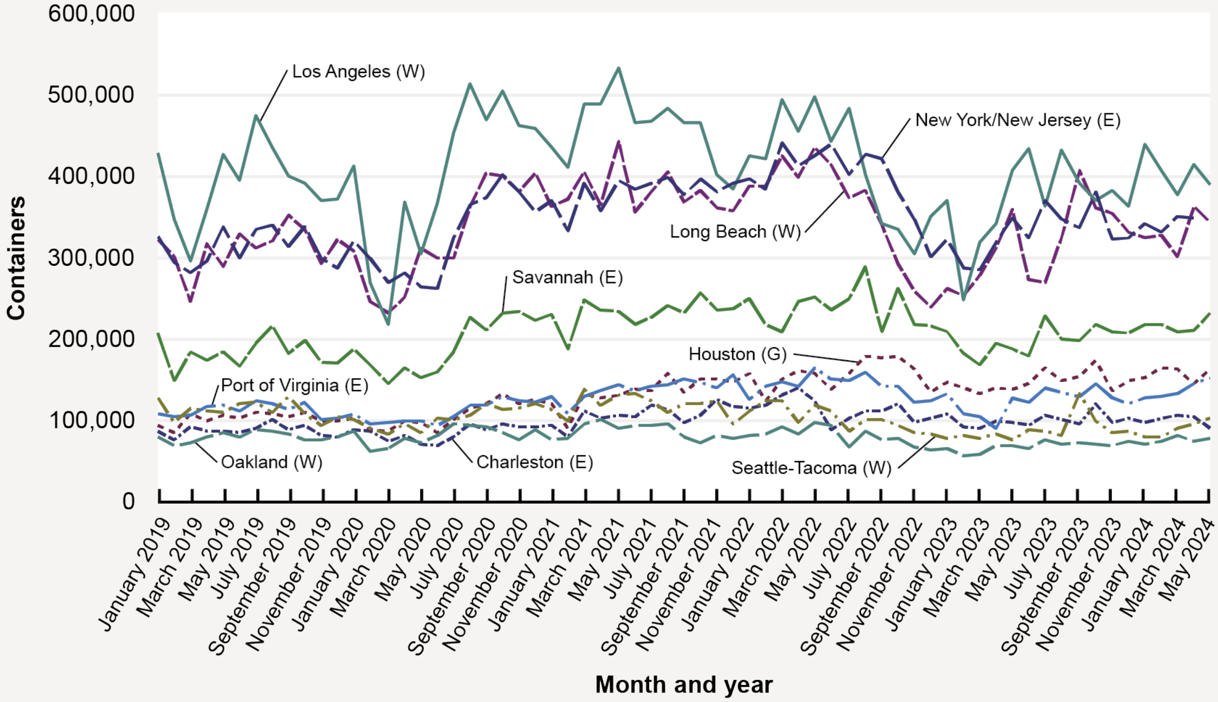
Year	Total lockages	Total number of vessels	Percent commercial lockages of all lockages	Average delay in minutes	Percent of vessels delayed
2010	641,846	855,121	74.5	79.8	36.0
2018	563,442	722,929	78.9	210.1	50.0
2019	506,838	662,314	78.7	246.9	52.0
2020	497,285	638,602	77.2	172.2	46.8

Source: 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 August 2024.

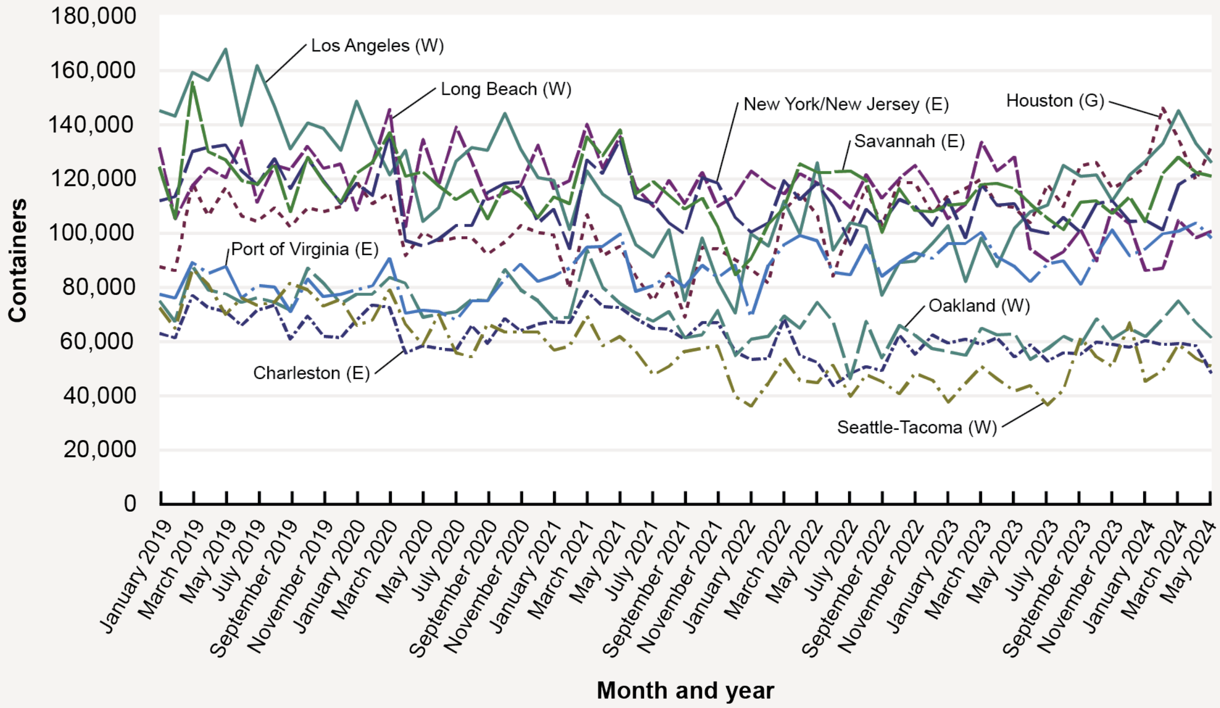
Note: A lockage is the movement through the lock by one or more vessels or extraneous matter (manatees, debris, ice, etc.) through a single lock cycle. Commercial lockage's are all those that service vessels operated for purposes of profit and include freight and passenger vessels.

Figure 1-21 Loaded Containers at Select Ports: 2019–2024

A. Import Containers



B. Export Containers

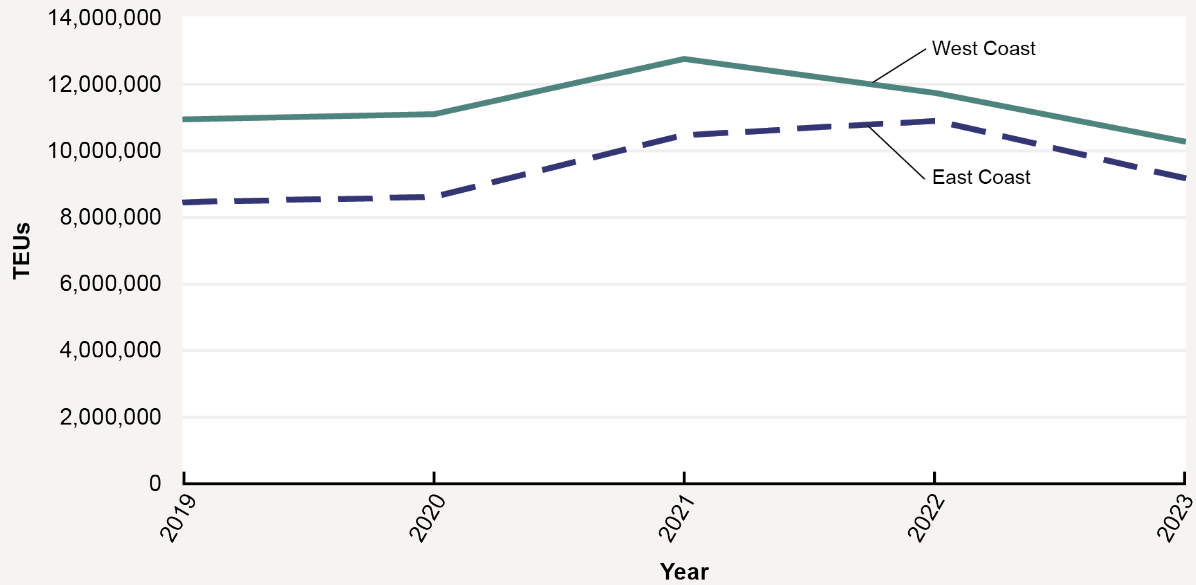


Source: Reprinted from U.S. Department of Transportation, Bureau of Transportation Statistics, Supply Chain and Freight Indicators Dashboards, available at https://www.bts.gov/freight-indicators#loaded-import as of August 2024; U.S. Department of Transportation, Bureau of Transportation Statistics, Supply Chain and Freight Indicators Dashboards, available at https://www.bts.gov/freight-indicators#loaded-export as of August 2024.

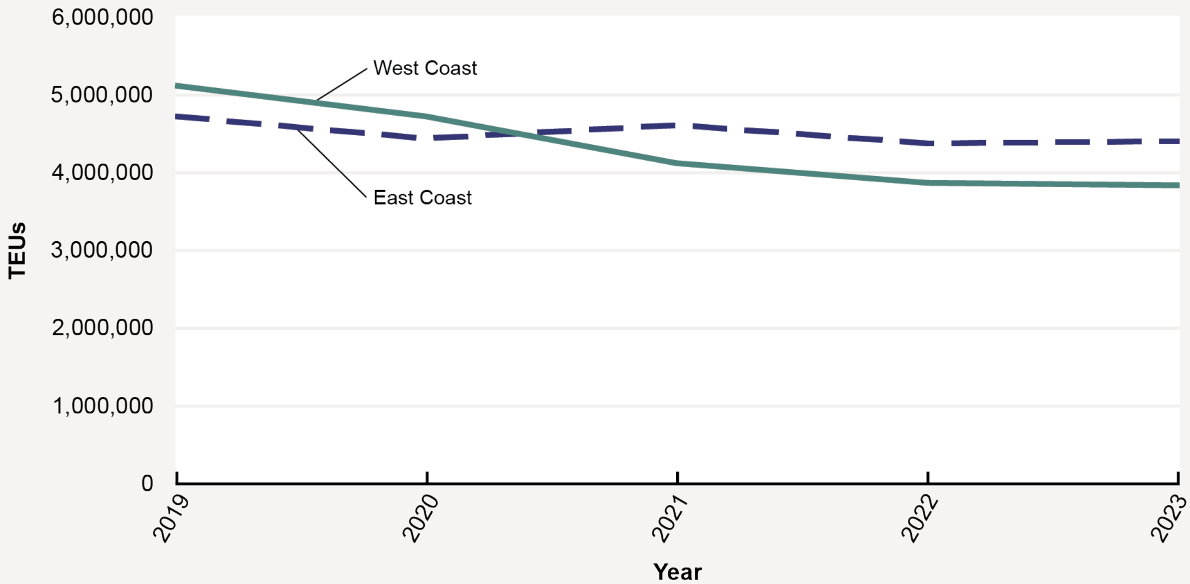
E = East Coast; W = West Coast; G = Gulf Coast.

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

A. Imported TEUs



B. Exported TEUs



Source: 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 August 2024.

Note: East Coast ports include the Port of Charleston, SC, Port of New York/New Jersey, Port of Virginia, and Port of Savannah. West Coast ports include the Port of Long Beach, Port of Los Angeles, Port of Northwest Seaport Alliance (Seattle/Tacoma), and the Port of Oakland.

TEU = twenty-foot equivalent unit.

Ports

A total of 204 ports handled at least 250,000 short tons annually in 2022 (Table 1-6). The top 25 U.S. ports by tonnage handled 69 percent of the short tons in 2021 [BTS 2024h]. The average 2022 dwell time of container vessels at the top 25 U.S. container ports was 34.6 hours, up 2.6 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.

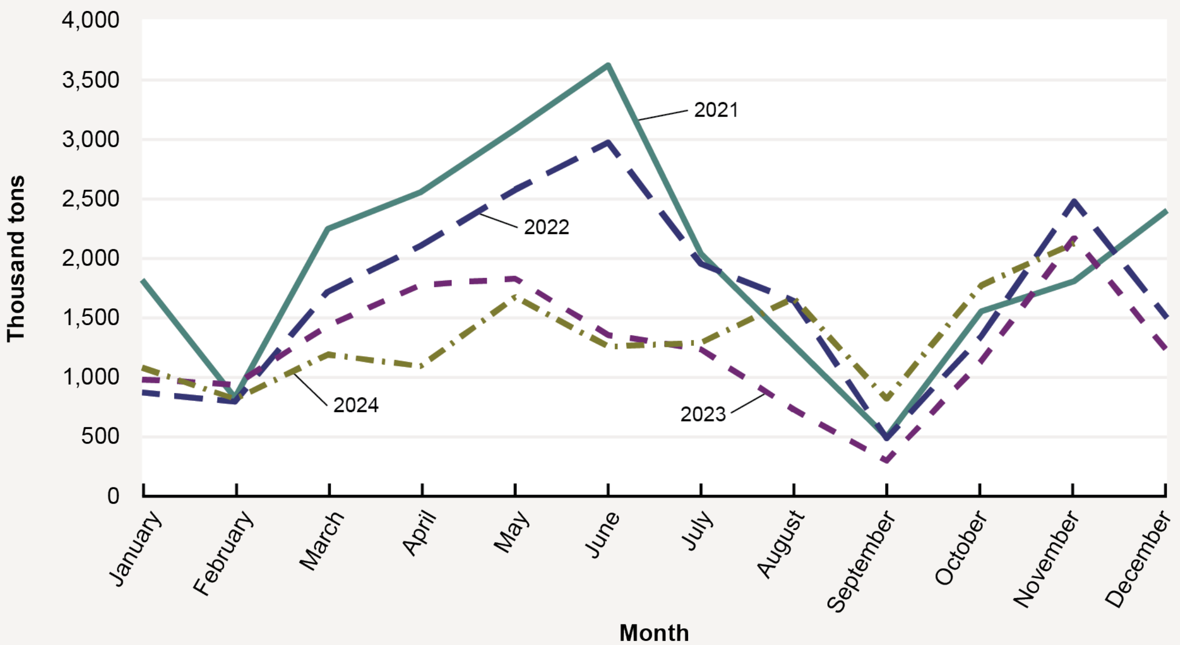
From 2019 to 2024, there has been a shift in the top 10 ports' market share of twenty-foot equivalent units (TEUs) when comparing the busiest U.S. East Coast ports to the busiest U.S. West Coast ports (Figure 1-21). The specific ports included here are the ports of Charleston, New York and New Jersey, Virginia, and Savannah for the east coast. For the West Coast, the ports included are 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), these are the top six ports representing 79 percent of total loaded TEU cargo for all U.S. ports, 44 percent were shipped to East Coast ports in 2019 and that percentage increased to 47 percent in 2023. For containerized exports (Figure 1-22B), 48 percent were shipped from East Coast ports in 2019 and that percentage increased to 53 percent in 2023.

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, 2023, and 2024 the 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 2024, downbound (southbound) grain shipments from the Upper Mississippi through Lock and Dam 27 near Granite City, IL, were even lower than the 2023 pattern, as shown in Figure 1-23.

Figure 1-23 Monthly Downbound Barge Grain Tonnage at Mississippi Lock and Dam 27: 2021–2024



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 2024.

Unfortunately, low water has again coincided with the peak shipping season for U.S. export crops. The downbound grain and agriculture product shipments on the Lower Mississippi below Lock and Dam 27 near Granite City, IL, are predominately soybeans and corn, leaving those major export commodities most vulnerable to the Lower Mississippi River disruption [USDOA 2024].

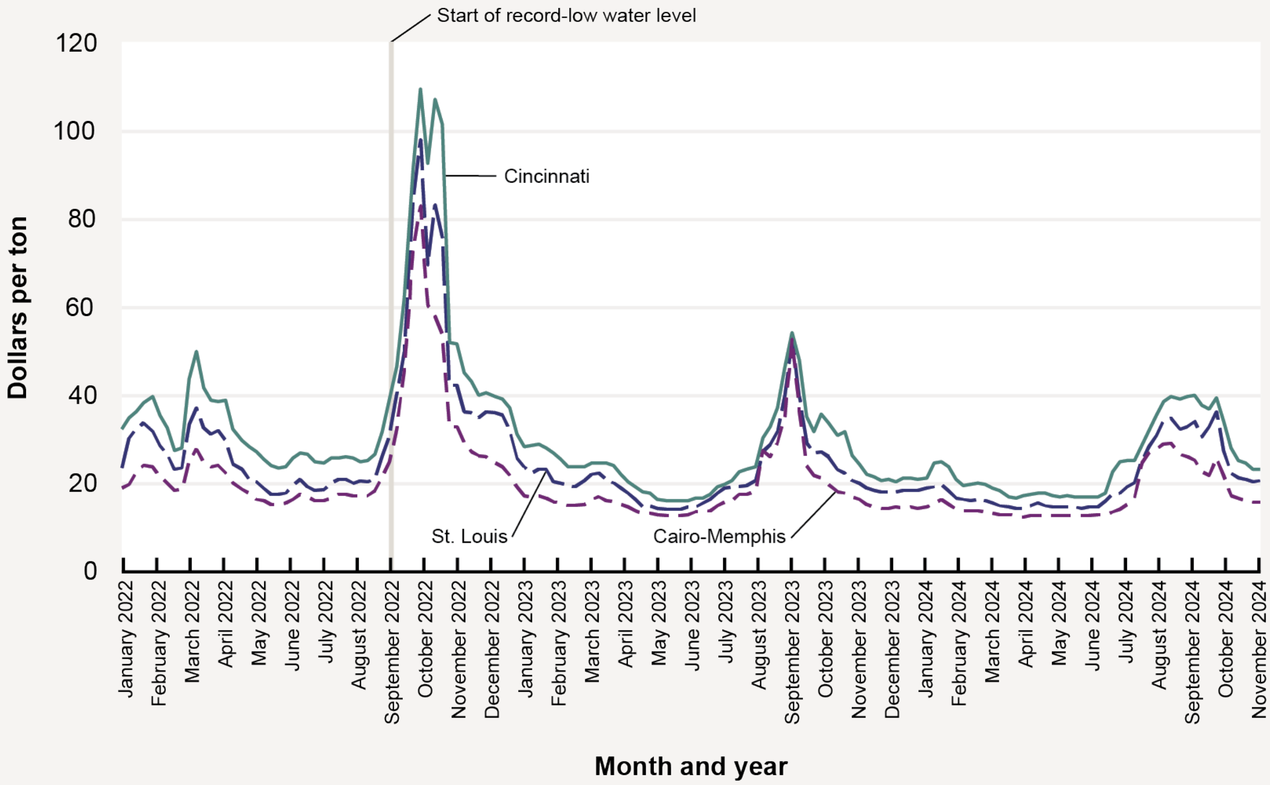
The implications are apparent in barge shipping rates. By early September 2022, barge rates were at record highs. Downbound grain rates on the Mississippi in October 2022 rose to more than double the 2021 peak and remained high in early November of that year [USDOA 2024]. As shown in Figure 1-24, the seasonal pattern of grain barge rates has been similar for these past three low-water years, with markedly higher rates in the fall due to the combination of high demand and light loading of barges.

U.S.-Flagged Vessels

The USACE classifies U.S.-flagged vessels primarily as self-propelled vessels or nonself-propelled vessels.[28] The age distribution of the self-propelled versus the nonself-propelled fleets is notable (Figure 1-25), with 60 percent of the self-propelled fleet over 25 years of age, while 31 percent of the nonself-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.

28 Self-propelled vessels include dry cargo, tanker, and offshore supply vessels, ferries, and tugboats and towboats. Nonself-propelled vessels primarily include barges.

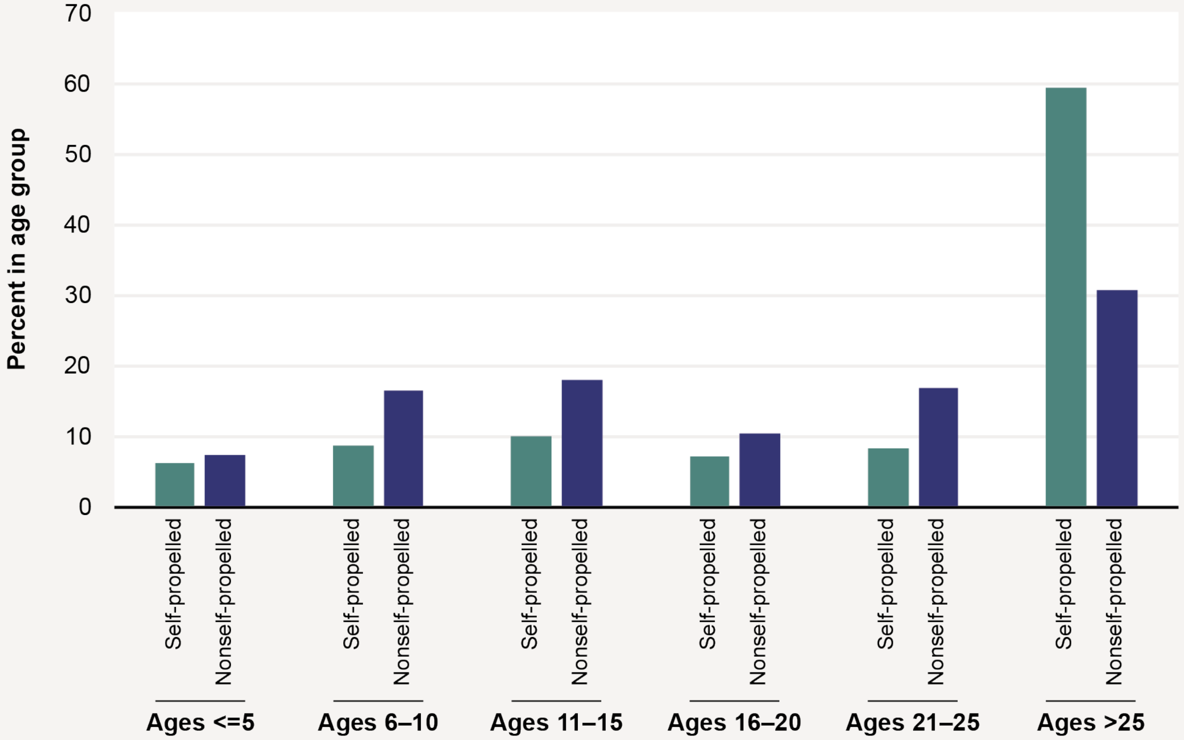
Figure 1-24 Weekly Downbound Grain Barge Rates: January 2019–December 2024



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, analysis based upon Downbound Grain Barge Rates (12/01/24), Latest Supply Chain Indicators, available at http://www.bts.gov as of December 2024.

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). Shown are St. Louis; Cincinnati, along the middle third of the Ohio River; and Cairo-Memphis from Cairo, IL, to Memphis, TN. Low water tends to happen in the late summer to early fall months.

Figure 1-25 Number of U.S.-Flagged Vessels by Age Group and Propelled Type: 2022



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://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll2/id/14463 as of July 2024.

Note: Self-propelled includes 10,497 vessels and nonself-propelled includes 34,962 vessels.

Ferries

Based on those ferry operations that responded to the biennial National Census of Ferry Operators in 2022 [BTS 2024b], a reported total of 102.3 million passengers and 24.2 million vehicles were transported by ferry in 2022. Washington and New York, the top two states for total passenger boardings, reported transporting a combined total of 46.8 million passengers (23.6 and 23.2 million passengers, respectively), a decrease of 32 percent since 2019 (Figure 1-26). Ferry operators in Washington state alone transported about 58 percent of all reported vehicles by ferry (10.8 million vehicles) in 2022. These traffic levels are substantially below those reported for the prepandemic year of 2019.

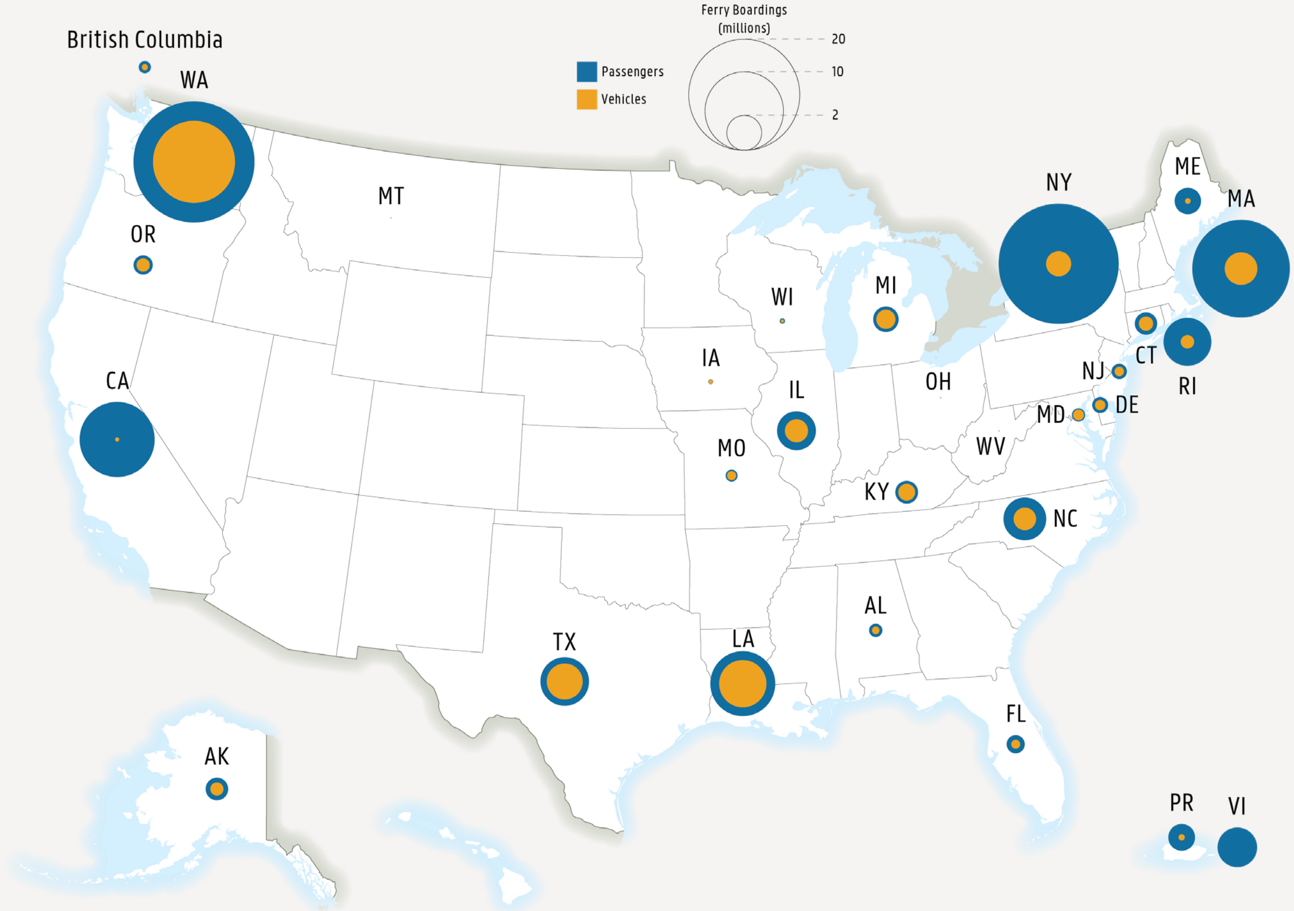
A ferry segment is the direct route that the boat takes between two terminals with no intermediate stops. The assigned state of the segment is that of the origin terminal. The reported ferry segments were concentrated in the northeast, on the west coast, and in Alaska. Nearly half (49.5 percent) of the total reported ferry segments came from just the top five states—New York (134 segments), Alaska (127 segments), California (99 segments), Washington (72 segments), and Michigan (48 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 2023, natural gas was transported via about

Figure 1-26 Ferry Passenger and Vehicle Boardings: 2022



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, National Census of Ferry Operators, available at https://www.bts.gov/NCFO as of November 2024.

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

412,000 miles of gathering[29] and transmission[30] pipelines and more than 1.4 million miles of distribution lines[31] [BTS 2024f]. These pipelines connect to 71 million households and 5 million commercial and industrial users [AGA 2024].

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 228,000 miles of crude/refined oil and hazardous liquid pipelines in 2023, up 276 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 3.9 billion barrels in 2023, exceeding the 2019 shipments by 5 percent [BTS 2024f].

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.
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].

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 [BTS 2024d]. Of this 61 percent, 46 percent connect to one other mode, 11 percent connect to two other modes, and 4 percent connect to three or more other modes (e.g., bus, air, rail, ferry, or bikeshare).

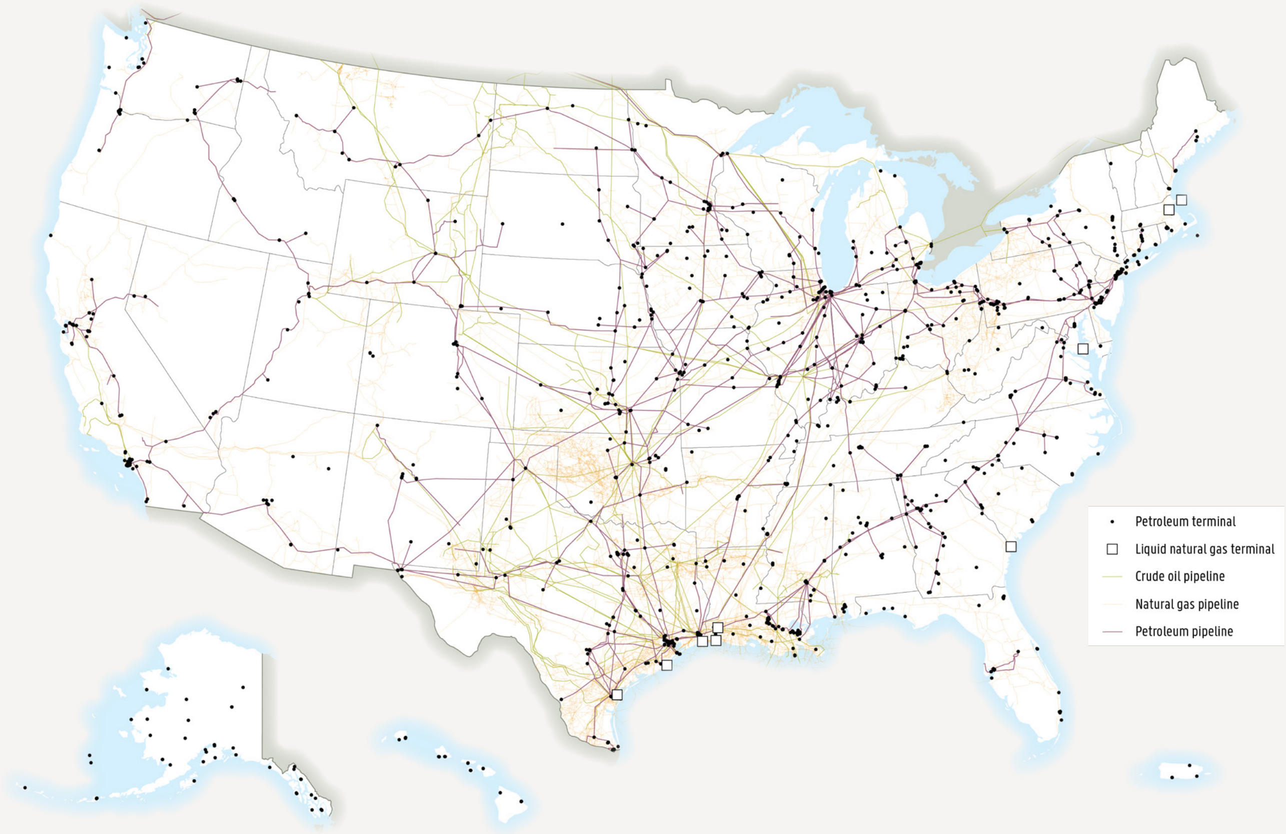
After bikeshare, the transit modes that have the highest percent of intermodal connections are heavy rail transit (approximately 89 percent of 1,043 facilities), commuter rail (71 percent of 1,167 facilities), and light rail transit (67 percent of 1,554 facilities) (Figure 1-28). Of the intercity modes,[33] 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).

33 These include intercity rail, bus, and ferries.

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, some of which are already being demonstrated in test cities (primarily in California and Arizona) without the use of on-board safety drivers. The *Transportation Statistics Annual Report 2022* [BTS 2022] provided a detailed discussion of autonomous vehicle development, and a portal into the latest USDOT

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 http://www.bts.gov as of November 2024.

Figure 1-28 Intermodal Passenger Facilities by Mode: 2022

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Intermodal Passenger Connectivity Database. Available at http://www.bts.gov as of August 2024.

Note: 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.

activities in support of vehicle automation is available at https://highways.dot.gov/automation. As such, connected vehicle technology has recently drawn attention on a number of fronts. For example, in February of 2024 the National Highway Traffic Safety Administration issued a report to Congress on vehicle-to-pedestrian research efforts focused on incorporating bicyclists and other vulnerable road users into the safe deployment of connected vehicle systems [NHTSA 2024]. Further, In September of 2024, the White House announced strong action to protect America from the national security risks associated with connected vehicle technologies from countries of concern [White House 2024].

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 2024]. Analysis of the Disengagement Report for 2023 shows that 21 companies doing autonomous vehicle testing in California operated their test vehicles for a total of 5,801,675 miles in autonomous mode and encountered

BOX 1-A

TRANSPORTATION VULNERABILITY AND RESILIENCE DATA PROGRAM

In 2023, the U.S. Department of Transportation's Bureau of Transportation Statistics launched the Transportation Vulnerability and Resilience (TVAR) Data Program. TVAR aims to provide data and tools to help local and state agencies assess and respond to natural, manufactured, and cybersecurity threats to transportation infrastructure. The TVAR program responds to the Transportation Research Board's 2021 Consensus Study Report, which recommended the development and dissemination of data and tools to support decision-making for infrastructure resilience.

6,570 disengagements, resulting in a mean distance of about 883 miles between disengagements [Herger 2024]. This is 22 percent better than the previous year, and a remarkable improvement over the average of 14 miles experienced in 2018. The better performing autonomous vehicles did markedly better than average in 2023. The top five performing companies' vehicles all drove at least 17,000 miles between disengagements, and the top performer operated their vehicles over 58,000 miles without a single reported disengagement.

Automation Beyond Highways

Autonomous vehicle development is not limited to highways. The Federal Transit Administration (FTA) has a Transit Automation Research Program [FTA 2024b] with a significant focus on transit bus automation. The maritime industry is investigating port automation and autonomous vessels. Railroads are building on long-standing experience with Automatic Train Control (ATC) to implement Positive Train Control (PTC)[34] systems, which are fully implemented and operating network-wide on 100 percent of Class I PTC route miles [AAR 2024]. Pipeline operators are also building on experience with instrumented capsules (sometimes called smart pigs) and supervisory control and data acquisition (i.e., SCADA) systems to develop new technologies to detect leaks and inspect and repair lines [PHMSA 2022]. Even autonomous civil aircraft are on the horizon, with air cargo likely the first application [Kelleher 2023].

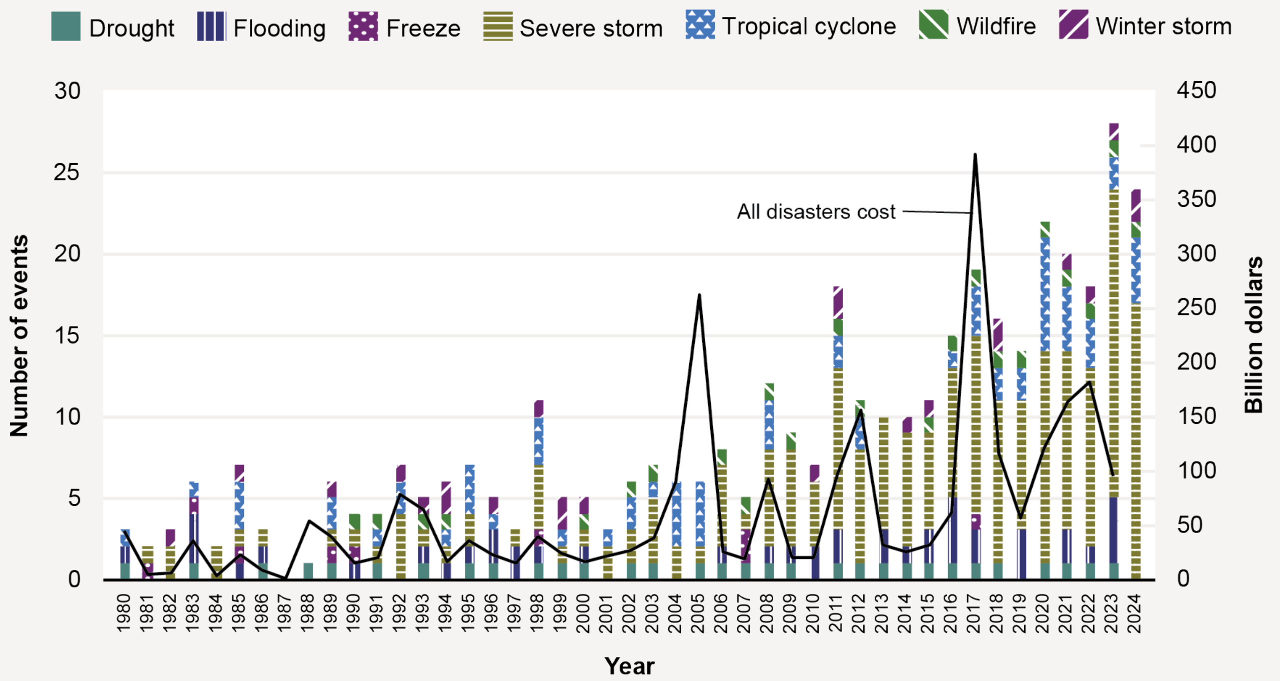
System Resiliency

Twenty-Eight Natural Disasters of a Billion Dollars or More Occurred in 2023

The U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA) tracks weather and climate disasters, including hurricanes, tornadoes, floods, droughts, and wildfires, in which overall damages reach or exceed $1 billion. In 2023, there were 28 of these events, which, is the highest number on record. These events included 2 tropical cyclones, 19 severe storms, 4 floods, and 1 each related to winter storms, drought, and wildfires [NOAA 2024]. The 28 events cost the Nation a combined $93 billion

34 Mandated by Congress as part of the Rail Safety Improvement Act of 2008, PTC is a set of technologies that prevent the most serious human-error accidents, like train-to-train collisions and over-speed derailments [AAR 2024]. These systems determine the precise location, direction, and speed of trains and warn train operators of potential problems and safely bring the train to a stop if the operator does not act.

Figure 1-29 U.S. Billion-Dollar Disaster Events: 1980–2024



Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, U.S. Billion-Dollar Weather and Climate Disasters (2024). Available at https://www.ncei.noaa.gov/access/billions/ as of November 2024.

Note: 2024 data are through October.

in damages. In the first 10 months of 2024, there were 24 such events, with an aggregate cost exceeding $60 billion.[35] As shown in Figure 1-29, over the past 2 decades the number and severity of these disasters have been increasing at an accelerated rate, driven largely by the marked increase in the annual number of severe storms. Part of the physical recovery costs and overall economic impact were due to damage and disruption of the transportation system.

The costliest climate disaster in 2023 was the severe drought and heatwave in the South and Midwest from April to September, which caused 247 deaths and nearly $15 billion in damages. Part of the damages were the increased costs of barge transportation due to low water conditions in the Mississippi River, as discussed earlier. This caused a reduced number of barge movements with lower tons per barge, as well as shifts to higher-cost freight transport modes and curtailment of some shipments. Further details are provided in Chapter 3 Freight and Supply Chain. There were several $6 billion dollar events through August 2024, including Hurricane Beryl, which made landfall in Texas on July 8, and two central and southern severe tornado outbreaks.

Accidental hazardous materials released during transport, primarily due to crashes and derailments, are another source of system vulnerability, leading to potentially large economic and environmental costs. One notable accident of this type occurred in 2023. On February 3, an eastbound Norfolk Southern Railway train derailed 38 mixed freight railcars near East Palestine, Ohio. Three tank cars carrying flammable and combustible hazardous materials were mechanically breached during the derailment. A fire ignited and grew to involve these and other cars. Emergency responders established a 1-mile evacuation zone that affected about 2,000 residents. The derailed equipment included five hazardous materials tank cars carrying vinyl chloride monomer (VCM), a compressed liquified flammable gas. The five VCM tank cars were not mechanically breached during the derailment but concerned that a dangerous chemical reaction was occurring within a VCM tank car, the incident commander managing the response chose to expand the evacuation zone and perform a vent and burn (a deliberate breach of a tank car) on all five derailed VCM tank cars [NTSB 2024b]. Analysis of data routinely collected by the National Atmospheric Deposition Program showed that the spatial extent of chemical depositions resulting from this event was widespread, covering portions of 16 states in the Midwest, Northeast, and perhaps as far south as North Carolina (1.4 million sq-km) [Gay et al. 2024].

Transportation Accidents Also Challenge System Resiliency

Major transportation accidents can also cause losses similar in magnitude to those due to climate and weather disasters. Box 1-B reports on a major bridge mishap that occurred in 2023 on interstate 95, and Box 1-B summarizes the collapse of the Francis Scott Key Bridge over the Baltimore harbor in 2024 due to a vessel strike and related consequences.

BOX 1-B

2023 INTERSTATE 95 HIGHWAY COLLAPSE

On June 11, 2023, a truck-tractor with a tank-trailer holding 8,500 gallons of gasoline was exiting Interstate 95 (I-95) northbound on the Cottman Avenue off-ramp in Philadelphia, Pennsylvania. At this location, I-95 is an eight-lane divided highway with four lanes each in the northbound and southbound directions. The truck driver was unable to maintain control of the vehicle on the off-ramp. The truck rolled over and subsequently caught fire under the northbound lanes of the I-95 overpass. The postcrash fire caused the northbound lanes of I-95 to collapse, and the southbound lanes were significantly damaged by the fire [NTSB 2023].

As a result of the collapse, the highway was closed in both directions. This section of I-95 carried about 160,000 vehicles per day, so major traffic disruptions occurred. In 2021, trucks traveled on this section of I-95 carried 21 million tons of freight worth $104 billion between major goods-producing and consuming areas to the north and south of the Philadelphia region. More than 11 billion dollars of electronics moved through the Philadelphia region on the I-95 corridor, slightly more than the value of the motor vehicles transported through the Philadelphia region on automobile transports [BTS 2024k].

The top five commodities in 2021 moved through I-95 by weight were as follows:

- Dairy products, coffee, frozen vegetables, and other foodstuffs
- Mixed freight (e.g., office supplies, hardware, restaurant supplies)
- Nonmetal mineral products
- Meat and seafood
- Plastics and rubber

The top five commodities in 2021 by value were as follows:

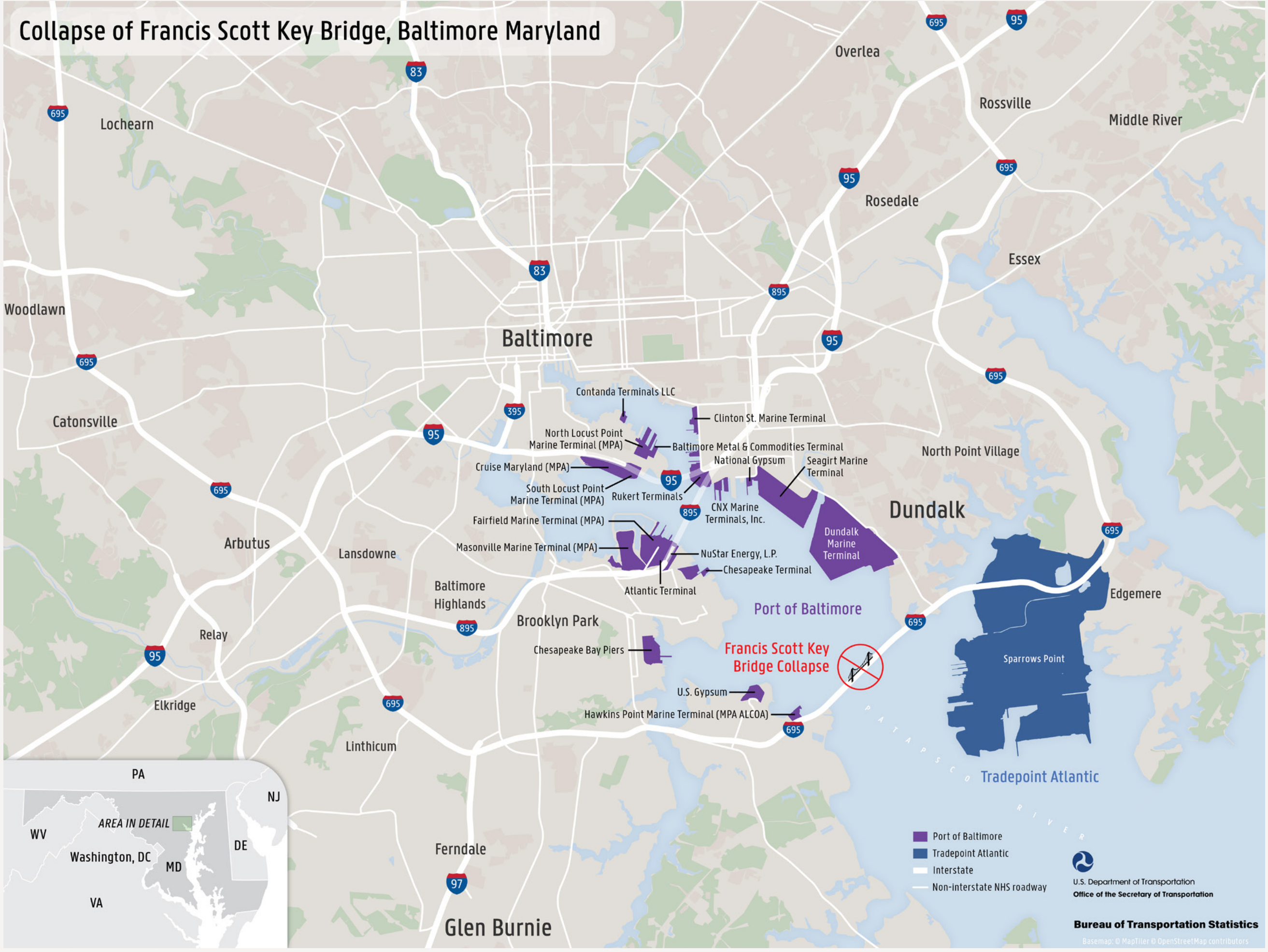
- Electronics
- Motorized Vehicles
- Pharmaceuticals
- Machinery
- Mixed freight (e.g., office supplies, hardware, restaurant supplies)

35 This cost does not include estimated losses due to Hurricanes Helene and Milton; adding them in will make 2024 one of the costliest years on record.

BOX 1-C

COLLAPSE OF THE KEY BRIDGE

The Port of Baltimore is among the top 20 U.S. ports by both tonnage and number of containers handled, ranks in dry bulk, and is a major hub for motor vehicles. A notable disaster in 2024 was the collapse of the Francis Scott Key Bridge crossing the Baltimore Harbor (the map below shows the location of the collapsed Francis Scott Key Bridge and nearby transportation infrastructure in Baltimore, MD). On March 26, a 947-foot-long containership was transiting out of Baltimore Harbor in Baltimore, Maryland, when it experienced a loss of electrical power and propulsion and struck a pier supporting the central truss spans of the bridge. A portion of the bridge collapsed into the river, killing 6 bridge workers, severing I-695, and completely closing the shipping channel into the Port of Baltimore [NTSB 2024a]. Thousands of cars and trucks per day have had to divert to other highways (primarily I-95 and I-895) at an unknown but sizable extra cost to drivers. Dun & Bradstreet estimated the weekly cost of the supply chain disruptions caused by the port closure to be $1.7 billion [Young 2024]. The shipping channel completely reopened in June, but the bridge remains closed as plans for a replacement structure proceed.



Source: BTS, 2024, "Collapse of Francis Scott Key Bridge, Baltimore MD." Available at https://www.bts.gov/geography/geospatial-2/collapse-francis-scott-key-bridge-baltimore-md.

BOX 1-D

HURRICANE HELENE

Category 4 Hurricane Helene made landfall in the Big Bend region of FL, on September 26, 2024, with 140 mph sustained winds. It caused up to 15 feet of storm surge along the Big Bend coast and 6 feet of surge as far south as St. Petersburg. Helene's most severe impacts were from the historic rainfall (up to 30+ inches) and catastrophic flooding across much of western North Carolina, eastern Tennessee, and southwestern Virginia. Damage came in many forms. Landslides, debris flows, and historic levels of flooding inundated and destroyed an immense number of homes, businesses, parks, hospitals, the electrical, cellular, and water system infrastructure, and damaged thousands of roads, highways, and bridges. Major washouts on I-40 near the Tennessee–North Carolina border and I-26 north of Asheville, NC, coupled with other road and bridge damage or collapse turned Asheville into a virtual island, accessible only by air. The human toll was also record-breaking, through November 1, 2024, there were 225 deaths attributed to Helene [NOAA 2024].

Emerging Issues: Cybersecurity and Climate Change

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.

A concerning example, which was not actually a cyberattack, was the botched software update initiated by security vendor CrowdStrike on July 19, 2024. The errant software patch shut down millions of Windows operating systems worldwide, causing an estimated loss of $5.4 billion to U.S. Fortune 500 companies alone. Several U.S. airlines (American, Delta, United) as well as international airlines and airports suffered loss of computer system services, causing cancellation of more than 10,000 flights. Public transit was disrupted in New York, Washington, Chicago, Minneapolis, and Cincinnati [Kerner 2024]. This massive and costly shutdown, caused by a routine software patch, illustrates the cyber-vulnerability of transportation enterprise information and computing systems.

The transportation and trucking industry was the 9th most targeted business sector for the number of cyberattacks in 2022 [Wombolt and Shaw 2023]. In 2023, cities such as Houston, TX, Richmond, VA, Virginia Beach, VA, and Fort Worth, TX, were identified as having had cyber attacks for logistics agencies [Kon Briefing 2024]. For example, a trucking company found that their dispatching software was hacked, disrupting driver communications and reducing the company's ability to invoice their customers. Other cases saw trucks being given fake loads of items to transport, or having funds being diverted to third parties using fake identities. The coming advent of autonomous vehicles opens up additional cybersecurity risks as the vehicle and communications software may be hacked, leading to a loss of control over the vehicle. The annual cost of cybercrimes (all sectors) is expected to reach $10.5 trillion by 2025 [Wombolt and Shaw 2023].

Climate Change Is Increasing the Number and Severity of Natural Disaster

Climate change has resulted in an increasing number of weather and climate disasters each year in the United States as well as worldwide. In 2023, there were 28 of these events (e.g., winter storm across the northeast U.S., wildfire at town of Lahaina on Maui, HI, and flooding events in CA and FL) in the United States with estimated damages for each of at least $1 billion, which is the highest number on record. Over the past 2 decades, the number and severity of these disasters have been increasing at an accelerated rate, driven largely by the increase in the annual number of severe storms. One of the deadliest and costliest such storms, Hurricane Helene, devastated the southeast late in 2024 (refer to Box 1-D). Changing climate patterns have also caused drought-induced low water levels on the Mississippi River and the Panama Canal from 2022 through 2024, which severely impacted waterborne freight shipments.

Data Gaps

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.
- Autonomous vehicle data at the national level.
- Number, location, and characteristics of freight intermodal facilities.
- Usage of passenger and freight intermodal facilities.
- Parking capacity.
- Dedicated infrastructure for bicycles and other forms of active transportation.

The 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 [BTS 2024e]. Expansion of the VIUS to automobiles and buses and a special VIUS targeted at the emerging population of electric vehicles (EVs) (known as the Electric Vehicle Inventory Use Survey [eVIUS]) will complete the picture.

The eVIUS is the first national survey on EVs and is being administered to gain an in-depth understanding of the characteristics and uses of EVs on our Nation's roadways as well as EV charging patterns and preferences. The eVIUS will be administered in 2024 and will focus on EV usage during 2023 and 2024 [BTS 2024i]. Whether VIUS will expand to cover automobiles and buses remains to be determined.

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 (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 measure. For example, private marine terminal operators may use different throughput measures, such as container volumes, tonnage, or TEUs. Data related to asset conditions to performance are also missing.

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 avoid double counting.

References

American Gas Association (AGA). 2024. Gas Facts: *End Users*. Available at https://www.aga.org/research-policy/resource-library/gas-facts-end-users/.

Association of American Railroads (AAR)

——2024. *Freight Railroads and Positive Train Control*. Available at https://www.aar.org/issue/positive-train-control/.

——2023. *Railroad Fact Book* (Annual issues). Available at https://www.aar.org/.

National Railroad Passenger Corporation (Amtrak). 2024. *Amtrak FY 2023 Company Profile*. Available at https://www.amtrak.com/.

American Transportation Research Institute (ATRI). 2024. *Top 100 Truck Bottlenecks - 2024*. Available at https://truckingresearch.org.

Bureau of Transportation Statistics (BTS)

——2022. *Transportation Statistics Annual Report 2022*. Available at https://rosap.ntl.bts.gov/view/dot/65841.

——2024a. Air Travel Consumer Report: June-December 2023, Full Year 2023 Airline Consumer Submissions Data. Available at https://www.transportation.gov/briefing-room/air-travel-consumer-report-june-december-2023-full-year-2023-airline-consumer.

——2024b. National Census of Ferry Operators (NCFO). Available at https://data.bts.gov/stories/s/am5x-xp9v.

——2024c. Quick Links to Popular Air Carrier Statistics. Available at https://www.bts.gov/topics/airlines-and-airports/quick-links-popular-air-carrier-statistics.

——2024d. Intermodal Passenger Connectivity Database (IPCD). Available at https://data-usdot.opendata.arcgis.com/.

——2024e. Vehicle Inventory and Use Survey (VIUS). Available at https://www.bts.gov/vius.

——2024f. National Transportation Statistics. Available at https://www.bts.gov/topics/national-transportation-statistics.

——2024g. Latest Supply Chain and Freight Indicators. Available at https://www.bts.gov/freight-indicators#freight.

——2024h. Port Performance Freight Statistics Program. Available at https://www.bts.gov/ports.

——2024i. eVIUS - The Electric Vehicle Inventory and Use Survey. Available at https://www.bts.gov/browse-statistical-products-and-data/surveys/evius/evius-electric-vehicle-inventory-and-use-survey.

——2024j. TransStats, Air Carrier Financial Reports (Form 41 Financial Data) Schedule B-43 Inventory. Available at https://www.transtats.bts.gov/.

——2024k. Ranking of commodities carried by trucks in Philadelphia region vary by weight and value. Available at https://www.bts.gov/.

California Department of Motor Vehicles (CA DMV). 2024. Autonomous Vehicles. Available at https://www.dmv.ca.gov/portal/vehicle-industry-services/autonomous-vehicles/.

Census Bureau. 2024. Quick Facts (QF). Available at https://www.census.gov/quickfacts/fact/table/US/PST045222.

Federal Aviation Administration (FAA)

——2024. Drones by the Numbers. Available at https://www.faa.gov/uas.

——2022. National Plan of Integrated Airport Systems (NPIAS): 2023-2027. Available at https://www.faa.gov/sites/faa.gov/files/npias-2023-2027-narrative.pdf.

Federal Highway Administration (FHWA)

——2023. Highway Statistics 2022. Available at https://www.fhwa.dot.gov/policyinformation/statistics/2022/index.cfm#sec4.

——2024e. 2023 Urban Congestion Trends. Available at https://ops.fhwa.dot.gov/publications/fhwahop24027/fhwahop24027.pdf.

——2024a. Bridge Condition by Functional Classification. Available at https://www.fhwa.dot.gov/bridge/fc.cfm.

——2024b. Bridge Condition by Owner. Available at https://www.fhwa.dot.gov/bridge/nbi/no10/owner24.cfm.

——2024c. Bridge Condition by Posting Status 2024. Available at https://www.fhwa.dot.gov/bridge/nbi/no10/posting24.cfm.

——2024d. National Household Travel Survey. Available at https://www.fhwa.dot.gov/.

——2021b. 2020 Urban Congestion Trends. Available at https://ops.fhwa.dot.gov/publications/fhwahop21010/index.htm.

Federal Railroad Administration (FRA). 2023. Fiscal Year 2023 Enforcement Report. Available at https://railroads.dot.gov/elibrary/fiscal-year-2023-annual-enforcement-report.

Federal Transit Administration (FTA)

——2024a. National Transit Database: 2022 Data Tables. Available at https://www.transit.dot.gov/ntd.

——2024b. Transit Automation Research. Available at https://www.transit.dot.gov/automation-research.

Gay, D., et al. 2024. Widespread Impacts to Precipitation of the East Palestine Ohio Train Accident. Environmental Research Letters, Vol. 19, No. 7. Available at https://iopscience.iop.org/article/10.1088/1748-9326/ad52ac.

Gordon, A. 2023. “I-95 Collapse in Philadelphia Didn’t Cause a Traffic Disaster, Data Shows,” *Vice*, June 21. Available at https://www.vice.com/en/article/i-95-philadelphia-carmageddon-never-happened-data-shows/.

Herger, M. 2024. “2023 Disengagement Report from California,” *The Last Driver License Holder*, February 3. Available at https://thelastdriverlicenseholder.com/2024/02/03/2023-disengagement-reports-from-california/.

Kelleher, S. 2023. “No Pilot, No Problem? Here’s How Soon Self-Flying Planes Will Take Off,” *Forbes*, February 27. Available at https://www.forbes.com/sites/suzannerowankelleher/2023/02/26/pilotless-autonomous-self-flying-planes/.

Kerner, S. 2024. Crowdstrike Outage Explained: What Caused It And What’s Next. TechTarget. Available at https://www.techtarget.com/whatis/feature/Explaining-the-largest-IT-outage-in-history-and-whats-next.

Kon Breifing. 2024. Cyberattacks on logistics companies 2023, Statistics: Ransomware, data breaches, Cyber incident overview. Available at https://konbriefing.com/en-topics/cyber-attacks-2023-ind-logistics.

National Highway Traffic Safety Administration (NHTSA). 2024. Report to Congress: Research on Connected Vehicle Technology February 2024. Available at https://www.nhtsa.gov/document/report-congress-research-connected-vehicle-technology-february-2024.

National Oceanic and Atmospheric Administration (NOAA). 2024. U.S. Billion-Dollar Weather and Climate Disasters (2023). Available at https://www.ncei.noaa.gov/access/billions/.

National Transportation Safety Board (NTSB)

——2024a. Contact of Containership Dali with the Francis Scott Key Bridge and Subsequent Bridge Collapse. Marine Investigation Preliminary Report. Available at https://www.ntsb.gov/investigations/Documents/DCA24MM031_PreliminaryReport%203.pdf.

——2024b. “Norfolk Southern Railway Derailment and Hazardous Materials Release; East Palestine, Ohio, February 3, 2023,” Railroad Investigation Report RIR-24-05, June 25. Available at https://www.ntsb.gov/investigations/AccidentReports/Reports/RIR2405.

——2023. “Combination Vehicle Fire and Interstate 95 Overpass Collapse,” Preliminary Report HWY23FH014, June 29. Available at https://www.ntsb.gov/investigations/Pages/HWY23FH014.aspx.

Pipeline and Hazardous Materials Safety Administration (PHMSA). 2022. Technology Research and Development: Success Stories. Available at https://www.phmsa.dot.gov/.

Schrank, D., et al. 2024. Urban Mobility Report 2023. Texas A&M Transportation Institute. Available at https://mobility.tamu.edu/umr/.

Transportation Security Administration (TSA). 2024. 2023 TSA Year in Review. Available at https://www.tsa.gov/.

U.S. Army Corps of Engineers (USACE)

——2024. The U.S. Coastal and Inland Navigation System: 2022, Transportation Facts and Information. Available at https://publibrary.planusace.us/#/series/Fact%20Cards.

——2021. Public Lock Usage Report Files. Lock Unavailabilities, Calendar Years 1993–2020. Available at https://www.iwr.usace.army.mil/.

U.S. Department of Agriculture (USDOA). 2024. Barge Dashboard. Available at https://agtransport.usda.gov/stories/s/Barge-Dashboard/si5y-wpqw/.

U.S. Department of Transportation (USDOT). 2023. R*ural Opportunities to Use Transportation for Economic Success (ROUTES)*. Available at https://www.transportation.gov/rural.

White House. 2024. *Fact Sheet: Protecting America from Connected Vehicle Technology from Countries of Concern*, September 23, 2024. Available at https://www.whitehouse.gov/briefing-room/statements-releases/2024/09/23/fact-sheet-protecting-america-from-connected-vehicle-technology-from-countries-of-concern/.

Wombolt, S., and S. Shaw. 2023. *A Glitch On The Road: Cybersecurity Trends Facing the Trucking And Transportation Industry*. Marsh McLennan Agency. Available at https://www.marshmma.com/us/insights/details/a-glitch-on-the-road-cybersecurity-trends-facing-the-trucking-and-transportation-industry.html.

Young, L. 2024. “Baltimore Bridge Collapse Triggers Extensive, Costly Logistics Diversions,” *Wall Street Journal*, April 3. Available at https://www.wsj.com/articles/baltimore-bridge-collapse-triggers-extensive-costly-logistics-diversions-763fbd7b.

CHAPTER 2

PASSENGER TRAVEL AND EQUITY

The landscape of passenger travel in the United States continued to evolve in 2023. Whether 2024 will define a new "normal," potentially marking 2023 as the final year of the COVID-19 recovery phase, remains to be seen. Americans, in many cases, rekindled their interest in travel, both locally and across longer distances.

In 2023, domestic flights increased 1 percent over 2019, while international flights approached 97 percent of that prepandemic level. Between fiscal years (FYs) 2021 and 2022, U.S. National Parks lost 15 percent of their staff, requiring parks to limit visitors. As Michael T. Reynolds from the U.S. Department of the Interior expressed before the House Committee on National Resources Subcommittee on Oversight and Investigations on July 27, 2023:

> Visitors may experience congestion at popular parks and at attraction hotspots and where entries and exits are limited. Crowding can also be felt at the most popular scenic viewpoints that are within one-quarter mile of a parking lot.
>
> The NPS is employing a range of park-specific strategies to provide a welcoming and enjoyable environment while ensuring the protection of nationally significant resources.
>
> Other managed access strategies, such as reservation and timed entry systems, are now in place or have been piloted at several parks, with each addressing specific park-level issues. Congestion can result in gridlock, visitor conflicts, crowding, safety issues, resource damage, and, of particular concern, delays in emergency response. [Reynolds 2023]

New data sources, such as those gleaned from cell phone tracks and other location-based service data as well as domestic migration data, provide valuable insights into travel patterns and trends, with key insights presented herein. These new data sources enable a greater understanding of recent shifts in travel behavior, largely spurred by the COVID-19 pandemic. The remainder of this chapter will provide details about such new data sources and the insights, trends and shifts that they provide.

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. Regional population shifts via out- and in-migration and natural growth likewise have similar implications for regional patterns of local and long-distance travel.

HIGHLIGHTS

As the U.S. population grows, so does it impact on all forms of transportation. More people traveling leads to increased congestion, economic and environmental costs, frustration, and mishaps that can cause injury and death. In 2023, the U.S. population grew by about 1.64 million people, marking the highest annual growth in this decade to date. U.S. counties experienced more population gains than losses in 2023, with faster growth in Southern counties and a shift from population losses to gains in many Northeast and Midwest counties.

Surveys show that the highest income group, defined by the Census Bureau as those earning $75,000 or more, accounts for the largest number of work-at-home (WAH) workers at 46.7 percent. The median earnings of all WAH workers is $70,280, which is significantly higher than other commute groups: $48,400 for those driving alone, almost $47,000 for transit users, and $36,500 for carpoolers.

Females account for a larger share of work trips under 20 minutes, while males comprise the majority of commuters in the over-60-minute range. Including those who work at home with zero travel time, the share of under-20-minute work trips rises to 52.6 percent for females and 45.7 percent for males, with the majority of all workers now having work travel times of under 20 minutes.

In 2023, transportation spending as a share of total consumer spending grew to 17.4 percent from 16.9 percent in 2022, more due to the increases in other kinds of spending such as spending on personal care, personal insurance, alcoholic beverages, education, and miscellaneous.

The percentage of households without vehicles nationwide has declined by more than half from 1970 to 2023, to 8.4 percent. Among Hispanics, this rate dropped from 21.8 percent in 1980 to below 10 percent. Similarly, the African-American rate fell from 43 percent in 1970 to less than half by 2010 with declines since. All these trends saw an uptick in 2023.

Post-COVID-19 in 2020–2022, the WAH movement gained momentum, but that momentum has slowed in recent years. However, the number of workers who report WAH is still greater than those who commute by any means other than by driving alone or carpooling. Many commute modes have recovered somewhat, but most are still below 2019 levels.

U.S. airline travel rebounded to prepandemic 2019 levels, with over 1 billion passengers; however, business travel still exhibited weakness. As Figure 2-20 shows, half of the U.S. population traveled by air in 2023, and the share of the population who had flown at least once in their lifetime reached an impressive 86 percent.

The cruise line industry experienced a strong recovery in 2023, with 18 million passengers, surpassing the pre-COVID 2019 tally by more than 2.7 million passengers. Florida has maintained its position as the world's leader in cruise travel embarkations.

Total U.S. citizen international departures reached 98.5 million in 2023, an increase of 17.6 million from 80.8 million in 2022, bringing the figure to 99 percent of the 99.2 million departures recorded in prepandemic 2019.

Highlights Continued ⟫

HIGHLIGHTS CONTINUED

Visits to national parks, which saw a notable decline in 2020, rebounded to 2019 levels by 2023, surpassing 325 million visitors.

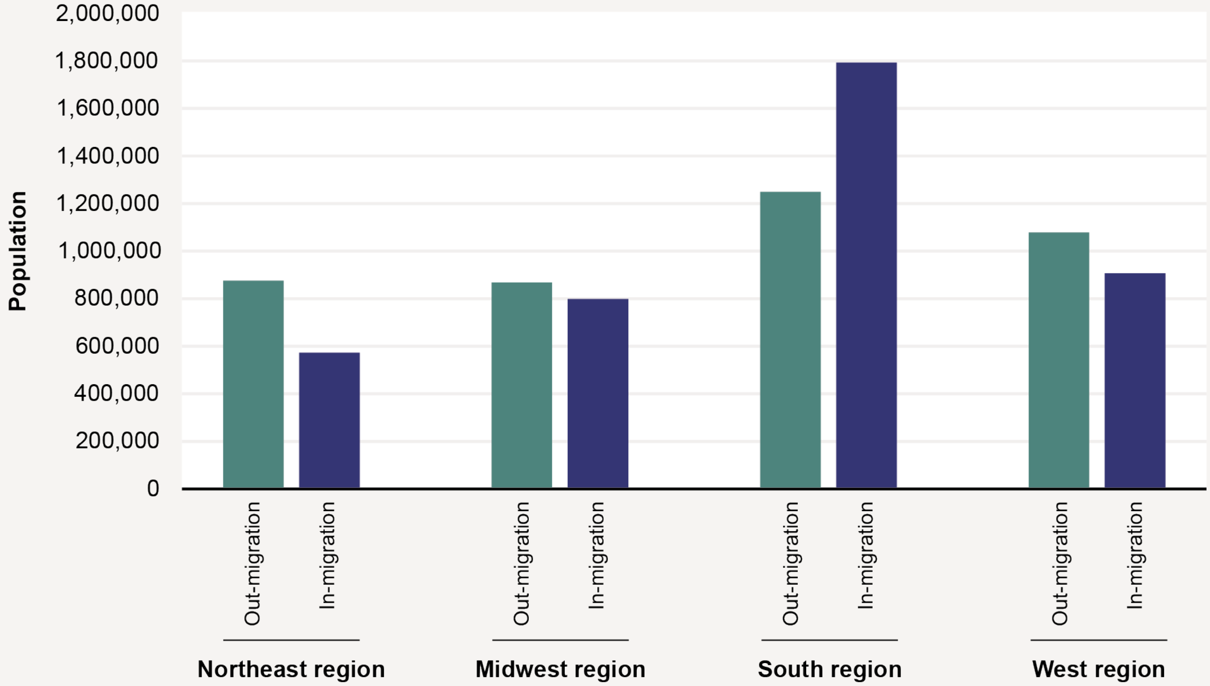
In 2023, globally the United States ranked third in number of foreign visitors and first in revenue generated from them.

In fiscal year (FY) 2023, Amtrak observed a 26 percent increase in ridership over FY 2022. About 28.5 million customers rode Amtrak services nationwide—almost 78,300 person trips on an average day in 2023.

Figure 2-1 shows that all regions but South experienced population loss via migration in 2023. It is important to note that the net change in population flows represents only a small part of the overall picture. As populations migrate from county to county and state to state, demographics can shift, creating unique transportation demands. For example, in the Northeast, almost 1.5 million people moved, leading to shifts in job skills and access, changes in travel preferences, and most likely, major financial impacts.

In 2023, more counties experienced positive net domestic migration compared to 2022, meaning more people moved into these counties than moved out. The share of such counties with positive net domestic migration increased from 60 percent in 2022 to 62 percent in 2023. Nevertheless, the magnitude of population gains or loss in terms of domestic migration generally lessened among some of the counties with the largest amounts of domestic population gains and loss. The 10 counties with the largest gains from domestic

Figure 2-1 Regional Population Shifts: 2022–2023



Source: Census Bureau, American Community Survey 2023, table S0702.

migration were mainly in the South, while the top 10 counties with the largest population loss from domestic migration were mainly in large metro areas.

The number of counties with population gains due to domestic migration increased in all regions except the West, where 253 counties saw population gains from domestic migration in 2023, which was down by 22 counties compared to in 2022. The Northeast had the largest increase in the share of counties with population gains from domestic migration, reaching 52 percent in 2023, an increase from 44 percent in 2022. In both the South and the Midwest, the number of counties with population gains from domestic migration increased slightly from 2022 to 2023—from 957 to 1,014 in the South and from 561 to 581 in the Midwest.

A greater majority of the Nation's 387 metropolitan statistical areas experienced population growth between 2022 and 2023, accounting for about 73 percent of all urban areas. A smaller majority of U.S. micropolitan statistical areas—about 58 percent—also saw population growth over the same period.

An important trend accelerated by COVID-19 is highlighted in the following quotations, derived from detailed census data analyses published by *NewGeography*:

> The new data on net domestic migration between major metropolitan areas (more than 1,000,000 residents) over the last three years (July 2020 to July 2023) shows a strong movement of people away from higher urban densities to lower urban densities. This is consistent with the strong national data showing movement away from higher urban density among the nation's more than 3,100 counties (and county-equivalent jurisdictions). Among the 40 major metropolitan areas that had counties with both gains and losses, people moved into counties with lower urban densities and people moving out left counties with higher urban densities *in all cases*. [Cox 2024]

Natural Change

Unlike migration, the population change via natural growth affects the overall level of travel in the Nation instead of its regional distribution. In 2023, about 70 percent of counties experienced a "natural" decrease in population size, where deaths outnumbered births. However, this was an improvement from more than 74 percent of counties in 2022. The West has the lowest proportions of counties with natural decreases, at approximately 54 percent. States where many counties faced natural population declines included Alabama, Arkansas, Illinois, Kentucky, Maine (where all counties reported natural population decrease) Michigan, Ohio, Pennsylvania, and Tennessee.

COVID-19 and the Disruption of Travel Trends

Consistent growth in travel each year has been a mainstay of American travel, interrupted infrequently by major economic downturns. The impact of the COVID-19 pandemic has been unparalleled, perhaps not seen since World War II. The marked decline in travel due to COVID-19 began in March 2020 and has been slowly recovering—or, more accurately, attenuating—as alternative travel and initiatives, such as e-commerce and work-from-home (virtual meetings and conferences), and shifts in medical appointments with telehealth technologies have generated national shifts in travel.

Figure 2-2 traces impact COVID-19 had on passenger travel trends from 2019 through September 2024 for the major modes. Notable in the figure is that highway travel, after a marked decline in 2020, reached roughly comparable levels to 2019 by 2021. Transit usage was heavily impacted by COVID-19 as travelers shunned crowded vehicles or terminals. Any form of transportation involving groups of unfamiliar people, such as taxi cabs, became less popular during this time. Public modes of transportation suffered further declines as technologies enabled people to work-at-home (WAH) in response to COVID-19.

An important facet of the WAH revolution is the widespread ownership of household computers and internet access (Table 2-1). These two key elements that enable WAH were already prevalent before COVID-19, but their reach expanded further, approaching ubiquity, much like the ownership of appliances such as televisions and refrigerators.

The rise of virtual interactions for work and social connections largely replaced physical trips, reshaping many previous trip patterns. In terms of intercity travel, changes were primarily driven by curtailed business and leisure travel rather than modal shifts.

Table 2-1 Household Computer and Internet Access: 2019–2023

Year	Own a computer	Have internet access
2019	92.90%	86.40%
2021	95.00%	90.10%
2022	95.70%	91.00%
2023	96.10%	92.10%

Source: U.S. Department of Commerce, Census Bureau, "Selected Population Profile in the United States." 2019–2023 American Community Survey 1-Year Estimates Selected Population Profiles, Table S0201.

Private-sector service providers, such as airlines, cabs, tour buses, cruise lines, and even some destinations quickly reduced services in response to declines in demand. The cruise industry experienced similar hardships, with effectively zero ridership in early 2020. During the COVID-19 pandemic, many countries closed their borders to visitors or even their own returning citizens.

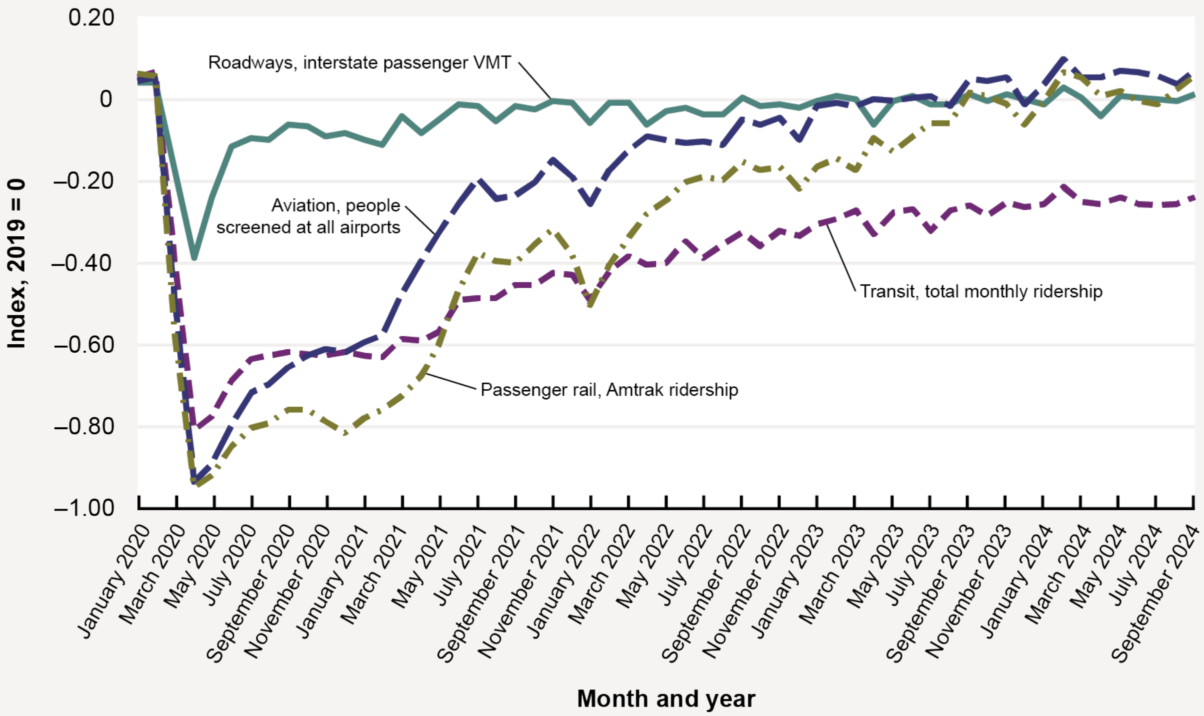
Local commuting journeys-to-work traditionally account for one-fifth of local travel, but that fifth is the major source of recurring urban congestion and a major source of ridership for public transit. Working at home has been replacing a share of journeys-to-work since at least 1980, and COVID-19 dramatically increased that share (Figure 2-3). In 2022, the 24 million working from home surpassed the 14 million workers carpooling and was second only to the 110 million workers commuting alone. In 2023, total work at home declined to about 22 million as its share slipped from 18 to just below 14 percent of total workers but still ranked second to those driving alone, which gained 2 million, reaching 112 million—still short of the 2019 level of 119 million (Table 2-2).

Workers according to their job WAH status can be summarized as follows:

- **Non-WAH—**Those who work with “stuff” (e.g., truck drivers, miners, warehouse workers).
- **Non-WAH—**Those who work with people (e.g., barbers, dentists, doctors, teachers, store clerks, cashiers).
- **WAH—**Those who work with concepts and are computer oriented (e.g., accountants, researchers, technical analysts, administrators).

Of the three groups listed, the WAH group has grown dramatically due to their increased ability to communicate virtually with clients and colleagues. In some cases, those in the medical and education fields have benefited from these technological advancements. In terms of occupation, 85 percent of WAH workers are either in management, business, science and arts, sales, or other office occupations [Census Bureau 2024h].

Figure 2-2 COVID-19 Passenger Impact: 2020–2024



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, The Week in Transportation, available at https://www.bts.gov/covid-19/week-in-transportation as of November 2024.

VMT = vehicle-miles traveled.

Table 2-2 Mode of Transportation to Work Change: 2019 and 2021–2023

Mode	2019 (prepandemic)		2021 (first pandemic year)		2022 (second pandemic year)		2023 (postpandemic year)		Change from 2019 to 2023
	Commutes	Share (%)	Commutes	Share (%)	Commutes	Share (%)	Commutes	Share (%)	
TOTAL	**156,941,346**	**100.00**	**154,314,179**	**100.00**	**160,577,736**	**100.00**	**162,434,675**	**100.00**	**5,493,329**
Worked from home	8,970,800	5.72	27,568,098	17.86	24,381,732	15.18	22,486,510	13.84	13,515,710
Car, truck, or van	133,054,328	84.78	116,668,475	75.60	124,126,435	77.30	126,985,709	78.18	−6,068,619
Drove alone	119,153,349	75.92	104,650,121	67.82	110,245,368	68.66	112,376,082	69.18	−6,777,267
Carpooled	13,900,979	8.86	12,018,354	7.79	13,881,067	8.64	14,609,627	8.99	708,648
In 2-person carpool	10,469,892	6.67	9,050,049	5.86	10,240,427	6.38	10,696,703	6.59	226,811
In 3-person carpool	1,982,471	1.26	1,776,397	1.15	2,173,594	1.35	2,325,425	1.43	342,954
In 4-or-more-person carpool	1,448,616	0.92	1,191,908	0.77	1,467,046	0.91	1,587,499	0.98	138,883
Public transportation	7,778,444	4.96	3,793,329	2.46	5,013,135	3.12	5,735,258	3.53	−2,043,186
Bus	3,601,403	2.29	1,971,235	1.28	2,401,748	1.50	2,636,607	1.62	−964,796
Subway or elevated rail	2,935,633	1.87	1,400,185	0.91	1,952,645	1.22	2,242,806	1.38	−692,827
Long-distance train or commuter rail	921,391	0.59	294,566	0.19	466,508	0.29	626,481	0.39	−294,910
Light rail, streetcar, or trolley	242,776	0.15	82,915	0.05	129,309	0.08	155,455	0.10	−87,321
Ferryboat	77,241	0.05	44,428	0.03	62,925	0.04	73,909	0.05	−3,332
Taxicab	385,756	0.25	296,457	0.19	382,417	0.24	405,531	0.25	19,775
Motorcycle	221,923	0.14	166,676	0.11	217,325	0.14	215,105	0.13	−6,818
Bicycle	805,722	0.51	616,153	0.40	731,272	0.46	761,757	0.47	−43,965
Walked	4,153,050	2.65	3,399,405	2.20	3,855,075	2.40	3,966,159	2.44	−186,891
Other means	1,571,323	1.00	1,805,586	1.17	1,870,345	1.16	1,878,646	1.16	307,323

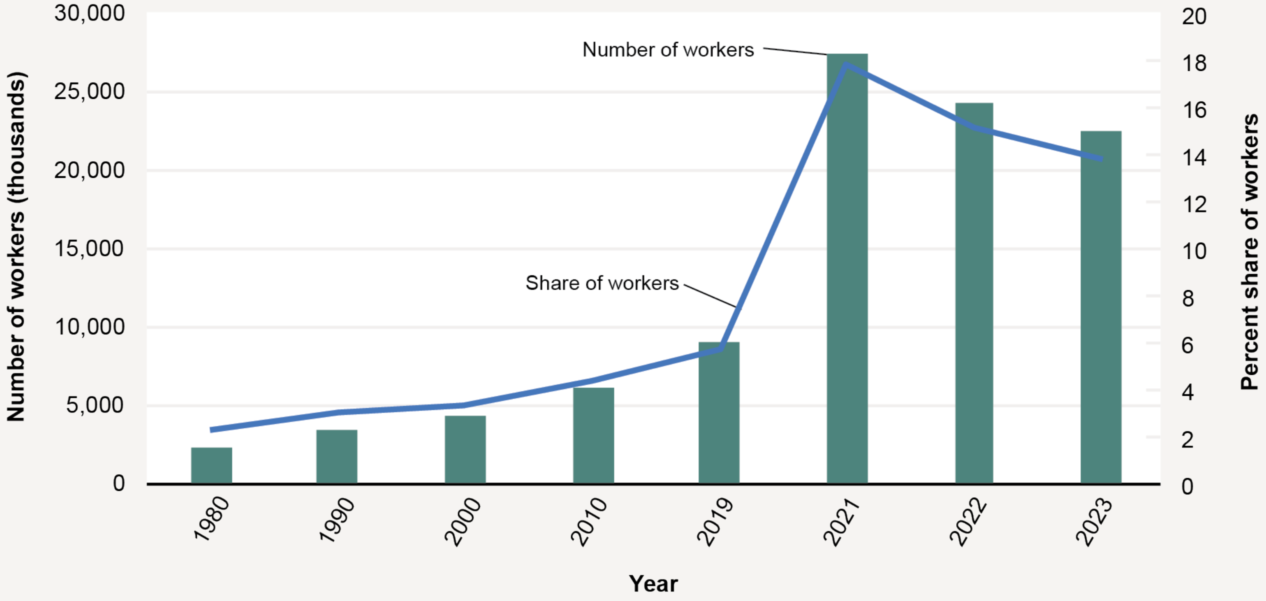
Source: U.S. Department of Commerce, Census Bureau, 2019, 2021-2023 American Community Survey, Table B08301, available at https://data.census.gov/cedsci/ as of November 2024.

Note: The ACS was not conducted in 2020.

Working at home is considered a major mode of "transportation" across all ages since COVID-19. The peak age group for WAH workers is 25–44 years, accounting for almost 48 percent of all WAH. This is followed by 45–54 age group, which accounts for 21.2 percent. The median of all WAH workers is 43.5 years [Census Bureau 2024h] This WAH trend may also be influenced by the competition for workers with technical skills, which are in short supply. The growth of WAH can have a major impact on transportation. No longer tied to daily commutes, those who WAH have less need for transit, driving or other means of transportation as they lessen congestion, and wear and tear on transportation infrastructure while cutting pollution and fuel usage.

Table 2-2 provides a detailed mode choice tabulation for the prepandamic year 2019 and the second and third full pandemic years in 2021 and 2022, and the postpandemic year 2023. The most immediate measure of change is the change in the number of commuters from 2019 to 2023. 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 was observed in 2022 and more in 2023. Working at home continued the decline that started in 2022, while driving alone continued to increase. It is worth noting that none of the public transportation modes has fully recovered the loss of ridership due to the pandemic while all forms of carpool have exceeded the pandemic level (Table 2-2).

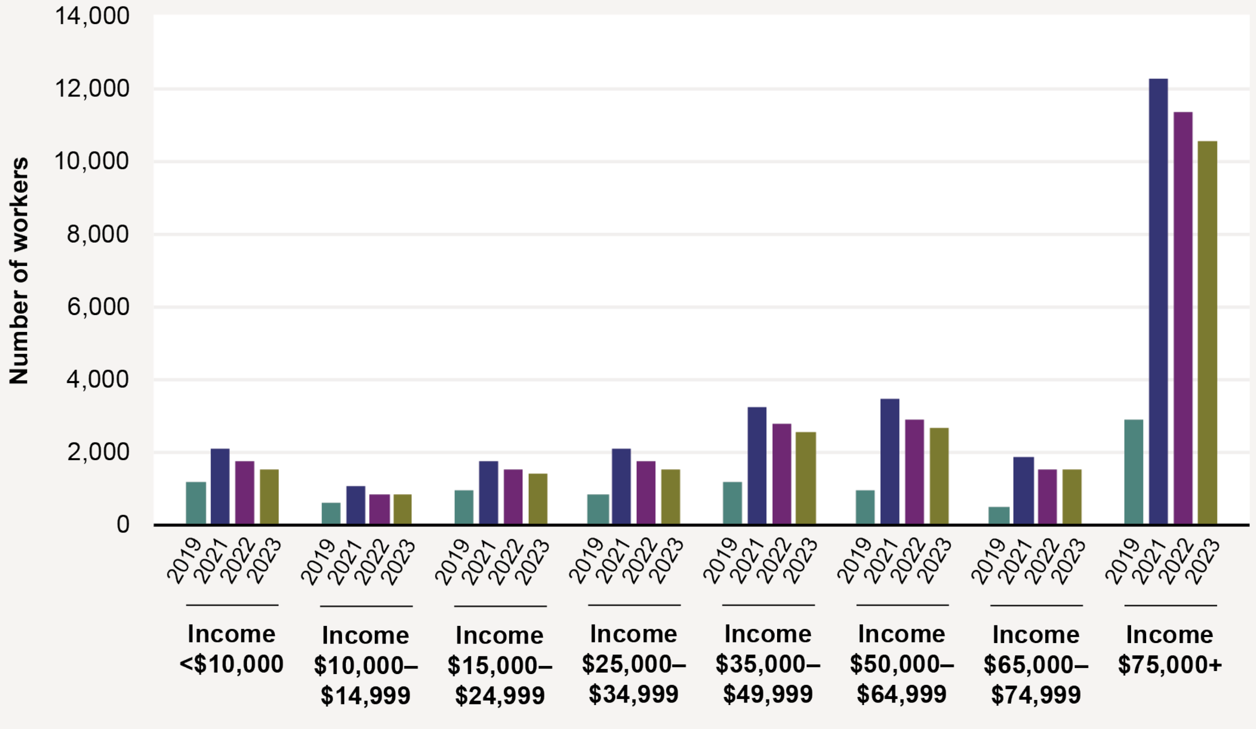
Figure 2-3 Long-Term Trend in Working at Home: 1980-2023



Source: U.S. Department of Commerce, Census Bureau, Decennial Census 1980-2000 and 2010-2023 American Community Survey, Table S0801, available at https://data.census.gov/cedsci/ as of November 2024.

Note: The ACS was not conducted in 2020.

Figure 2-4 Workers Working at Home by Income: 2019–2023



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

Note: The ACS was not conducted in 2020.

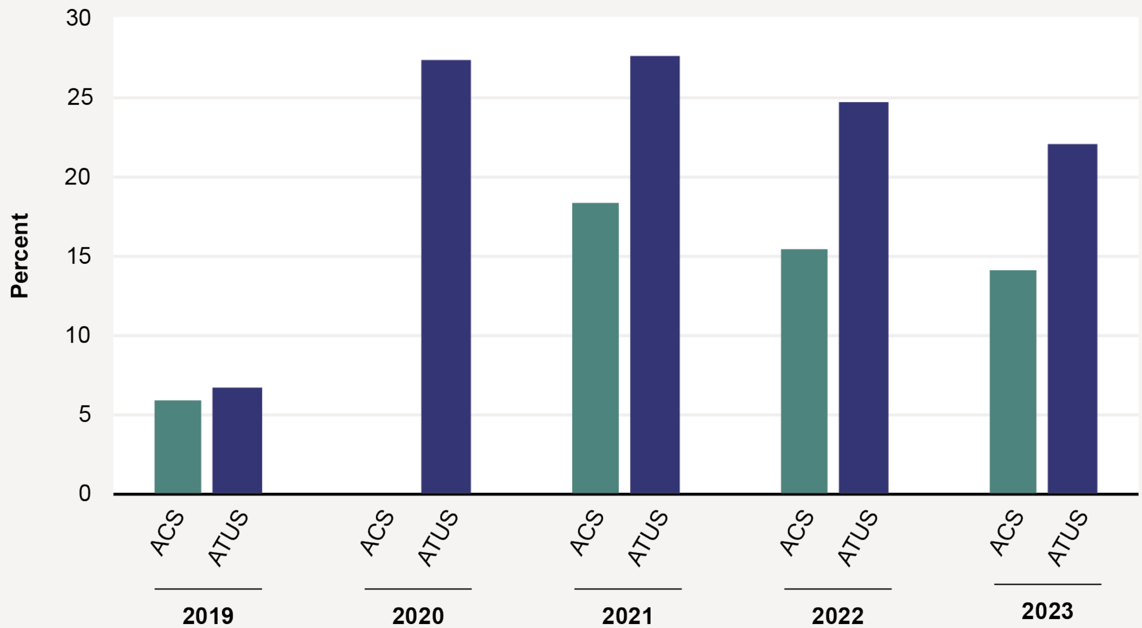
Surveys (specifically, the American Community Survey [ACS]) consistently show that the highest income group, defined by the Census Bureau as those earning $75,000 or more, accounts for the largest number of WAH workers at 46.7 percent (Figure 2-4). The median earnings of all WAH workers is $70,280, which is significantly higher than other groups: $48,400 for those driving alone, almost $47,000 for transit users, and $36,500 for carpoolers [Census Bureau 2024h]. So, one might argue that working at home may be more common among high paying workers with occupations that do not require a physical presence.

Figures 2-3 and 2-5 highlight a decline in WAH since its peak in 2021 as COVID-19 pressures eased, but it remains a clear trend. The American Community Survey's (ACS's) structure of the Census question on commute mode asked about the mode "usually" used last week, which may have excluded some hybrid workers who split their time between home and the office. The American Time Use Survey (ATUS) asked respondents about their mode of transportation to work "yesterday," aligning with a more standard transportation survey approach. From 2021 to 2023, the ATUS yielded a higher percentage of workers reporting that they worked from home than that reported via the ACS—respectively ranging from 27.0 to 21.6 percent versus 17.9 to 13.8 percent. The ATUS also provided data for 2020 (when the ACS was not conducted) when 26.7 percent of respondents reported that they worked from home.

Overall, total travel times to work in 2023 are about 1 minute shorter than those in 2019 for both males and females (Table 2-3). Average travel times in 2023 remain shorter than in 2019, although with less than 1-minute differences for both males and females over that time period. Another key measure on travel time is the share of workers with commute times under 20 minutes or over 60 minutes. Females account for a greater share of commutes under 20 minutes, while males account for a greater share of commutes over 60 minutes. Including those working at home, the share of workers with zero travel time or commutes under 20 minutes among all workers increased between 2019 and 2023, from 46 percent to 52.6 percent for females and from 40.7 to 45.7 percent for males, highlighting that many workers have commutes that are under 20 minutes.

Females exhibit lower travel times than males, partly due to differences in work destinations (Table 2-4). Males are more likely to work outside their county of residence, while females tend to work within their home county of residence. Additionally, 3.8 percent of males cross a state line to work compared to 2.7 percent of females.

Figure 2-5 Working at Home Usually Last Week (ACS) vs. Work at Home Yesterday (ATUS): 2019–2023



Source: Insights from 2023 National Transportation Data, National Center for Travel Behavior and Demand as of October 2024.
ACS = American Community Survey; ATUS = American Time Use Survey.

Table 2-3 Travel Time to Work: 2019–2023

Travel time	Year	All	Male	Female
Average travel time to work (minutes)	2019	27.6	29.1	25.8
	2021	25.6	27.3	23.7
	2022	26.4	28	24.5
	2023	26.8	28.4	25.0
Overall travel time under 20 minutes (percent of commuters)	2019	39.7	37.40	42.5
	2021	42.5	39.5	46.0
	2022	41.30	38.60	44.70
	2023	40.9	38.0	44.0
Overall travel time over 60 minutes (percent of commuters)	2019	9.80	11.40	8.1
	2021	7.7	9.3	5.9
	2022	8.50	10.10	6.70
	2023	8.90	10.50	7.20
Total of zero and under 20 minutes travel time (percent of all workers)*	2019	43.1	40.7	46.0
	2021	52.8	49.4	56.5
	2022	50.2	47.1	53.9
	2023	49.0	45.7	52.6

Source: U.S. Department of Commerce, Census Bureau, "Commuting Characteristics by Sex." American Community Survey 1-Year Estimates Subject Tables, Table S0801, 2019–2023.

* These percentages are calculated based on the percent of workers who worked at home and the percent of workers who traveled to work under 20 minutes.

The following data provide insights into understanding the travel time differences between males and females:

- Table 2-4 highlights the percentage distribution of work destination by sex in 2023. A greater share of females tended to work within their residence county, whereas males are more oriented to working outside their residence county and more outside their state of residence as depicted in the table.

- Figure 2-6 shows the times of departure by sex in 2023. Given the differences in destinations, it is not surprising that work departure times vary significantly. Males predominately commute in the early morning, from midnight to about 7 am, while females are more likely to commute later, from 7 am until noon.

Table 2-4 Percentage Distribution of Workplace Destination by Sex: 2023

Workplace destination	All	Male	Female
Worked in state of residence	96.7	96.2	97.3
Worked in the county of residence	74.7	72.3	77.4
Worked outside the county of residence	22	23.9	19.9
Worked outside the state of residence	3.3	3.8	2.7

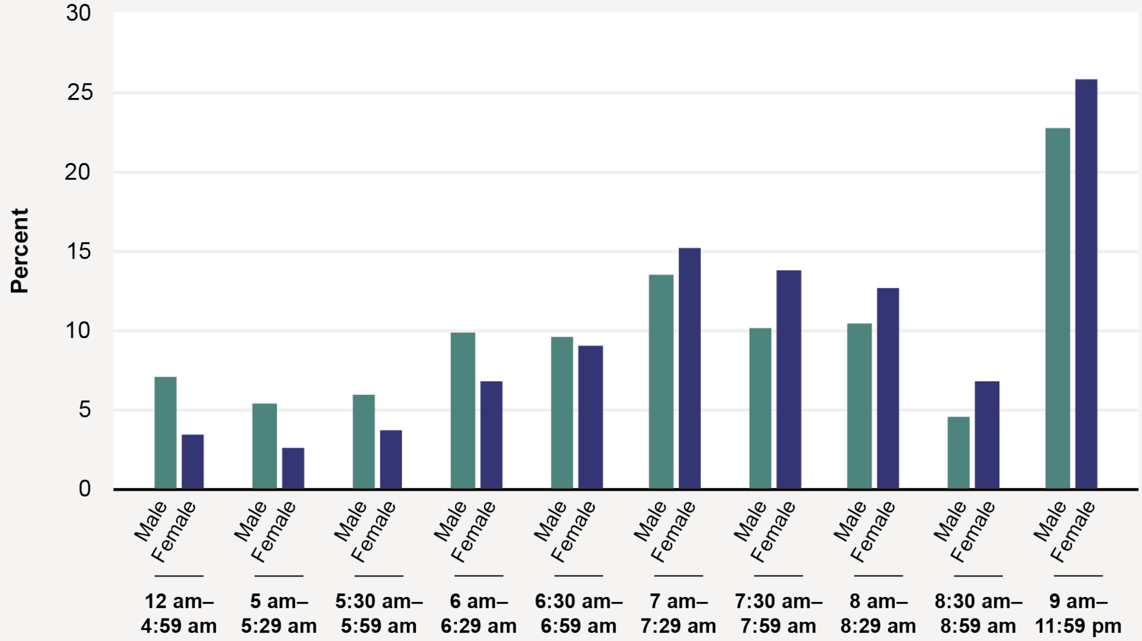
Source: U.S. Department of Commerce, Census Bureau, "Commuting Characteristics by Sex." American Community Survey 1-Year Estimates Subject Tables, Table S0801, 2023.

Household Vehicle Ownership

The most dramatic shifts in household vehicle ownership were observed from 1960 to 1980, when two-vehicle households surpassed one-vehicle households (Figure 2-7). Similarly, three-vehicle or more households have grown from 2.5 percent of households in 1960 to almost 22 percent in 2023. Zero-vehicle households experienced a marked decline, from 21.5 percent in 1960 to 8.4 percent in 2023. Although the changes were relatively slight, COVID-19 impacts on jobs and incomes negatively affected trends. As might be expected, households with no workers and, hence, no commuters, comprised more than half of zero-vehicle households (Figure 2-8). There are still substantial members of the workforce with no household vehicles or where there are more workers than vehicles in a household.

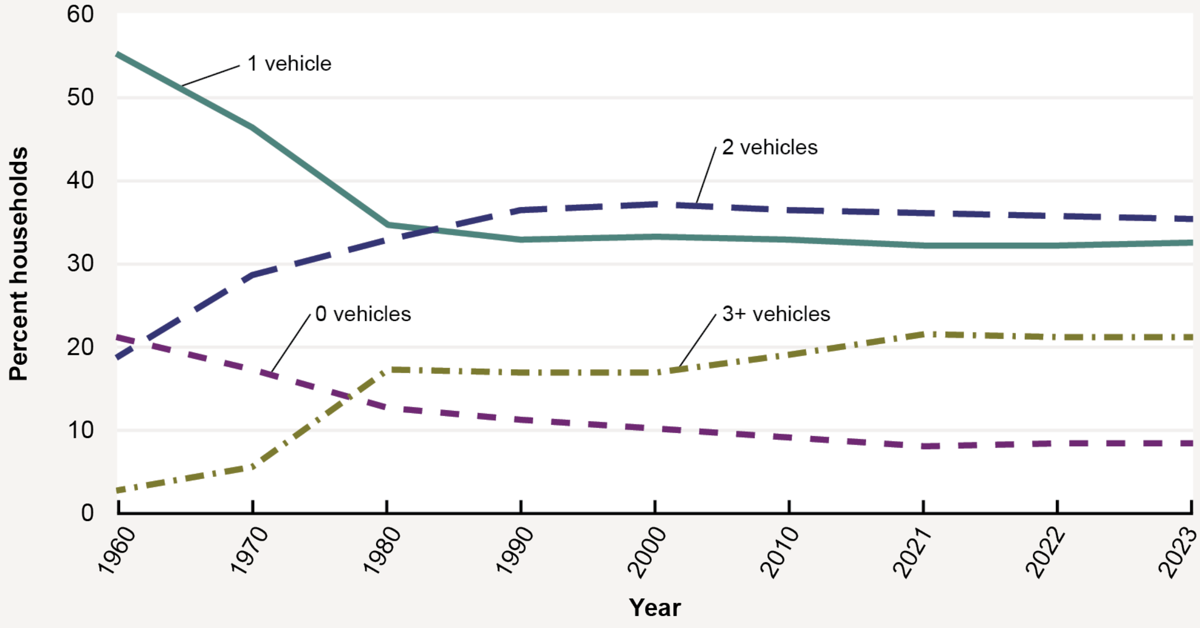
Figure 2-9 traces long-terms trends of zero-vehicle ownership as they apply to all U.S. households as well as Hispanic and African-American households. Overall, zero-vehicle households have more than halved between 1970 and 2023. Among Hispanic households, first measured in 1980 at 21.8 percent, the share has dropped by more than half to 10 percent in 2023. For African-American households, the percentage was 43 percent in 1970, halving by 2010 and continuing to decline since then. However, all the trends showed a slight increase in recent years.

Figure 2-6 Time of Departure to Work by Sex: 2023



Source: U.S. Department of Commerce, Census Bureau, "Commuting Characteristics by Sex." 2023 American Community Survey 1-Year Estimates Subject Tables, Table S0801.

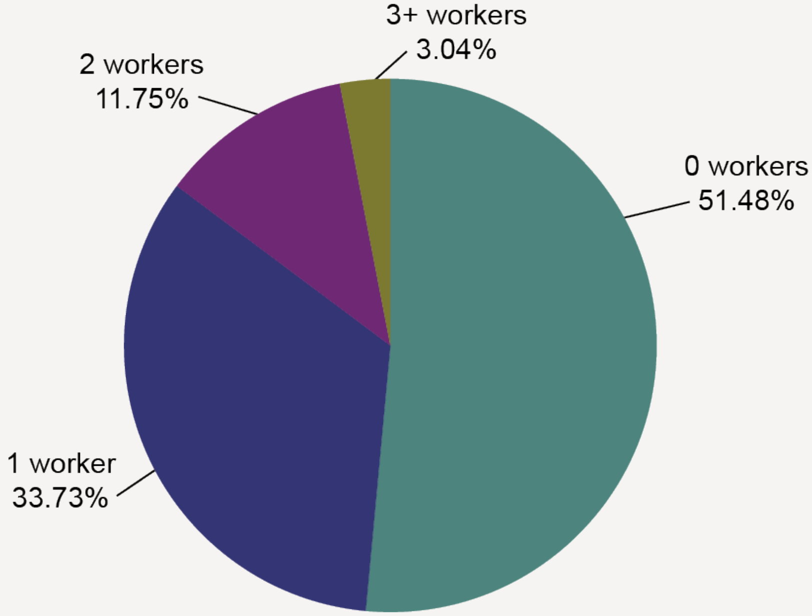
Figure 2-7 Share of Household by Vehicles Available: 1960–2023



Number of vehicles	1960	1970	1980	1990	2000	2010	2021	2022	2023
0 vehicles	21.5%	17.5%	12.9%	11.5%	10.3%	9.1%	8.0%	8.3%	8.4%
1 vehicle	57.0%	47.7%	35.5%	33.7%	34.2%	33.8%	32.9%	33.2%	33.3%
2 vehicles	19.1%	29.3%	34.0%	37.4%	38.4%	37.6%	37.1%	36.9%	36.5%
3+ vehicles	2.5%	5.5%	17.5%	17.4%	17.1%	19.5%	21.9%	21.6%	21.7%

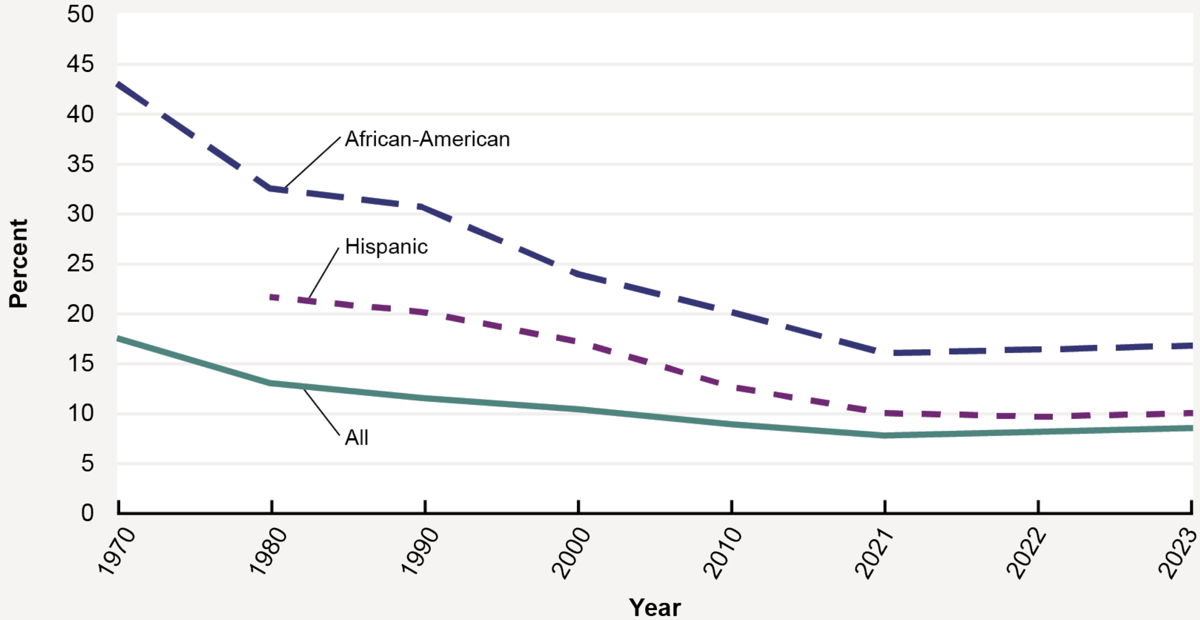
Source: U.S. Department of Commerce, Census Bureau, Decennial Census, and American Community Survey as of October 2024.

Figure 2-8 Workers in Zero-Vehicle Households by Number of Workers: 2023



Source: U.S. Department of Commerce, Census Bureau, "Number of Workers in Household by Vehicles Available." 2023 American Community Survey 1-Year Estimates Detailed Tables, Table B08203.

Figure 2-9 Long-Term Trends in Zero-Vehicle Households: 1970–2023



Ethnicity	1970	1980	1990	2000	2010	2021	2022	2023
All	17.5%	12.9%	11.5%	10.3%	9.1%	8.0%	8.30%	8.40%
African-American	43.1%	32.6%	30.5%	23.8%	20.0%	16.1%	16.40%	16.80%
Hispanic	—	21.8%	20.0%	17.2%	12.6%	9.9%	9.80%	10.00%

Source: U.S. Department of Commerce, Census Bureau, Decennial Census, and American Community Survey as of October 2024.
— No data available.

Data are somewhat limited for less-used commute modes. Table 2-5 provides the available data on the number of workers in these less-used categories in 2023 and the shares of these workers in total workers. There were twice as many males than females who biked to work in 2023. More males used taxicab, motorcycle or other means to commute than females.

Examining Household Transportation Expenditures

A useful starting point in examining household transportation expenditures is to differentiate geographic patterns (specifically, urban versus rural characteristics). Rural residents spend more on transportation than their urban counterparts and have more vehicles but fewer zero-vehicle households, The U.S. rural population constitutes only about 19 percent of the national total, while the urban population accounts for 81 percent. Urban areas are further divided into urban principal cities (35 percent), which include central cities and some major suburban centers, and other urban areas, defined as suburbs per the Consumer Expenditure Survey (46 percent). Rural populations are predominantly White non-Hispanics, with only about 7 percent African Americans and 6 percent Hispanics.

Residents in urban principal cities and rural areas have similar average incomes of around $95,000. Those living in other urban areas (i.e., suburban areas) have higher average annual incomes of around $110,000 [BLS 2024a]. Many of the demographic characteristics across these areas are surprisingly similar, including household size, the number of children, and the number of earners per household [BLS 2024a]. The major variation is in those over 65; more tend to live in rural households than in metro households. Interestingly, as highlighted in Table 2-6, such similarities did not carry into vehicle ownership. Rural households average about 2.5 vehicles per household, which is well above the urban average of about 1.7.

Table 2-5 Limited Volume Commute Modes by Sex: 2023

	All		Male		Female	
Mode	Number	Percent of total workers	Number	Percent of total workers	Number	Percent of total workers
TOTAL	**7,227,000**	**4.45**	**4,015,000**	**4.68**	**3,212,000**	**4.19**
Walked	3,966,000	2.44	2,087,000	2.43	1,879,000	2.45
Bicycle	762,000	0.47	530,000	0.62	232,000	0.30
Taxicab, motorcycle, or other means	2,499,000	1.54	1,398,000	1.63	1,101,000	1.44

Source: U.S. Department of Commerce, Census Bureau, “Means of Transportation to Work.” American Community Survey 1-year Estimates Detailed Tables, Table B08006, 2023.

Note: Details may not sum to the total due to rounding. Percentages are computed based on unrounded numbers.

Table 2-6 Average Number of Persons per Household by Demographic Characteristic and Geographic Area: 2023

		Urban			
Demographic characteristic	All Persons per household	TOTAL urban persons per household	Urban principal city persons per household	Other urban persons per household	Rural persons per household
Household size	2.5	2.4	2.3	2.5	2.6
Children under 18	0.6	0.6	0.5	0.6	0.6
Adults 65 and older	0.4	0.4	0.3	0.4	0.6
Earners	1.3	1.3	1.3	1.4	1.3
Vehicles	1.9	1.7	1.5	1.9	2.5

Source: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, 2023, Table 1721 Type of Area Expenditures. Available at: https://www.bls.gov/cex/tables/calendar-year/aggregate-group-share/cu-area-type-2023.xlsx as of October 2024.

Housing and transportation spending together typically account for about 50 percent of total household spending. In central cities, this percentage is closer to 51 percent due to higher housing costs despite lower transportation spending. The opposite is true in rural areas, where this percentage is approximately 49 percent. Transportation costs in rural areas are higher at 14 percent, while housing expenses are lower despite higher homeownership rates. Rural areas effectively trade lower housing costs for higher transportation spending. For example, vehicle insurance per vehicle in rural areas is 75 percent of metropolitan costs, but fuel expenses are nearly 20 percent higher than in metropolitan areas.

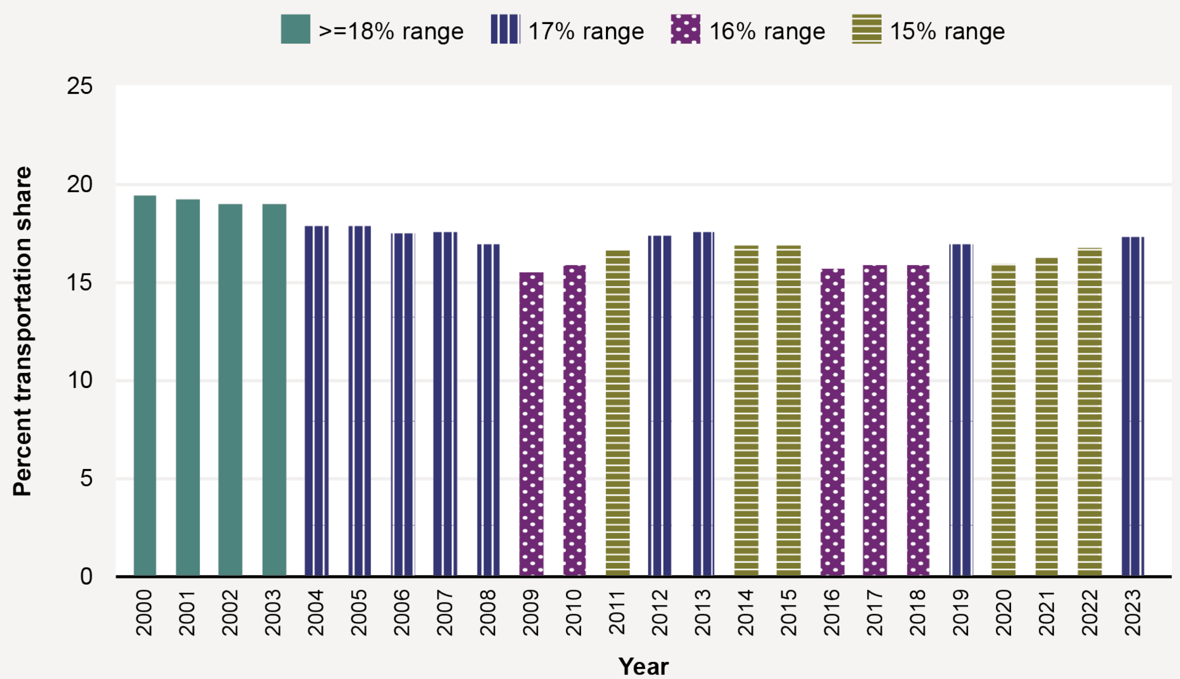
Figure 2-10 highlights transportation spending expressed as the share of total consumer spending throughout this century [BLS 2024b]. Initially, at 18 to 19 percent at the beginning of this century, that share has slowly declined, reaching 17 percent in 2023. This decrease reflects growth in other spending categories rather than a reduction in transportation costs. Notably, overall transportation spending grew by about 7 percent from 2022 to 2023 but was outpaced by spending on personal care, personal insurance, alcoholic beverages, education, and miscellaneous spending. This spending does not include expenditures reimbursed by an employer, an education institution, churches, or other sources.

Historically, transportation spending has been closely tied to the number of workers in a household as shown in Figure 2-11 [BLS 2024c]. Similar to the trends in 2022, in 2023, the number of non-earners remained stable at approximately 31 million, representing about 23 percent of census units—typically a single address, like a house or apartment, used by the Census Bureau to count population and housing data. In 2023, as in 2022, the number of persons in non-worker households made up nearly 14 percent of the total population. As noted previously, the baby boomer generation is expected to reach retirement age this decade. This shift, along with changes in worker patterns related to COVID-19, could result in substantial differences in the cost, time, and direction of local and intercity travel.

Low Income Households and Travel

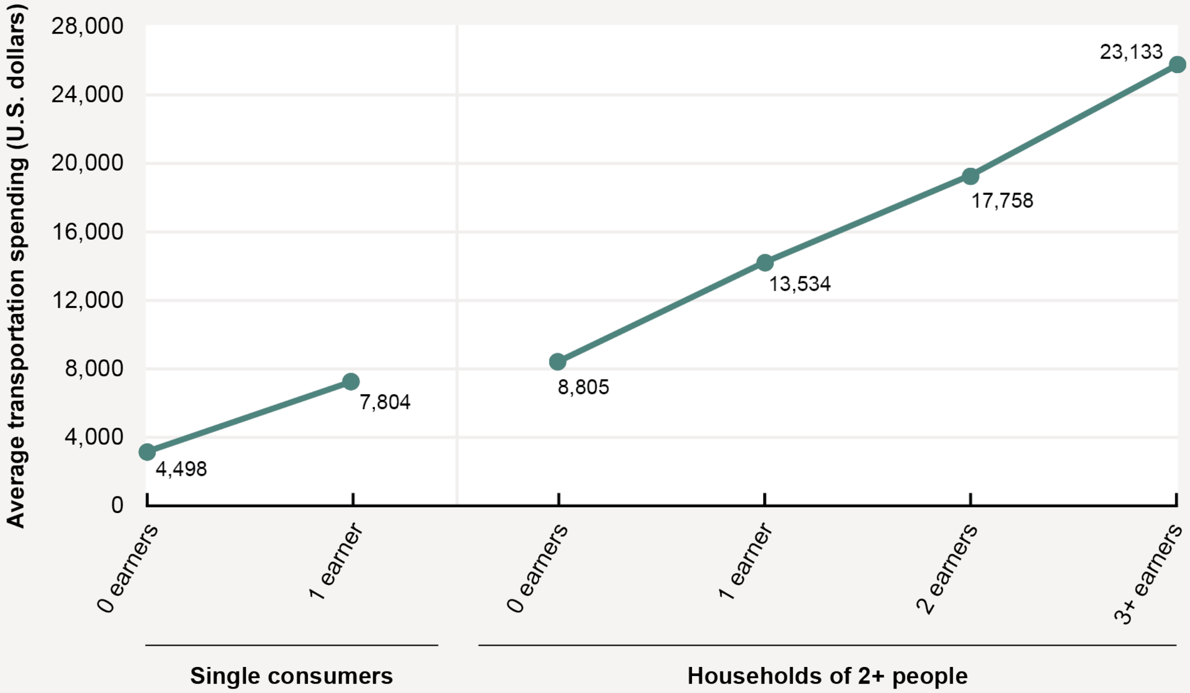
Demographics and incomes have a close relationship with vehicle ownership, which in turn influence travel patterns and mode choice. Figure 2-12 highlights demographic patterns by income quintile in 2023. Only three values changed from those in 2022, representing increases—specifically, auto ownership rose from 1.5 to 1.6 in the second lowest quintile, and in the middle quintile there was an increase of people per unit from 2.4 to 2.5 and an increase in adults over age 65 from 0.4 to 0.5 [BLS 2024c].

Figure 2-10 Transportation Share of Consumer Spending: 2000–2023



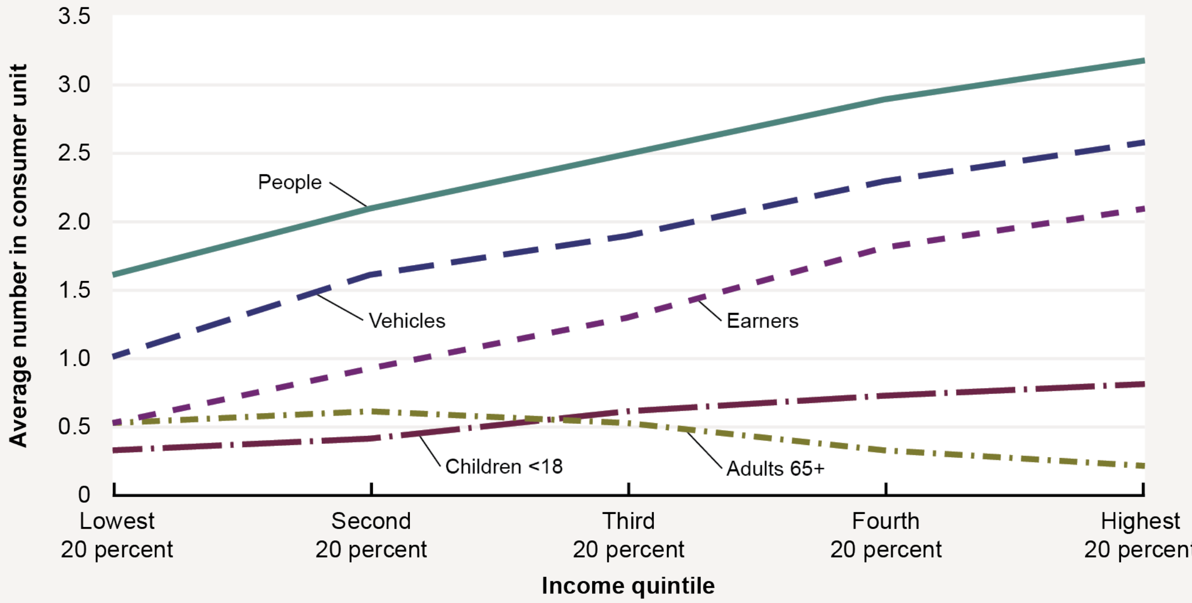
Source: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Surveys, available at https://www.bls.gov/cex/tables/top-line-means.htm as of October 2024.

Figure 2-11 Transportation Spending by Earner: 2023



Source: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, 2023, Table 1600, available at www.bls.gov/cex/tables.htm as of October 2024.

Figure 2-12 Demographic Patterns and Mean Household Income by Income Quintile: 2023



Measure	Lowest 20 percent	Second 20 percent	Third 20 percent	Fourth 20 percent	Highest 20 percent
People	1.6	2.1	2.5	2.9	3.2
Children <18	0.3	0.4	0.6	0.7	0.8
Adults 65+	0.5	0.6	0.5	0.3	0.2
Earners	0.5	0.9	1.3	1.8	2.1
Vehicles	1	1.6	1.9	2.3	2.6

Source: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, 2023, Table 1101, available at www.bls.gov/cex/tables.htm as of October 2024. Based on table B1908-1.

Households in the lowest quintile, with an average household income of $16,345 in 2023, exhibit several unexpected characteristics despite comprising 20 percent of households, like all other quintiles. The average household size in this quintile is 1.6 in contrast to the overall average of 2.5, meaning it represents about 13 percent of the total population while comprising 20 percent of all households. This results in anomalies, such as a higher vehicles-per-worker ratio than other quintiles (2.2 versus 1.4), prompting a deeper examination of its composition beyond income levels.

Table 2-7 breaks down in detail the lowest quintile. The quintile includes about 1 million college student households and almost 11 million retiree households, which probably explains the higher vehicle ownership in the quintile. Both groups are likely to have expenditures well beyond their incomes. There are more than 10 million households that include workers. The "All other" category in Table 2-7 includes workers.

African Americans represent just over 13 percent of the U.S. population but make up slightly more than 20 percent of those in the lowest income quintile. This group has a relatively small share of retirees and college students, but non-earners account for almost 30 percent of the quintile's population, and African Americans comprise almost 22 percent of workers in the quintile. Hispanics have only a slightly larger share of the population in the lowest quintile—16.6 percent compared to their overall share of 15.3 percent. Among Hispanics in this quintile, non-earners are underrepresented, while college students (22 percent) and workers (24.5 percent) have higher shares.

Emerging Issues: COVID-19 Impacts on Long-Distance

While this chapter is able to focus on the impacts of COVID-19 on local travel, limited data on longer-distance travel hinders the examination of COVID impacts. Nevertheless, the trend of spending on travel provides an important measure to examine the impact of COVID-19 on different demographic groups. The data from the Consumer Expenditure Survey may be the only public source of intercity travel spending by minority groups.

Using 2019 as the base year, Table 2-8 shows that the national average for intercity spending among all households was about $790. Hispanics spent about $610, African Americans spent about $560, while Asians spent over $1,900. Asians, identified as the highest income group, spend an average of $1,300 on airline fares—more than double the

Table 2-7 Characteristics of Lowest Income Quintile of Members per Household with Vehicle Ownership: 2023

Characteristic	All households	All households in lowest quintile	Household members in college	Household members retired	Household members nonearners	All other
Households (number)	134,555,809	26,753,626	975,609	10,759,635	4,908,236	10,110,147
Black or African American (percent)	13.34	20.06	16.11	14.61	29.32	21.76
White (percent)	79.00	73.57	55.53	81.75	64.26	71.11
Asian (percent)	5.53	3.98	26.75	2.24	3.36	3.93
All other races not including Black or African American (percent)	2.12	2.39	1.61	1.40	3.07	3.19
Hispanic or Latino (percent)	15.29	16.62	22.17	9.82	14.15	24.53
Not Hispanic or Latino (percent)	84.71	83.37	77.83	90.18	85.85	75.47
At least one vehicle owned or leased (percent)	88.98	70.40	53.03	77.37	49.01	75.03
Average number of vehicles	1.88	1.03	0.68	1.16	0.68	1.10
Average number of people	2.46	1.62	1.47	1.24	1.65	2.02
Average number of children <18	0.57	0.29	0.21	0.02	0.34	0.55
Average number of adults 65+	0.43	0.53	0.01	1.02	0.27	0.18
Average number of earners	1.32	0.46	0.52	0.00	0.00	1.16

Source: Special tabulation of Consumer Expenditure Survey by Bureau of Labor Statistics for the Bureau of Transportation Statistics.

Note: The Consumer Unit (CU) in the source data is renamed Household for the narrative purpose in this report. According to BLS, "A consumer unit (CU) is the measurement unit collected for the eligible individuals represented in the expenditure reports. Students living in university-sponsored housing are also included in the sample as separate CUs." (BLS 2024d).

Table 2-8 Average Annual Household Expenditures on Intercity Transportation (2023 Dollars): 2019–2023

Year	Public and other transportation purchased	All Households	Hispanic or Latino	Black or African-American	Asian
2019	**TOTAL**	**$789.83**	**$610.76**	**$558.92**	**$1,926.51**
	Airline fares	513.14	337.80	274.69	1,300.27
	Intercity bus fares	15.28	14.29	8.86	24.82
	Local transportation on out-of-town trips	20.33	12.38	11.00	44.15
	Taxi fares and limousine services on trips	11.94	7.27	6.46	25.93
	Intercity train fares	30.35	19.50	18.26	57.10
	Ship fares	56.39	37.91	43.09	147.08
2020	**TOTAL**	**$263.58**	**$292.32**	**$224.71**	**$432.11**
	Airline fares	159.89	150.80	69.70	261.01
	Intercity bus fares	2.23	4.23	0.38	2.15
	Local transportation on out-of-town trips	6.89	4.21	3.55	6.79
	Taxi fares and limousine services on trips	4.05	2.48	2.08	3.99
	Intercity train fares	8.12	6.63	2.75	7.58
	Ship fares	11.24	9.63	1.65	12.84
2021	**TOTAL**	**$483.00**	**$424.54**	**$472.77**	**$753.12**
	Airline fares	321.99	257.83	236.74	512.80
	Intercity bus fares	4.18	4.94	2.57	4.93
	Local transportation on out-of-town trips	14.21	8.82	9.47	19.31
	Taxi fares and limousine services on trips	8.35	5.18	5.56	11.34
	Intercity train fares	11.16	6.92	7.94	19.74
	Ship fares	19.51	10.14	10.17	19.06
2022	**TOTAL**	**$845.17**	**$671.56**	**$595.14**	**$1,648.72**
	Airline fares	606.41	442.03	362.05	1,187.21
	Intercity bus fares	9.25	11.12	4.31	12.41
	Local transportation on out-of-town trips	24.81	15.61	20.36	41.73
	Taxi fares and limousine services on trips	14.57	9.17	11.96	24.51
	Intercity train fares	24.24	10.85	15.77	34.56
	Ship fares	37.64	12.85	21.60	39.38
2023	**TOTAL**	**$1,095.60**	**$834.42**	**$820.30**	**$2,658.04**
	Airline fares	690.25	480.53	332.77	1,855.89
	Intercity bus fares	12.76	7.53	9.21	35.05
	Local transportation on out-of-town trips	28.60	19.51	14.69	75.10
	Taxi fares and limousine services on trips	16.79	11.46	8.63	44.11
	Intercity train fares	31.01	10.75	24.44	73.47
	Ship fares	127.27	39.80	61.73	247.99

Source: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey, 2023. Special tabulation by the Bureau of Transportation Statistics.

national average for all households. This may be due to long-distance visits to friends and family who remain in Asia. Even Asians' other spending reached levels more than double the average. In 2020, all consumers' spending dropped to one-third of 2019 levels, with Asians experiencing a more significant decline, reaching only about one-quarter of their 2019 spending. In contrast, Hispanics and African Americans saw smaller declines. By 2023, spending had rebounded and surpassed 2019 levels by approximately 40 percent, in what some have referred to as "revenge tourism," as families made up for trips deferred over the previous 3 years. However, trends varied considerably by race/ethnicity and mode of transportation.

Two crucial areas stand out in Table 2-8: intercity bus fares and train fares. Overall, in 2023, national train spending had returned to just above 2019 levels, with Hispanics spending only about half of their 2019 spending. The other two racial groups saw spending levels approximately 30 percent higher than in 2019. Intercity bus spending remained below 2019 levels for the Hispanic group and the overall population. African-American spending was on par with 2019 spending, while Asian spending was well above 2019 levels.

Changes in Intercity and International Travel

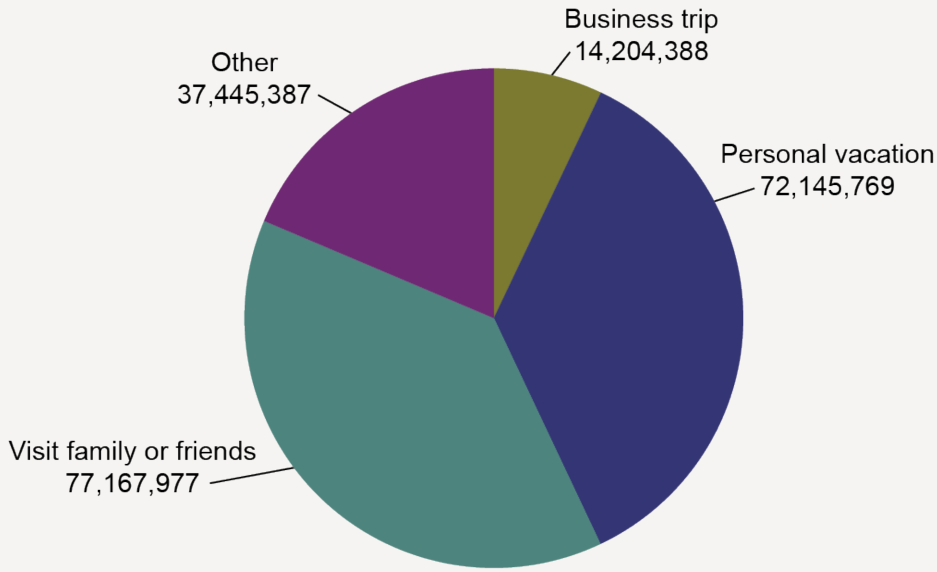
The 2022 NHTS collected intercity data for the first time in decades, providing valuable indicators of travel patterns observed during the COVID-19 recovery period [FHWA 2022]. The survey identified almost 201.4 million total trips within the country, each over 50 miles—the threshold to define intercity travel. Of these, 85 percent were made by private vehicles, while air travel accounted for an additional 12 percent. In 2022, Over 14 million business-related trips were made by vehicles and another 3.4 million by air. For visits to family and friends, vehicles again dominated with over 77 million trips and almost 11 million trips by air. Other modes of transportation were minimal, totaling around 1.5 million. Personal vacations followed the same pattern, with more than 72 million trips by vehicle and about 13 million by air, while all other modes totaled less than 1 million.

Auto travel during this period accounted for over 200 million trips, with business travel accounting for about 7 percent, vacation travel accounting for almost 36 percent, visits to family accounting for 38 percent, and other (i.e., health, religious, or personal) accounting for just below 19 percent (Figure 2-13).

Amtrak

In FY 2023, Amtrak observed a 26 percent increase in ridership over FY 2022 [Amtrak 2024]. About 28.6 million customers rode Amtrak services nationwide—almost 78,300 trips on an average day in 2023. This was largely the product of Northeast Corridor growth, where ridership was often back to pre-COVID-19 levels. Of the top 10 Amtrak stations only 2 (i.e., Chicago and Los Angeles) are

Figure 2-13 Long-Distance Auto Travel by Trip Purpose: 2022



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 2022 National Household Travel Survey, Explore NHTS Data - Data Explorer (DE) Tool, available at https://nhts.ornl.gov.

outside the Northeast. State-supported ridership grew nearly 23 percent. Some routes in the Amtrak system include thruway connecting services, which include transportation provided by bus, train, ferry, van, or taxi via a variety of operators.

National Parks

Changing trends in destinations in 2023 can be seen through visits to national parks, as summarized in Figure 2-14 [NPS 2024a]. After a sharp 2020 decline due to park closures, recovery was swift, driven by the appeal of outdoor spaces that avoided confining visitors inside with others and were largely accessible. At the same time, the National Park Service responded well to national needs and desires. The Blue Ridge Parkway, the Golden Gate National Recreation Area, and the Great Smokey Mountains National ranked as the top three facilities by number of visits in 2023, collectively receiving over 45 million recreation visits. Each site recorded between 13 and 17 million visitors [NPS 2024b].

School Travel

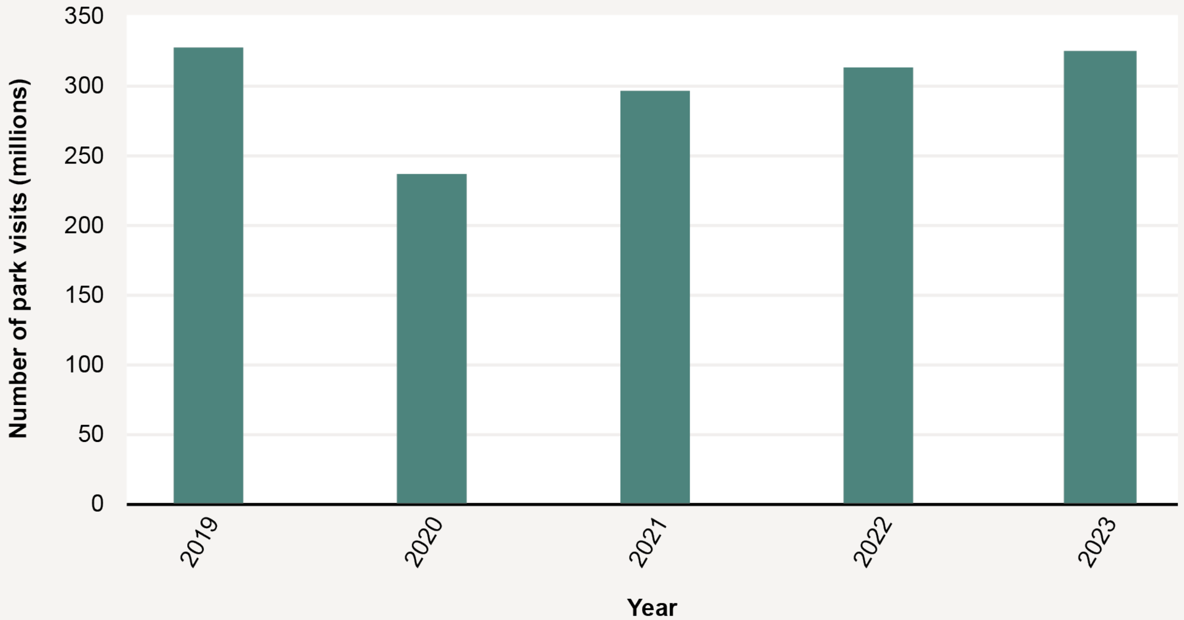
The School Pulse Panel (SPP) Survey is administered by the National Center for Education Statistics (NCES). The survey sample comprises 4,000 public elementary, middle, high, and combined-grade schools selected to participate in the panel. The results of SPP are considered "experimental data" since the data are collected using new data sources or methodologies, the details of which are not publicly available. Table 2-9 presents a summary of school transportation available to and used by students by mode from the 2023–2024. School bus, car drop-off/pick-up, walking, and biking, scooter, and skateboard, and so forth, are available for a dominant proportion of schools while public transportation was only available for less than one third of the public schools. The top transportation modes used by students were school bus, accounting for 40 percent, followed by car drop-off/pick-up (33 percent) and walking (13 percent).

Air Travel

A notable aspect of air travel in America is that 86 percent of U.S. adults have flown at least once in their lifetime, and half of the total population has flown in the last 12 months, as shown in Figure 2-15 [Airlines for America 2023, 2024].

The Nation's airline industry enjoyed a booming year in 2019, with projections that domestic travel alone could reach 1 billion passengers by 2021 or 2022. However, as shown in Table 2 10 the system collapsed in 2020, with passenger levels dropping to just over 40 percent. It took until 2023 for carriers to regain 2019 levels domestically; international travel still fell short in the same year. However, the overall total level of 2023 ridership was back to 2019 levels.

Figure 2-14 National Park Visits: 2019–2023



Source: Annual Visitation Statistics Release, National Reports, National Park Service, available at https://www.nps.gov/subjects/socialscience/visitor-use-statistics-dashboard.htm.

Table 2-9 Modes of Transportation Available for and Used by Students to Travel to and From School

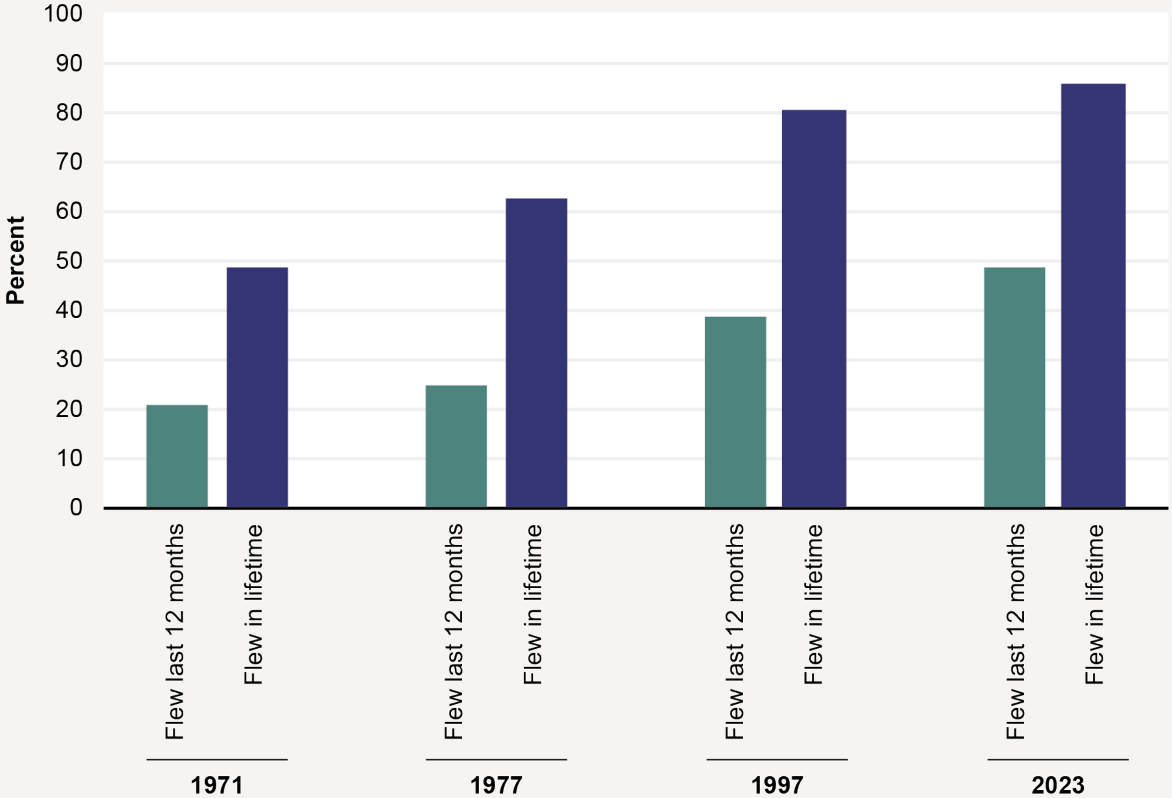
Mode	Availability			Used by students
	Yes	No	Missing	
School bus	87	13	1	40
Public transportation	31	69	7	3
Bike, scooter, skateboard, other	78	22	3	4
Walking	87	13	2	13
Auto drop-off/pick-up	98	2	#	33
Drive car	34	66	8	6
Other	44	56	84	‡

Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, School Pulse Panel Survey 2023–2024.

Rounds to zero.

‡ Reporting standard not met.

Figure 2-15 Share of U.S. Adults Who Have Flown in an Airplane



Source: Airlines for America, *Air Travelers in America: Key Findings of a Survey Conducted by Ipsos*, available at https://www.airlines.org/wp-content/uploads/2024/03/A4A-Air-Travel-Survey-Key-Findings-March-2024.pdf as of August 2024.

Intercity Bus

The industry suffered during the COVID-19 period, losing tour charters to entertainment sites and events such as sporting events and transporting students to and from colleges and universities. They also suffered losses among long-distance worker charters due to company shutdowns or shifts to WAH. Intercity bus travel is a valuable segment of the travel industry that needs sound annual statistical reporting.

Cruise Industry

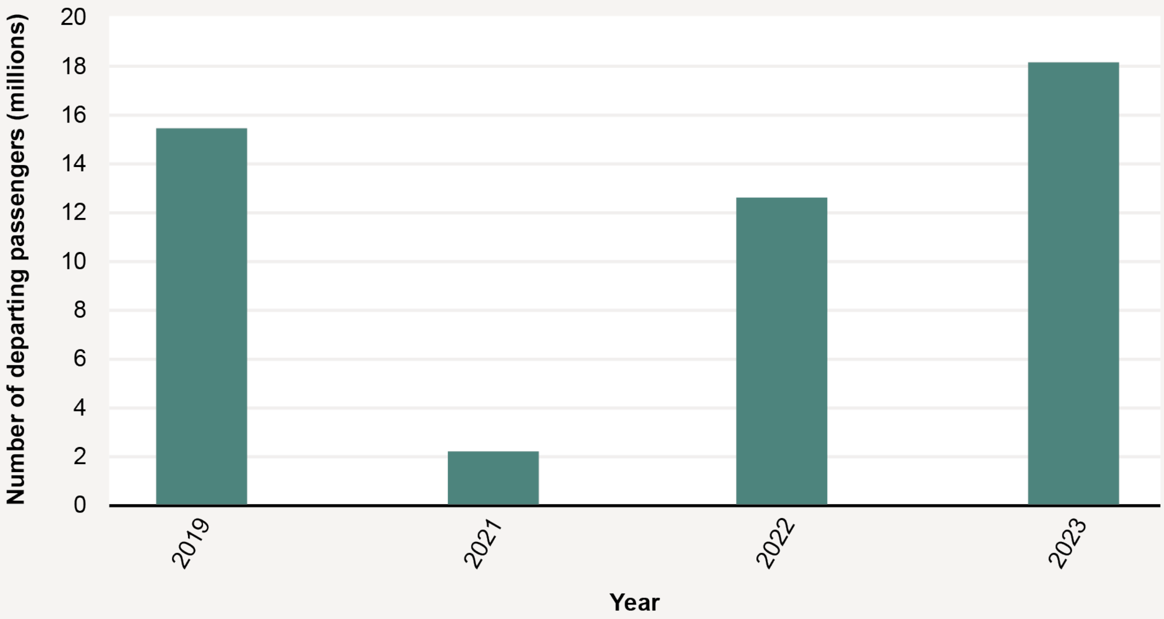
According to the Cruise Lines International Association (CLIA), the cruise industry carried 18.1 million passengers in 2023, surpassing 2019 levels by more than 2.7 million passengers. This is impressive given the near-zero passenger count in 2020 and a small gain in 2021 (Figure 2-16). The average stay aboard a ship was 6.8 days, which is consistent with 2019 trends. About 65 percent of cruisers

Table 2-10 U.S. Domestic and International Air Travel: 2019–2023

Year	Domestic	International	TOTAL
2019	811,545,260	241,419,751	**1,052,965,011**
2020	337,519,065	63,049,602	**400,568,667**
2021	605,935,383	94,624,181	**700,559,564**
2022	750,558,998	186,808,094	**937,367,092**
2023	819,320,692	233,875,278	**1,053,195,970**
2023 share of 2019	100.96%	96.87%	**100.02%**

Source: BTS T-100 Market data, available at https://www.transtats.bts.gov/Data_Elements.aspx?Data=1 as of November 2024.

Figure 2-16 North American Cruise Departures: 2019–2023



Source: CLIA, available at https://cruising.org/-/media/clia-media/research/2024/clia-003-overview-north-america-2023-year-end.ashx as of November 2024.

Note: 2020 data are not available.

are destined to the Caribbean, making Florida the world's center for cruise departures. The second largest destination is Alaska at 8.3 percent, with origins on the West Coast. In 2024, Galveston, TX, has now emerged as a cruise port.

International Travel

The United Nations World Tourism Organization's International Barometer estimated that global tourist arrivals in 2023 reached 1.3 billion visitors, approximately 11 percent below 2019 levels [UNWTO 2024]. Advanced economies (an International Monetary Fund classification[1]) accounted for 55 percent of that travel, and emerging economies[2] accounted for the remainder. Tourist arrivals reached 96 percent of prepandamic levels between January and July 2024.

U.S. Citizen Departures from the United States in 2023

Total U.S. citizen departures reached 98.5 million in 2023, which was a 22 percent increase from 80.8 million in 2022. This brought the number of departures close to 2019 levels, as shown in Figure 2-17.

Table 2-11 shows travel flows from the United States to other parts of the world in 2023. It differentiates overseas travel from land border crossings to Mexico and Canada.

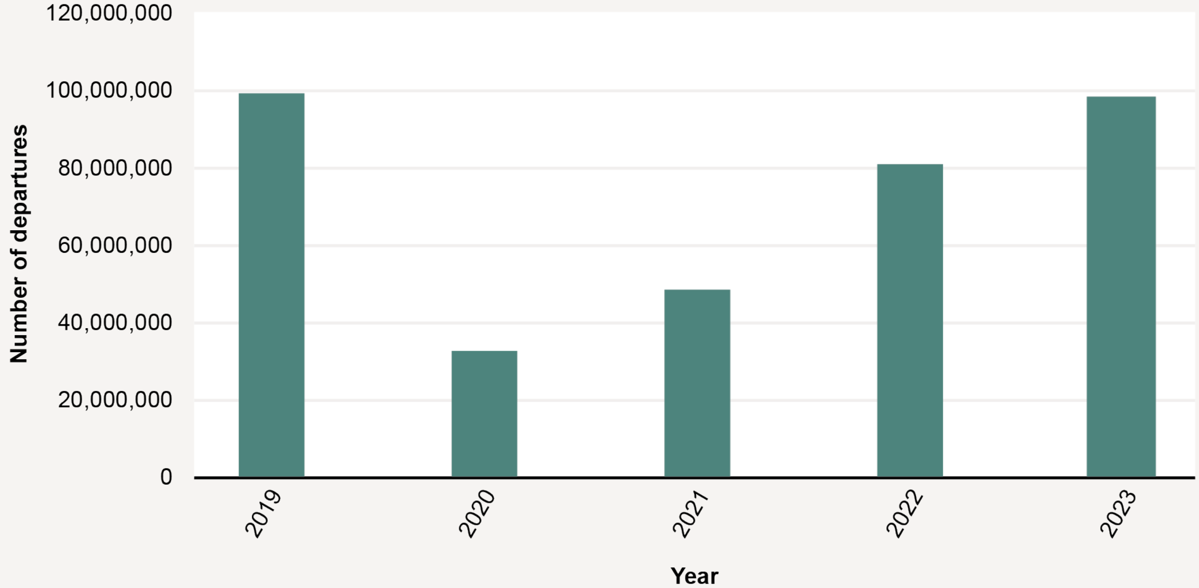
International Inbound Travel

Table 2-12 presents a measure of current international land border crossing visits to the United States from Canada and Mexico, which have still not recovered. Part of that is work and business related. Little of this travel is on commercial transports, mostly in personal vehicles and in the case of Mexico, pedestrians. The results show that 2023 levels in Mexico and Canada were roughly stable.

International arrivals to the Unites States increased by 15.7 million over 2022, reaching about 84 percent of arrivals in 2019, which was almost 80 million. The International Trade Administration's National Travel and Tourism Office (NTTO) forecasts that by 2025, arrivals will exceed 2019 levels, potentially reaching around 85 million.

1 An advance economy is a country with a high level of development as defined by the IMF, based on factors such as per capita income, exports, financial integration, industrialization, legal and regulatory environment and commercial infrastructure.
2 A country transitioning from a low income, often preindustrial economy toward a modern industrial economy with a high standard of living.

Figure 2-17 U.S. Citizen International Departures Recovery Trend: 2019–2023



Source: Department of Commerce, National Travel and Tourism Office 2023 Annual Report.

Table 2-11 U.S. Citizen Travel to International Regions: 2023

Category	Region	TOTAL	Percent change	Percent market share
Overseas	**TOTAL overseas**[1]	**48,962,778**	**28.5**	**49.7**
	Europe	20,059,137	26.8	20.4
	Caribbean	10,741,221	16.7	10.9
	Asia	5,578,533	110.2	5.7
	South America	3,037,937	21.2	3.1
	Central America	4,354,982	17.6	4.4
	Oceania	822,003	78.4	0.8
	Middle East	3,591,677	15.1	3.6
	Africa	777,288	23.3	0.8
North America	**TOTAL North America**	**49,494,449**	**15.9**	**50.3**
	Mexico (TOTAL)[2,P]	36,706,104	9.0	37.3
	Mexico (Air)[1]	13,398,747	3.9	[4]
	Canada (TOTAL)[3]	12,788,345	40.7	13.0
	Canada (Air)[3]	4,607,955	36.1	[4]
Grand TOTAL		**98,457,227**	**21.8**	**100.0**

Source: U.S. Department of Commerce, International Trade Administration, National Travel and Tourism Office as of March 2024.

[1] Overseas and Mexico air traffic (nonstop from U.S. port to foreign port) source: DHS APIS I-92.

[2] Mexico aggregate total (Including air, land and border 1+ nights), source: INEGI/Banco de Mexico; P = Preliminary 2022.

[3] Canadian aggregate total (including air, land and border 1+ nights), source: STATS Canada.

[4] Market share of air travel compared to all U.S.-international air travel: Mexico-air 20.0 percent; Canada-air 6.9 percent year-to-date.

Table 2-12 U.S. Border Land-Passenger Gateways Entering the United States (Thousands): 2019–2023

Year	Country	TOTAL	Person 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	26,773	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	68,548	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
2023	**TOTAL**	**218,961**	**175,547**	**39,638**	**3,412**	**251**	**96,500**	**167**
	Mexico	**176,922**	134,928	39,422	2,454	5	75,892	119
	Canada	**42,039**	40,619	216	958	246	20,608	48

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 July 2024.

Foreign Arrivals

In 2023, the United States welcomed over 66.5 million international tourists—a 31 percent increase from 2022 at 50.8 million [NTTO 2024a]. However, this number was still 16.2 percent below 2019 at 79.4 million visitors (Figure 2-18). Despite this shortfall, with 66.5 million visitors, the United States ranked third globally in visitor numbers behind France (100 million) and Spain (85 million) and ranked first in spending, often due to longer stays.

NTTO's future visitor forecasts categorize countries into the following groups based on how their current tourism levels compare to historical patterns from 2019 [NTTO 2024b]:

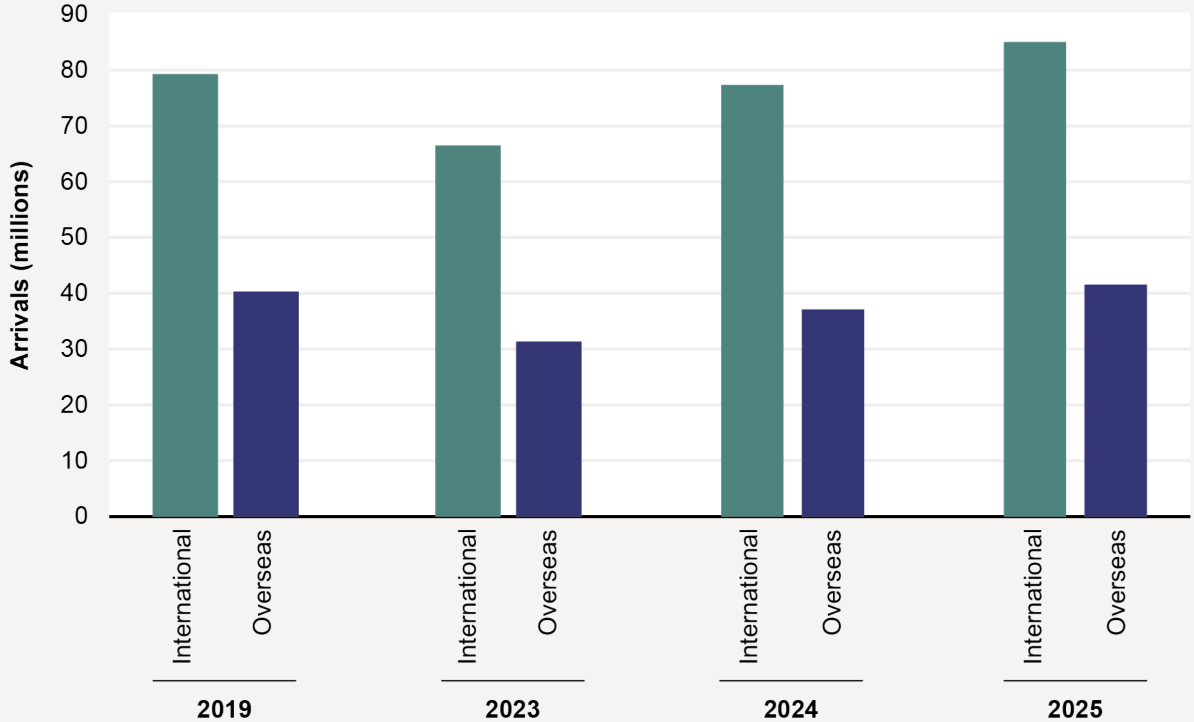
- **Group 1—fully recovered:** India and Canada.
- **Group 2—close to fully recovered (i.e., 80–90 percent):** European countries.
- **Group 3—medium recovery (i.e., 70–80 percent):** Mexico, Brazil, Australia, and S. Korea
- **Group 4—slow recovery:** Japan and China may reach 2019 levels by 2026.

In 2023, Canada and Mexico remained the top sources of visitor arrivals to the United States, with 20.5 million and 14.5 million visitors, respectively (Table 2-13) [NTTO 2024a].

Excluding Canada and Mexico, the United Kingdom topped the list with 3.9 million visitors, followed by Germany (1.84 million), India (1.76 million), Brazil (1.63 million), South Korea (1.6 million), and France (1.59 million). Japan and China round out the countries sending more than a million visitors annually [NTTO 2024a].

In 2019, international visitors spent $233.5 billion visiting the United States, injecting nearly $640 million daily to the U.S. economy. By 2023, spending by international visitors to the United States totaled $213.1 billion, an increase of $47.6 billion from $165.5 billion in 2022, reaching 89 percent of 2019 levels. At 14.5 percent of international travel spending globally, international travelers spend more in the United States than any other country. Despite being the world leader in revenue from foreign tourism, the United States suffered a 2.3 billion trade deficit in 2023 as citizens spent more traveling abroad. This leads to the inference that U.S. travelers are the world leader in tourism spending.

Figure 2-18 Total Foreign Arrivals: 2019–2025 (Millions)



Source: National Travel and Tourism Office, International Visitor Forecast, February 1 2024, available at https://www.trade.gov/sites/default/files/2024-01/2024-Forecast-Summary.pdf.

Note: 2025 forecast is projected to reach 2019 levels. Oversea arrivals equals international arrivals minus arrivals from Canada and Mexico.

Table 2-13 International Visitors to the U.S. by World Region of Residence: 2023

Year	Overseas visitors to the U.S. by world region of residence	Number of arrivals	Percent 2023 share	Percent change from 2022
2023	**TOTAL overseas**	**31,468,481**	**100.0**	**31.4**
	Western Europe	12,229,492	38.9	18.3
	Eastern Europe	930,347	3.0	32.0
	Asia	7,549,188	24.0	83.1
	Middle East	1,035,463	3.3	20.2
	Africa	530,513	1.7	44.7
	Oceania	1,232,590	3.9	54.4
	South America	4,833,339	15.4	14.7
	Central America (excluding Mexico)	1,473,063	4.7	23.6
	Caribbean	1,654,486	5.3	22.4
Year-to-date 2023	**TOTAL overseas**	**31,468,481**	**47.3**	**31.4**
	Mexico	14,499,093	21.8	16.6
	Canada	20,514,314	30.9	42.6
Grand TOTAL		**66,481,888**	**100.0**	**30.9**

Source: International Trade Association, *NTTO Releases International Travel Statistics for 2023*, available at https://www.trade.gov/feature-article/ntto-releases-international-travel-statistics-2023.

Lack of Transportation

The last topic in this section highlights the issue the Nation faces in transportation accessibility. The National Center for Health Statistics (NCHS) estimated the percentage of adults who lacked reliable transportation for daily living in the past 12 months in the United States [NCHS 2024]. The overall findings suggest that variations in the Nation and among different population segments are limited. The most significant geographic difference is between the North Central and New England regions. The percentage of adults who lacked reliable transportation for daily living in the past 12 months was 7.5 for North Central region and 4.1 for New England, while the national average of the same measure was 5.7 percent.

Key findings from the survey include the following:

- In 2022, 5.7 percent of adults lacked reliable transportation for daily living in the past 12 months. Females (6.1 percent) were more likely than males (5.3 percent) to lack reliable transportation.
- The percentage of adults who lacked reliable transportation was lowest among Asian non-Hispanic adults (3.6 percent) compared with other races and Hispanic origin groups.
- Lack of reliable transportation decreased as education levels and family income increased.

Adults living in the West North Central region of the United States (7.5 percent) were more likely to lack reliable transportation compared to the national average (5.7 percent), while adults in New England (4.1 percent) were less likely.

Data Gaps

This chapter examines the shifts in passenger transportation during the COVID-19 years and explores their implications within existing data constraints. Given that the full effects of the pandemic may take years to fully understand, a more comprehensive analysis should be made in the future when the implications have stabilized further, the assessment is less speculative, and statistical capabilities are better. Long-term monitoring is critical. Key questions to explore might include *When will passenger transportation return to 2019 levels?* and *How have passenger behaviors changed permanently in the postpandemic landscape?*

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 that many statistical agencies were able 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 like cell phone tracks and other location-based service data provide a wealth of timely observations on the volume and patterns of travel, these sources rarely can indicate socioeconomic characteristics associated with the observed travel behavior. Much is known about travel volumes, but little is known about a 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 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 NHTS and its predecessors, understanding of long-distance travel is limited to airline passenger counts and itineraries and sporadic national surveys last conducted by the U.S. Department of Transportation in 1995. Progress has been made in that a new NHTS was published this year that provides some level of intercity travel information. Because of survey weaknesses, it is unknown how much travel on local transportation infrastructure is performed by people traveling through an area or by those 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, aviation planners, and responsible government agencies lack basic information on the demographics and trip purposes of their customers, which limits forecasting and effective understanding of air travel 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 are immensely valuable but 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 fragmented in coverage and scope. There is information that the National Park Service is now conducting visitor surveys that will broaden our knowledge substantially. Also, 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. All of this argues for the need to design and conduct an in-depth national travel survey of away-from-home travelers.

Concerning local travel, a better understanding is needed on the use of micro-mobility modes, typically found in the urban environment, and includes 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. Two beneficial surveys are briefly presented in this chapter. The studies address means of access to schools at a detailed level and access to other needs, such as medical and social services, among others.

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 WAH a majority of the days of a usual work week. ATUS, which has asked the WAH question of respondents for “yesterday,” is a beneficial step forward. The transportation profession now needs statistics on occasional telework, recurring telework by day of the 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 WAH changes, a significant part of the traditional travel landscape—the workplace—has been altered; both the directions and temporal structure of many trip patterns have been reformed. Survey data on travel tabulated at the workplace has been reduced in value.

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. For example, the Washington metro area has seven separately designated principal cities in addition to Washington, DC, itself. At present, transportation flows between these disparate locations are treated as one internal area. This chapter suffered gaps in the rural statistics and other areas due to this distinction. Separating the two groups by renaming the central cities as such and then labeling suburban centers as principal cities wherever 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 datasets can give some insights, there is not a comprehensive multimodal framework for reporting on transportation services availability. Work toward developing these measures needs to be underway on many levels.

References

Airlines for America

——2023. *New Survey: Nearly 90 Percent of Americans Have Flown Commercially*. Available at https://www.airlines.org/new-survey-nearly-90-percent-of-americans-have-flown-commercially/.

——2024. *Air Travelers in America: Key Findings of a Survey Conducted by Ipsos*. Available at https://www.airlines.org/wp-content/uploads/2024/03/A4A-Air-Travel-Survey-Key-Findings-March-2024.pdf.

Amtrak. 2024. *FY 2023 Company Profile*. Available at https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/corporate/nationalfactsheets/Amtrak-Company-Profile-FY2023-041824.pdf.

Bureau of Labor Statistics (BLS)

——2024a. Consumer Expenditure Surveys, 2023. Table 1721. Type of area: Shares of annual aggregate expenditures and sources of income. Available at https://www.bls.gov/cex/tables/calendar-year/aggregate-group-share/cu-area-type-2023.xlsx.

——2024b. Consumer Expenditure Surveys, Top line means tables. Available at https://www.bls.gov/cex/tables/top-line-means.htm.

——2024c. Consumer Expenditure Surveys, 2023. Table 1101. Quintiles of income before taxes: Annual expenditure means, shares, standard errors, and relative standard errors, Consumer Expenditure Surveys. Available at https://www.bls.gov/cex/tables/calendar-year/mean-item-share-average-standard-error/cu-income-quintiles-before-taxes-2023.xlsx.

——2024d. "Consumer Expenditures and Income: Concepts" Available at https://www.bls.gov/opub/hom/cex/concepts.htm.

——2024e. Consumer Expenditure Survey, 2023. Table 1600, "Number of earners in consumer unit: Annual expenditure means, shares, standard errors, and relative standard errors." Available at https://www.bls.gov/cex/tables/calendar-year/mean-item-share-average-standard-error/cu-earners-2023.xlsx.

U.S. Census Bureau (Census)

——2024a. Annual Estimates of the Resident Population for Selected Age Groups by Sex for the United States: April 1, 2020, to July 1, 2023 (NC-EST2023-AGESEX). Available at https://www2.census.gov/programs-surveys/popest/tables/2020-2023/national/asrh/nc-est2023-agesex.xlsx.

——2024b. Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin for the United States: April 1, 2020, to July 1, 2023 (NC-EST2023-SR11H). Available at https://www2.census.gov/programs-surveys/popest/tables/2020-2023/national/asrh/nc-est2023-sr11h.xlsx.

——2024c. Estimates of the Components of Resident Population Change by Race and Hispanic Origin for the United States: April 1, 2020, to July 1, 2023 (NC-EST2023-COMPN). Available at https://www2.census.gov/programs-surveys/popest/tables/2020-2023/national/asrh/nc-est2023-compn.xlsx.

——2024d. More Counties Saw Population Gains in 2023. Press Release Number: CB24-44. March 14, 2024. Available at https://www.census.gov/newsroom/press-releases/2024/population-estimates-more-counties-population-gains-2023.html.

——2024e. New Estimates Highlight Differences in Growth Between the U.S. Hispanic and Non-Hispanic Populations. June 27, 2024. Press Release Number: CB24-109. Available at https://www.census.gov/newsroom/press-releases/2024/population-estimates-characteristics.html.

——2024f. "Movers Between Regions." American Community Survey, ACS 1-Year Estimates Subject Tables, Table S0702, 2023. Available at https://data.census.gov/table/ACSST1Y2023.S0702?q=S0702.

——2024g. "Movers Between Regions." American Community Survey, ACS 1-Year Estimates Subject Tables, Table S0702, 2022. Available at https://data.census.gov/table/ACSST1Y2022.S0702?q=S0702.

——2024h. "Means of Transportation to Work by Selected Characteristics." American Community Survey, ACS 1-Year Estimates Subject Tables, Table S0802, 2023. Available at https://data.census.gov/table/ACSST1Y2023.S0802?q=S0802.

——2024i. "Commuting Characteristics by Sex." American Community Survey, ACS 1-Year Estimates Subject Tables, Table S0801, 2023. Available at https://data.census.gov/table/ACSST1Y2023.S0801?q=S0801.

——2024j. "Means of Transportation to Work by Workers' Earnings in the Past 12 Months." American Community Survey, ACS 1-Year Estimates Detailed Tables, Table B08119, 2023. Available at https://data.census.gov/table/ACSDT1Y2023.B08119.

——2024k. "Selected Population Profile in the United States." American Community Survey, ACS 1-Year Estimates Selected Population Profiles, Table S0201, 2010, 2019, 2021, 2022 and 2023. Available at https://data.census.gov/table/ACSSPP1Y2023.S0201?q=S0201.

Cox, W. 2024. "More on the Flight from Density: Within Major Metropolitan Areas," *NewGeography*. Available at https://www.newgeography.com/content/008255-more-flight-density-within-major-metropolitan-areas.

Federal Highway Administration (FHWA). 2022. *2022 National Household Travel Survey*. Available at https://nhts.ornl.gov.

National Center for Health Statistics (NCHS). 2024. *Lack of Reliable Transportation for Daily Living Among Adults: United States, 2022*, NCHS Data Brief, N0. 490. Available at https://www.cdc.gov/nchs/data/databriefs/db490.pdf.

National Park Service (NPS)

——2024a. Annual Summary Report for Recreation Visits, National Reports. Available at https://www.nps.gov/subjects/socialscience/visitor-use-statistics-dashboard.htm.

——2024b. Annual Park Ranking Report for Recreation Visits in: 2023, National Reports. Available at https://www.nps.gov/subjects/socialscience/visitor-use-statistics-dashboard.htm.

National Travel and Tourism Office (NTTO)

——2024a. International Visitor Forecast table. Available at https://www.trade.gov/sites/default/files/2024-01/2024-Forecast-Tables.pdf.

——2024b. International Visitor Forecast summary report. Available at https://www.trade.gov/sites/default/files/2024-01/2024-Forecast-Summary.pdf.

Reynolds, M. T. 2023. *National Park Visitor Issues: Examining Barriers to Access: Ongoing Visitor Experience Issues at America's National Parks.* National Park Service, U.S. Department of the Interior, Before the House Committee on National Resources Subcommittee on Oversight and Investigations. Available at https://www.doi.gov/ocl/national-parks-visitor-issues#:~:text=Visitors%20may%20experience%20congestion%20at,mile%20of%20a%20parking%20lot.

United Nations World Tourism Organization (UNWTO). 2024. World Tourism Barometer, 22(3). Available at https://pre-webunwto.s3.eu-west-1.amazonaws.com/s3fs-public/2024-09/UNWTO_Barom24_03_Sep_EXCERPT.pdf?VersionId=dZpzCBJfy7zZpRJkFf4A9h6uXKnuuuYC.

World Economic Forum. 2024. Travel and Tourism Development Index. Available at https://www.weforum.org/publications/travel-tourism-development-index-2024/.

CHAPTER 3

FREIGHT AND SUPPLY CHAIN

Efficient U.S. freight transportation is essential to the country's economic strength, directly impacting industries' abilities to access materials, ship products, and manage logistics operations. Freight movement underpins the supply chain, from procurement and production to delivery. The transportation and logistics industry forms the connective tissue, providing critical links between suppliers, manufacturers, and end customers.

Recent global events have highlighted the freight sector's role in economic resilience. The COVID-19 pandemic triggered supply chain disruptions. This event was followed by shifts in international trade flows that were influenced by geopolitical factors, such as the Russia–Ukraine conflict, and environmental challenges, including droughts in major waterway regions. Additionally, labor challenges and shifting trade dynamics with key partners—particularly China and Mexico—have underscored the sector's vulnerabilities and the pressing need for adaptable infrastructure and logistics strategies.

This chapter examines the factors contributing to the demand for freight movement followed by the volumes of freight by commodity and mode moved domestically and between the United States and its trading partners. The chapter then presents selected performance measures and factors affecting performance and concludes with gaps in data for a more thorough understanding of the freight system.

Factors Affecting U.S. Freight Transportation Demand

Freight transportation demand is closely linked to domestic industrial output and international trade activities. As illustrated in Table 3-1, the gross output of industries that are heavily reliant on freight transportation has exhibited notable shifts over recent years. Manufacturing remains the sector most dependent on the U.S. freight system, accounting for approximately 39.4 percent of the total output among the eight most freight-dependent industries.

Manufacturing; retail trade; construction; mining; and agriculture, forestry, fishing, and hunting all experienced output growth from 2022 to 2023, with retail trade achieving an all-time high from 2017 to 2023. Wholesale trade, in contrast, generally declined in output from 2021 to 2023,

HIGHLIGHTS

The U.S. freight system accommodated around 5,465 billion ton-miles in 2023, with trucking dominating short-haul distances below 100 miles (75 percent of ton-miles) and rail taking the lead on distances from 1,000–2,000 miles (37.8 percent of ton-miles), emphasizing the importance of modal efficiency across varying distances.

By tonnage, natural gas and other fossil products led all U.S. domestic commodities in 2023, comprising 23.3 percent of total volume among the top 10 commodities, with most transported by pipelines.

In 2023, U.S.–Mexico trade totaled $798 billion, a 2.4 percent increase from 2022, making Mexico the top U.S. trade partner for the first time, surpassing U.S.–Canada trade, which declined by 2.5 percent to $772.9 billion. Meanwhile, U.S.–China trade experienced a significant decline of 16.8 percent, from $690.3 billion in 2022 to $574.7 billion, highlighting shifting trade dynamics.

Pipelines continued to dominate in U.S.–Canada trade, carrying 45 percent of the total freight weight, while vessel transport led in U.S.–Mexico trade with a 60 percent share of the total freight weight.

Emerging issues for the freight sector include concerns over potential overcapacity in the liner shipping industry, ongoing vessel diversions around the Suez Canal due to the Middle East conflict, and increased foreign direct investment in Mexico, driving up cross-border freight demand.

Significant data gaps remain in freight transportation analysis, including real-time metrics on port congestion, truck turn times, and capacity utilization, as well as data on shipment routing, first- and last-mile freight movements, and shipping costs. Addressing these gaps is critical for improving system efficiency, enhancing resilience, and achieving sustainability goals.

The gross output of U.S. industries reliant on freight transportation reached significant levels in 2023, with manufacturing alone accounting for 39.4 percent of the total output among the most freight-dependent sectors.

Electronics, valued at $1.86 trillion, topped the list of high-value U.S. commodities transported in 2023, with Truck and Multiple Modes and Mail options as the primary modes, reflecting the high demand for efficient logistics in high-value, low-weight goods.

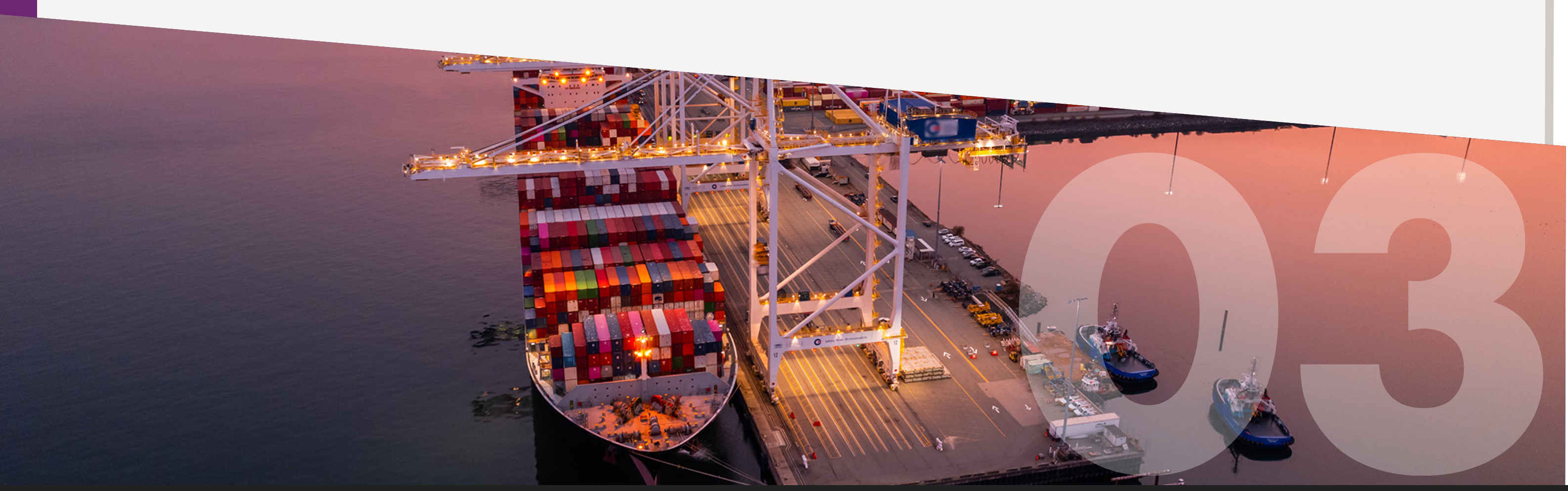
Containerized Asian imports at East Coast ports surpassed those of the West Coast for the second consecutive year in 2023, with East Coast ports handling 63.8 billion kilograms of containerized Asian imports compared to the West Coast's 55.0 billion kilograms.

The Liner Shipping Connectivity Index ranked the Port of New York and New Jersey highest among U.S. ports in 2023. The port reached a score of 517, up from 506 in 2022, while West Coast ports like Los Angeles and Long Beach experienced declines in connectivity scores to 276 and 233, respectively.

Average truck speeds within 5 miles of the Ports of Los Angeles and Long Beach were consistently higher than those at the Port of New York and New Jersey from 2019 to 2023, with speeds peaking at 20.96 mph in 2023 at Los Angeles/Long Beach compared to 18.95 mph at New York/New Jersey, reflecting operational improvements and smoother traffic flows.

The total value of U.S. foreign trade reached approximately $5.1 trillion in 2023, representing a slight decline from 2022 but underscoring the continued importance of international trade in the U.S. economy.

Highlights Continued »



HIGHLIGHTS CONTINUED

The U.S. freight transportation system moved 20.1 billion tons of goods valued at about $18.7 trillion in 2023. Trucking remained the dominant mode, transporting 64.5 percent of the total freight weight and 72.5 percent of the total value.

Vessel dwell time at the top 25 U.S. ports decreased to an average of 28.5 hours in the first half of 2023, down from the peak of 35.5 hours in 2022, indicating a recovery in port efficiency after COVID-19 disruptions.

East Coast ports have consistently gained share in U.S.–Asian containerized trade over the past decade, with total volumes surpassing those of West Coast ports in 2023. East Coast ports handled a combined 102.2 billion kilograms of containerized imports and exports, compared to 86.3 billion kilograms for West Coast ports.

Pipelines transported 4 billion tons of freight in 2023, accounting for 20 percent of the total weight moved, underscoring the heavy reliance on this mode for energy-related freight and its critical role in supporting bulk transport logistics.

with 2023's output being lower than that of the pre-COVID-19 year of 2019. Additionally, while transportation and warehousing shows a decline in output from 2022 to 2023, it still reached its second-highest output between 2017 and 2023, surpassing pre-COVID-19 peaks between 2017 and 2019, along with utilities.

In 2023, the United States' northern and southern neighbors, Canada and Mexico, remained pivotal trade partners (Figure 3-1). The total freight exchanged between the United States and Canada reached $773 billion, marking a 3.0 percent decrease from 2022's peak of $796.7 billion. Meanwhile, trade with Mexico rose by 2.8 percent, with freight flows totaling $798 billion in 2023. In stark contrast, trade with China saw a substantial decline, dropping by nearly 16.8 percent from $690.4 billion in 2022 to $574.7 billion in 2023.

Between 2021 and 2023, the U.S. trade landscape shifted significantly, particularly in its relationships with China and Mexico. U.S.–China trade saw a marked decrease over this period, with the total value falling from a 2022 peak of $690.3 billion to $574.7 billion in 2023—a 16.7 percent drop. This trend signals changing dynamics between the two largest economies. Canada and Mexico both surpassed China as the United States' top trade partners during this period. Canada was the leading partner in 2021 and 2022, but Mexico overtook that position in 2023, with China remaining in third place throughout these years.

Trends in Total Freight Movements

In 2023, the U.S. freight transportation system handled approximately 20.1 billion tons of goods valued at around $18.7 trillion (in 2017 dollars). This extensive system is supported by capital assets valued at $8 trillion in 2022, including critical infrastructure, such as ports, highways, rail systems, airports, and pipelines. The asset value in 2022 represents an increase of $143.3 billion from the previous year [BTS 2023a].

The data from 2023 show that, while freight weight experienced a slight growth of 196 million tons compared to 2019 (Table 3-2), the last pre-COVID-19 year, the overall freight value saw a minor decline of $250 billion (Table 3-3, reported in constant 2017 dollars). Notably, the "Air (air and truck)" category exhibited stability in freight weight, remaining unchanged at 7 million tons, though its value decreased by $11 billion. Similarly, the Multiple Modes and Mail category recorded a modest decline of 9 million tons in freight weight between 2019 and 2023, accompanied by a slight drop in value.

Additionally, certain modes like pipeline transportation saw increases in both freight weight and value, with pipeline freight tonnage rising by 117 million tons and its value increasing by $38 billion in constant 2017 dollars compared to 2023. These shifts reflect the dynamic nature of the U.S. freight transportation system and highlight areas where growth and decline have occurred, though changes in value can also reflect fluctuations in commodity prices, such as the volatility often seen in energy markets.

Trucking continued to dominate as the principal mode of freight transportation in 2023, moving 13.0 billion tons of cargo valued at more than $13.6 trillion. This accounted for 64.5 percent of the total freight weight and 72.5 percent of the total value. Trucking's freight volume remained significantly higher than that of rail, the third-ranked mode, by approximately 8.1 times. Pipelines played a crucial role as well, transporting 4.0 billion tons in 2023, representing about 20 percent of total freight tons, emphasizing the importance

Table 3-1 Gross Output of Freight System–Dependent Industry Sectors: 2017–2023 (Billions of 2017 Chained Dollars)

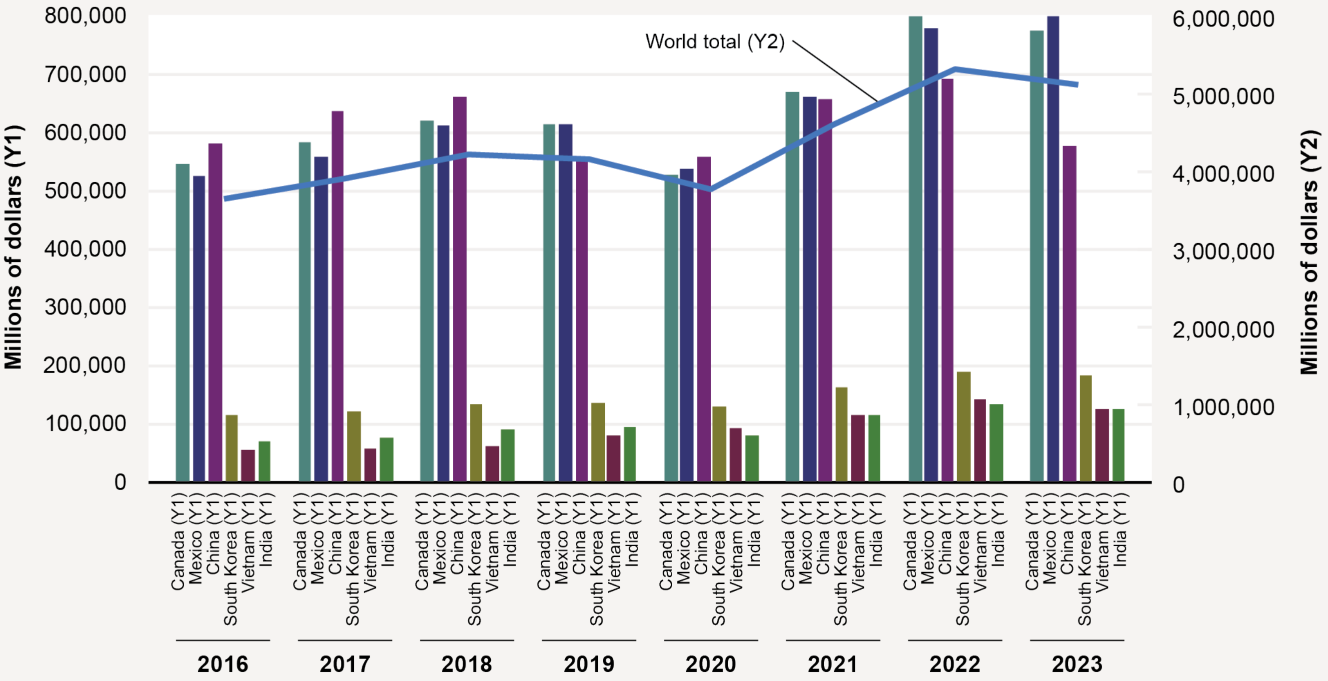
Industry sector*	2017	2018	2019	2020	2021	2022	2023
TOTAL	**13,768.1**	**14,181.9**	**14,165.9**	**13,446.8**	**14,177.3**	**14,231.4**	**14,301.3**
Agriculture, forestry, fishing, and hunting	448.9	447.2	440.1	454.5	454.8	434.8	444.5
Mining	462.8	536.2	568.2	471.8	501.7	531.9	539.8
Utilities	474.1	496.4	492.9	481.5	492.5	507.1	501.5
Construction	1,578.0	1,601.3	1,614.9	1,643.6	1,669.3	1,564.3	1,610.5
Manufacturing	5,676.6	5,786.4	5,724.7	5,335.3	5,498.2	5,541.9	5,629.0
Wholesale trade	2,053.9	2,115.5	2,089.1	1,986.7	2,203.5	2,198.7	2,068.5
Retail trade	1,846.9	1,914.6	1,932.0	1,931.2	2,089.5	2,092.2	2,163.4
Transportation and warehousing	1,226.9	1,284.3	1,304.0	1,142.2	1,267.8	1,360.5	1,344.1

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 July 2024.

Note: Chain dollars adjust for inflation over time allowing for equitable comparisons among dollar amounts. Transportation and Warehousing includes warehousing and storage, 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.

* Industry sectors include those highly dependent on transportation and warehousing.

Figure 3-1 U.S. Trade Growth With Selected 6 of Top 10 Trading Partners: 2016–2023 (Current Dollars)



Source: Bureau of Census, U.S. Department of Commerce, "U.S. International Trade in Goods and Services: 2023, Annual Revision," Exhibit 13, available at https://www.census.gov/foreign-trade/Press-Release/ft900/final_2023.pdf as of August 2024.

Table 3-2 Freight Weight in Millions of Tons by Mode: 2019 and 2023

	2019				2023			
Mode	TOTAL	Domestic	Exports[1]	Imports[1]	TOTAL	Domestic	Exports[1]	Imports[1]
TOTAL	**19,930**	**17,825**	**1,139**	**968**	**20,126**	**17,867**	**1,218**	**1,041**
Truck	12,852	11,941	468	443	12,975	12,015	462	497
Rail	1,599	1,160	267	172	1,598	1,113	317	169
Water	819	657	112	51	797	644	110	43
Air (air and truck)	7	2	3	2	7	2	3	2
Multiple modes and mail	653	538	63	52	645	526	61	57
Pipeline	3904	3,437	221	247	4,021	3,490	259	272
Other and unknown	96	89	5	2	84	77	6	1

Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, as of August 2024.

Note: Numbers may not add to totals due to rounding. 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 and Mail to avoid double counting. As a consequence, rail and water totals in this table are less than other published sources.

[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.

Table 3-3 Freight Noninflation Adjusted Value in Billions of 2017 Dollars by Mode: 2019 and 2023

	2019				2023			
Mode	TOTAL	Domestic	Exports[1]	Imports[1]	TOTAL	Domestic	Exports[1]	Imports[1]
TOTAL	**18,945**	**15,126**	**1,575**	**2,243**	**18,695**	**14,877**	**1,535**	**2,283**
Truck	13,809	11,294	985	1,530	13,562	11,036	945	1,582
Rail	584	226	138	220	577	223	135	219
Water	268	182	47	39	256	178	44	35
Air (air and truck)	611	150	237	223	600	153	228	219
Multiple modes and mail	2,582	2,343	78	161	2,573	2,352	66	155
Pipeline	1,061	929	73	59	1,099	934	98	67
Other and unknown	30	2	17	11	28	2	19	7

Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, as of August 2024.

Note: Numbers may not add to totals due to rounding. 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 and Mail to avoid double counting. As a consequence, rail and water totals in this table are less than other published sources.

[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.

of energy-related flows within U.S. freight movements. Trucking's substantial share in both freight weight and value underscores its critical role in the U.S. freight system. Despite changes in overall trends, trucking remains the primary mode of freight transportation.

Distance of Freight Movement and Modes of Transportation Used

In 2023, the U.S. freight transportation system not only handled approximately 20.1 billion tons of goods valued at around $18.7 trillion but also facilitated the movement of these goods over vast distances, totaling 5,465 billion ton-miles [BTS, FHWA n.d.].

Figure 3-2 presents value, tonnage, and ton-miles for freight shipments by distances. Shares of value, tonnage, and ton-miles by mode are also presented by distance bands. Trucks maintained a prominent role across all distances, especially dominant in shorter ranges, accounting for 75 percent of ton-miles for distances less than 100 miles, which aligns with their flexibility and capacity for quick delivery. For mid-range distances of 100 to 499 miles, the importance of rail and pipelines became more pronounced, with pipelines playing a significant role between 250 and 499 miles, handling 33.6 percent of the ton-miles and more than 34.1 percent of the total value moved in this range. This highlights their efficiency in transporting bulk commodities such as oil and gas where continuous movement over moderate distances is critical.

As distances increased further in 2023, rail took the lead in moving ton-miles, particularly in distances from 1,000–2,000 miles, accounting for 37.8 percent of ton-miles and a substantial portion of the value. This emphasizes rail's capacity for efficient long-haul transport, suitable for heavy and bulk commodities that benefit from the economies of scale offered by rail transportation. At the longest distances—more than 2,000 miles—Multiple Modes and Mail emerged as vital for the longest hauls, managing nearly one-third of the ton-miles and demonstrating a significant share of the total freight value. This diversity in modal use underlines the complexity and integration required for transcontinental and international logistics, catering to logistics of high-value, multifaceted goods that require careful handling over considerable distances.

Leading Commodities in U.S. Freight

In 2023, the U.S. freight transportation system handled a significant volume of commodities, as detailed in Table 3-4 and Table 3-5 and illustrated in Figure 3-3 and Figure 3-4, which outline the top 10 domestic commodities ranked by both weight and transportation mode, as well as by value and mode. These commodities collectively accounted for nearly 13.5 billion tons, representing approximately 67.0 percent of all domestic commodity weight, predominantly falling within the bulk freight category.

Table 3-4 Top 10 Commodities by Weight and Share: 2023

Commodities by weight	Thousands of tons
Natural gas and other fossil products	3,135,356
Gravel	2,075,021
Gasoline	1,439,329
Cereal grains	1,343,053
Nonmetal mineral products	1,199,802
Crude petroleum	1,166,626
Fuel oils	960,839
Other agriculture prods.	741,396
Natural sands	709,856
Waste/scrap	709,294
TOTAL, Top 10	**13,480,570**
TOTAL of all commodities	**20,240,154**
Top 10 share of TOTAL	**66.6%**

Source: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, September 2024.

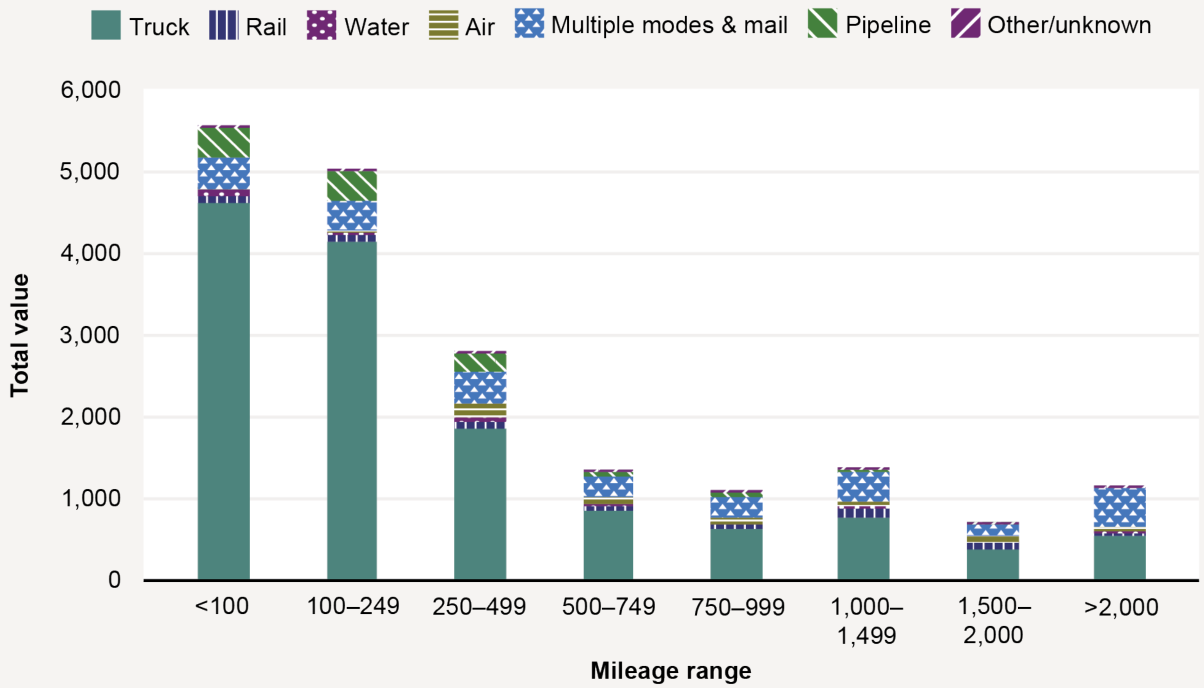
Table 3-5 Top 10 Commodities by Value: 2023

Commodities by value	Billions of 2017 dollars
Electronics	1,860,933
Motorized vehicles	1,604,890
Mixed freight	1,522,017
Pharmaceuticals	1,469,259
Machinery	1,176,483
Plastics/rubber	784,441
Miscellaneous manufacturing products	772,471
Gasoline	771,114
Natural gas and other fossil products	748,872
Other foodstuffs	740,277
TOTAL, top 10	**11,450,757**
TOTAL of all commodities	**18,733,941**
Top 10 share of TOTAL	**61.1%**

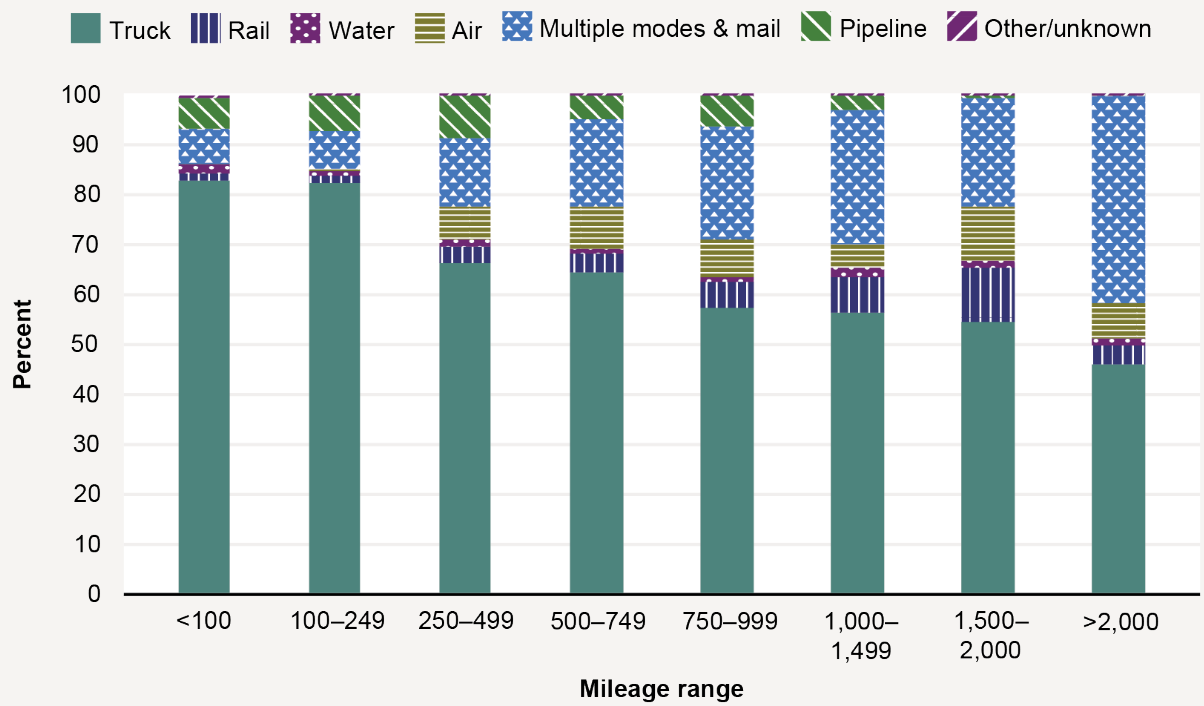
Source: U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, September 2024.

Figure 3-2 Value, Tonnage, and Ton-Miles by Distance Traveled: 2023

A. Total Value by Distance



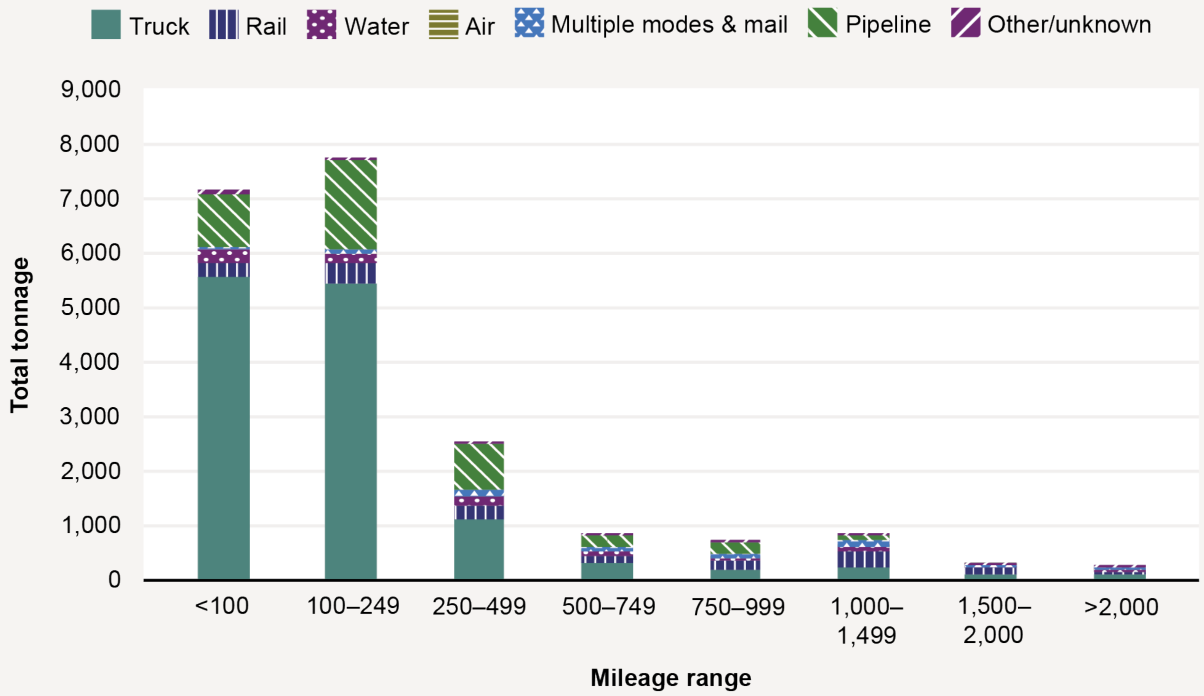
B. Mode Share of Value by Distance



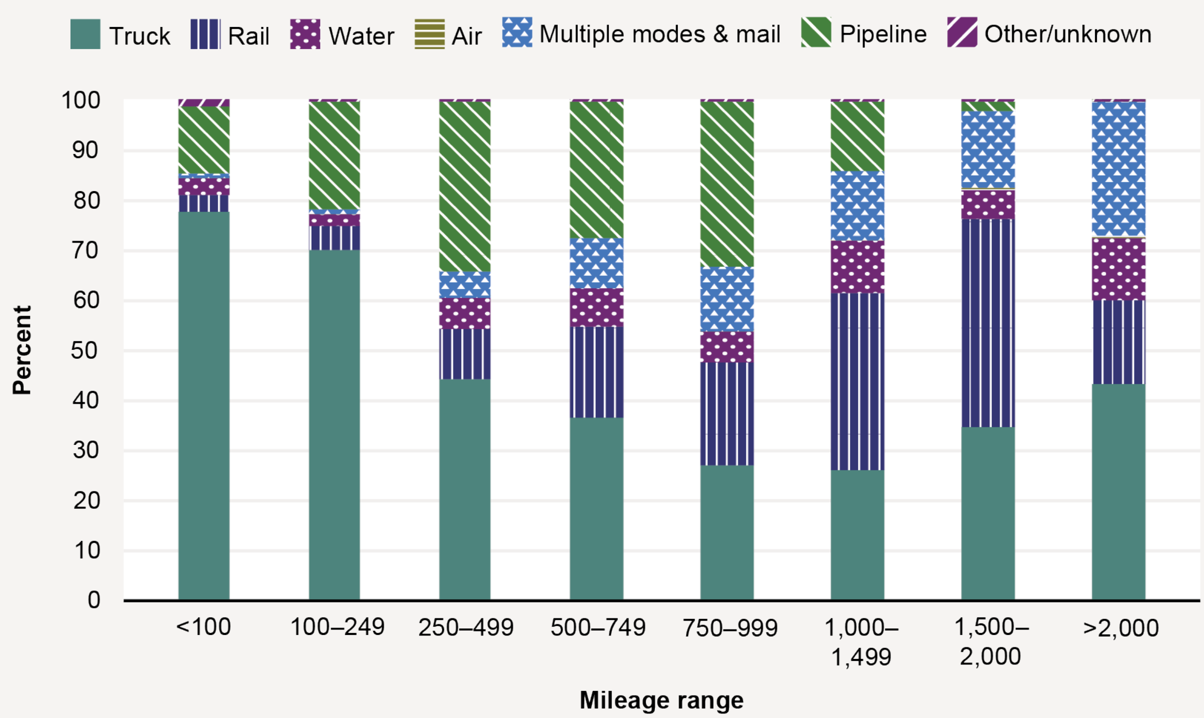
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, as of July 2024.

FIGURE 3-2 Continued

C. Total Tonnage by Distance



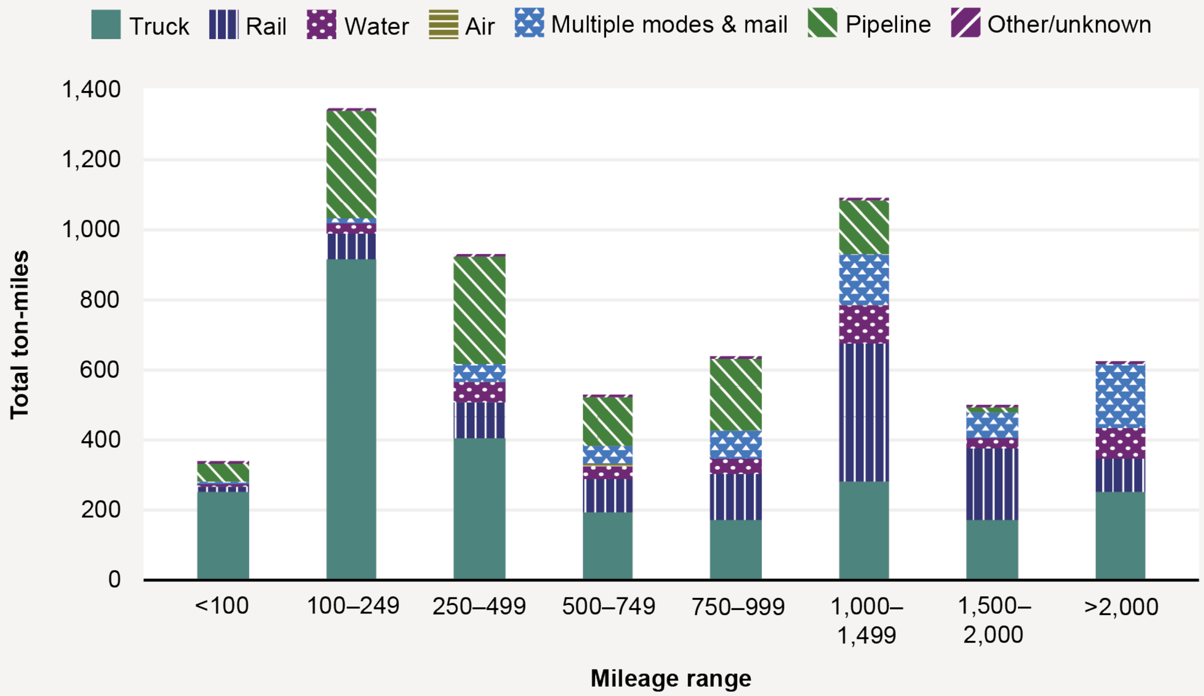
D. Mode Share of Tonnage by Distance



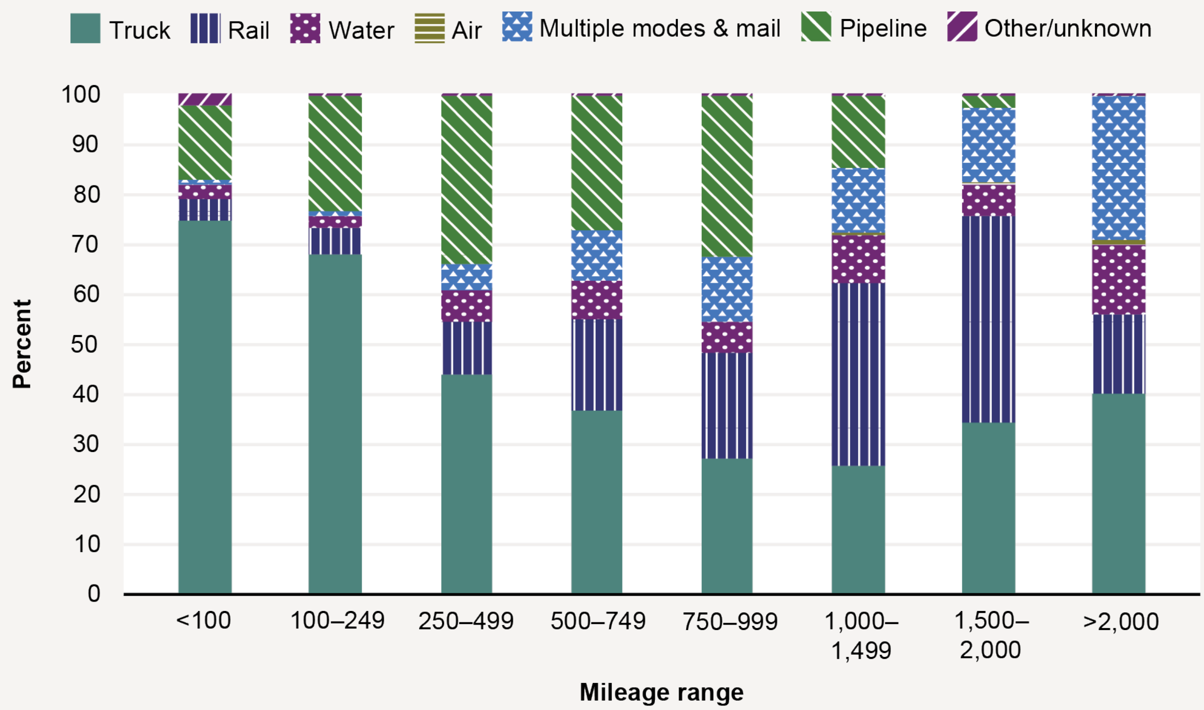
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, as of July 2024.

FIGURE 3-2 Continued

E. Total Ton-Miles by Distance

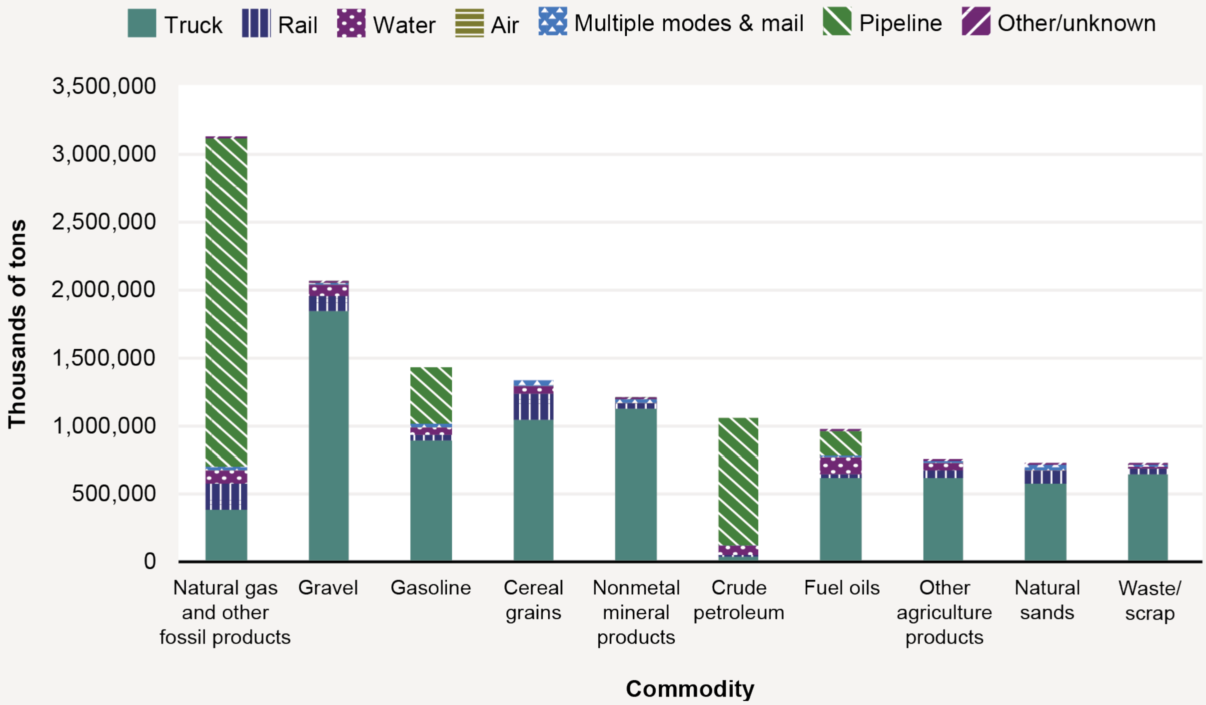


F. Mode Share of Ton-Miles by Distance



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, as of July 2024.

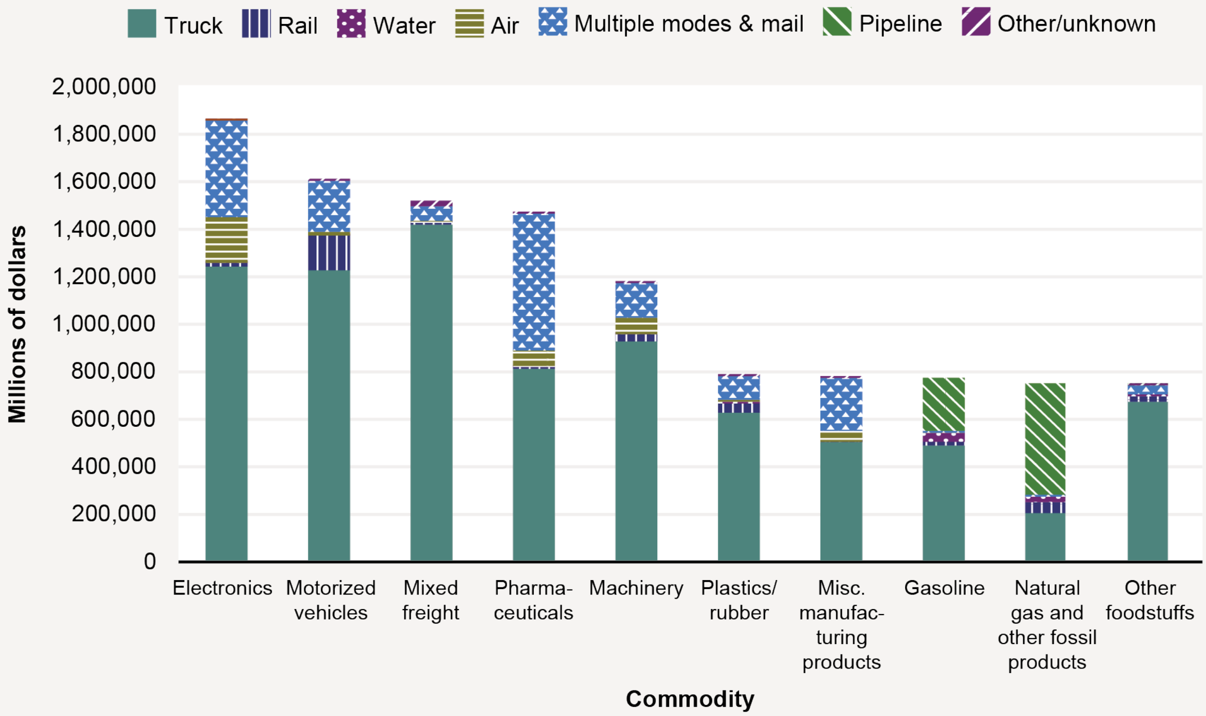
Figure 3-3 Tonnage of Top 10 Commodities by Transportation Mode: 2023



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, July 2024.

Note: Air includes truck-air.

Figure 3-4 Value of Top 10 Commodities by Transportation Mode: 2023



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, and Federal Highway Administration, Freight Analysis Framework, version 5.6.1, July 2024.

Note: Air includes truck-air.

The perspective of value presents a contrasting picture, where high-value commodities like electronics and pharmaceuticals dominated. Electronics led the list with a total value of approximately $1.86 trillion, with significant portions transported by trucks and the Multiple Modes and Mail category, highlighting the high-value, low-weight nature of electronics compared to bulk commodities. Motorized vehicles and mixed freight also contributed significantly to the total value of U.S. freight, with trucks transporting the majority of these goods, underscoring the importance of road transport in the distribution of manufactured goods. The pharmaceutical sector, known for its high-value products, primarily relies on trucks and the category for transport, much like other high-value goods like electronics. Interestingly, pharmaceuticals show the highest use of Multiple Modes and Mail among the top-10 commodities, perhaps reflecting the shipping and handling processes required to maintain product integrity across various exchanges in the pharmaceutical supply chain. This complexity contributes to its high placement in value terms.

International Freight

The nominal value of international import and export freight reached an estimated $5.1 trillion in 2023 (as detailed in Table 3-6), a decline of $200.2 billion from 2022. Although international freight accounts for approximately 27.3 percent of the total U.S. freight value—estimated at $18.7 trillion in 2023—this share belies the crucial role that international freight plays in the U.S. economy. The logistics activities concentrated in the Nation's maritime ports, land borders, and airports, particularly in regions like Los Angeles and Long Beach, underscore the strategic importance of international trade.

Table 3-6 provides a breakdown of U.S. international freight flows by geography and transportation mode in terms of freight value. Vessel transport continues to dominate trade with Asia, with the value of goods moved by vessels amounting to $1.11 trillion in 2023. Though this figure represents a decline of about $110.4 billion from the previous year, Table 3-6 shows the continuing dominance of maritime transport serving U.S. trade. First, vessel freight flows serving the U.S.–Asian trades represent 52.4 percent of all vessel freight flows between the United States and global markets. Second, vessel transport represents 60.6 percent of the value of freight flows between the United States and Asia.

Air transport shows a 27.4 percent share of all modes serving U.S. international trade. This contrasts sharply with air transport's share of 34.6 percent for U.S.–Asia trade, though there was a decline in U.S.–Asia trade transported by air of $75.8 billion from 2022 to 2023. Despite this decrease, the total value of U.S.–Asia air freight reached $633.1 million in 2023 still underscores the ongoing importance of air transport for time-sensitive and high-value goods, even as maritime transport gains a larger share of the market.

For trade with Europe, a more balanced distribution between air and vessel transport is observed. The value of goods transported by air reached $599.6 billion in 2023, while vessel transport accounted for $540.9 billion in the same year. This balance underscores the competitive dynamics between air and maritime transport in U.S.–Europe trade, with air transport holding a slight edge in market share.

Trade with Canada and Mexico, the United States' largest trading partners by land, continues to be dominated by truck transport, which carried $435.7 billion worth of goods

Table 3-6 Value of U.S.–International Freight Flows by Geography and Transportation Mode: 2023 (Millions of 2017 Dollars)

	Mode						
Geography	**Truck**	**Rail**	**Pipeline**	**Air**	**Vessel**	**Other**	**TOTAL**
TOTAL	**996,352**	**209,224**	**112,563**	**1,399,452**	**2,117,239**	**265,204**	**5,100,034**
Canada	435,702	113,860	105,197	35,577	34,901	48,702	**773,939**
Mexico	560,650	95,364	7,366	21,563	91,414	22,477	**798,834**
Asia	—	—	—	633,134	1,109,398	89,444	**1,831,977**
Europe	—	—	—	599,573	540,917	81,799	**1,222,289**
Other	—	—	—	109,605	340,609	22,782	**472,996**

Source: Truck, Rail, and Pipeline: U.S. Department of Transportation, Bureau of Transportation Statistics, TransBorder Freight Data, available at www.bts.gov/transborder; Air, Vessel, and Other: U.S. Department of Commerce, Census Bureau, USA Trade Online, https://usatrade.census.gov/ as of August 2024.

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.

— Not applicable.

to Canada and $560.7 billion to Mexico in 2023. Rail and pipeline modes also play significant roles, particularly in trade with Canada, where they accounted for a combined $219.1 billion in freight value. These modes are essential for the movement of bulk commodities and energy products, which are key components of trade with Canada.

Table 3-7 provides a breakdown of U.S. international freight flows by geography and transportation mode in terms of tonnage. The total tonnage of U.S. international freight reached approximately 1.29 billion tons in 2023. This represents the physical volume of goods moved across various transportation modes between the United States and its trading partners. Although tonnage provides an alternative metric to value for understanding trade, certain modes, such as pipelines and vessels, transport much heavier cargo compared to others, like air transport. This weight disparity reflects the composition of goods moved internationally, where merchandise goods and bulk commodities such as petroleum and agricultural products often dominate.

Vessel transport dominates U.S.–Asia trade, with 290.9 million tons of goods moved by vessels in 2023. This represents the largest share of tonnage among all regions and modes, reflecting Asia's extensive involvement in U.S. imports and exports. Similarly, vessel transport between the United States and Europe accounted for 177.3 million tons, emphasizing the continued importance of maritime transport for transatlantic trade.

In North America, land-based modes, particularly trucks, rail, and pipelines, play a dominant role in trade with Canada and Mexico. In 2023, truck transport accounted for 63.2 million tons and 61.2 million tons of freight to Canada and Mexico, respectively. Additionally, pipelines moved significant volumes, particularly in U.S.–Canada trade, where 201.4 million tons of goods were transported by this mode, largely reflecting energy product flows. Mexico, by contrast, saw the movement of just 259,000 tons via pipeline, with most goods transported by truck and vessel. Figure 3-5 summarizes the modal shares.

Figure 3-6 highlights the prominence of the Nation's top 25 gateways in 2022, where 17 out of these gateways handled more imports than exports. Los Angeles, CA, emerged as the leading gateway, processing a substantial $310.7 billion in combined export and import freight value. Of this, imports amounted to $282.2 billion, positioning Los Angeles well ahead of second-ranked Laredo, TX, by $107.1 billion. However, Los Angeles trailed behind Laredo in exports by $83.7 billion.

At the land border, Laredo, TX, held the top position as the leading land gateway, managing international freight valued at $287.3 billion, which reflects the significant trade volumes between the United States and Mexico. Although ranked fifth overall, Houston, TX, was the Nation's primary export gateway with an impressive $133.0 billion in exports, followed closely by John F. Kennedy International Airport with $117.5 billion in exports.

The Port of Los Angeles stood out as the premier maritime gateway, with a total freight throughput of $310.7 billion in exports and imports. Notably, the port also secured the top spot for imports among the top 25 gateways, handling $282.2 billion in imports, surpassing the Houston gateway by a significant margin of $173.8 billion.

Table 3-7 Weight of U.S.–International Freight Flows by Geography and Transportation Mode: 2023 (Thousands of Short Tons)

	Mode						
Geography	**Truck**	**Rail**	**Pipeline**	**Air**	**Vessel**	**Other**	**TOTAL**
TOTAL	**124,478**	**100,873**	**201,700**	**4,315**	**853,200**	**9,310**	**1,293,877**
Canada	63,229	82,047	201,440	242	92,710	8,532	**448,200**
Mexico	61,249	18,826	259	135	122,124	777	**203,372**
Asia	—	—	—	1,807	290,901	—	**292,709**
Europe	—	—	—	1,371	177,253	—	**178,624**
Other	—	—	—	760	170,211	—	**170,971**

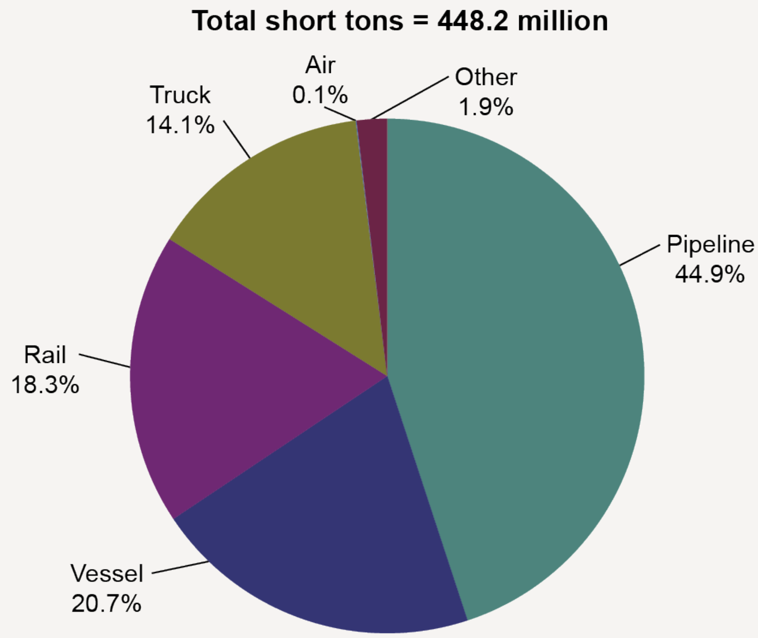
Source: Truck, Rail, and Pipeline: U.S. Department of Transportation, Bureau of Transportation Statistics, TransBorder Freight Data, available at www.bts.gov/transborder; Air, Vessel, and Other: U.S. Department of Commerce, Census Bureau, USA Trade Online, https://usatrade.census.gov/ as of August 2024.

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.

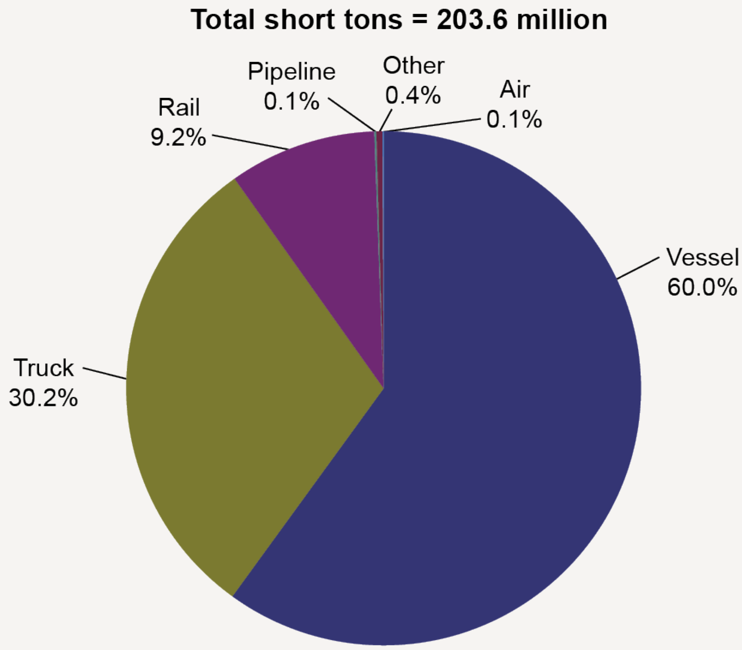
— Not applicable.

Figure 3-5 Modal Shares of U.S. Trade With Canada and Mexico: 2023

A. U.S.–Canada Trade in Short Tons



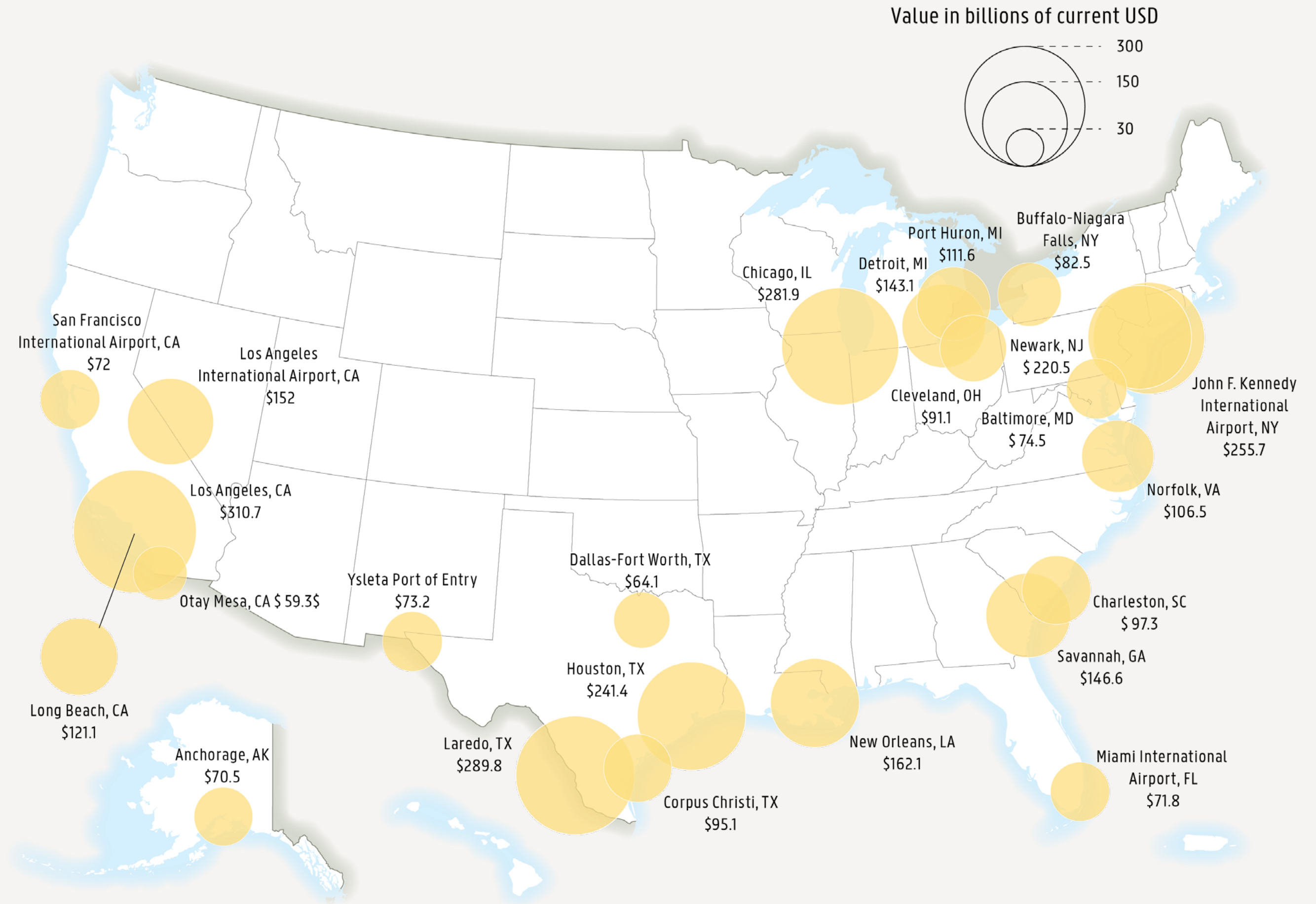
B. U.S.–Mexico Trade in Short Tons



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Freight Data, available at https://data.bts.gov/stories/s/myhq-rm6q as of August 2024.

Note: Other includes imports into free-trade zones, mail, and unknown.

Figure 3-6 Top 25 U.S. International Freight Gateways by Freight Value: 2022



Source: U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, USA Trade Online, available at https://ustrade.census.gov as of November 2024. Land: U.S. Department of Transportation, Bureau of Transportation Statistics, North American Transborder Freight Data, available at https://www.bts.gov/transborder as of November 2024. Water: U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, USA Trade Online, available at https://usatrade.census.gov as of November 2024.

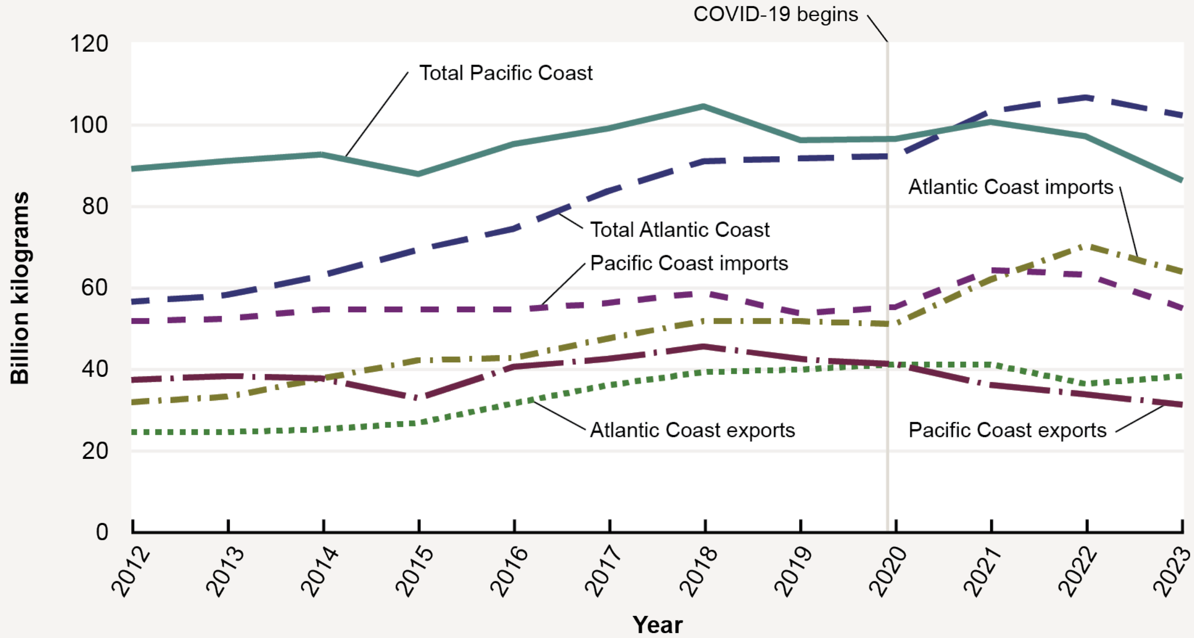
Shifts in Containerized Freight

The logistics landscape within the United States has experienced a significant transformation, particularly in the movement of containerized freight from Asian countries to the East Coast of the United States. Earlier editions of this report were the first to observe the marked shift of U.S.–Asian trade containers to U.S. East Coast ports.

In 2023, U.S. East Coast ports continued to capitalize on these developments, demonstrating an increasing capability to handle Asian imports and exports. According to Figure 3-7, East Coast ports handled 63.8 billion kilograms of imports and 38.4 billion kilograms of exports, totaling 102.2 billion kilograms. Despite a slight decrease from 2022, these figures underscore the ongoing preference for East Coast ports over their West Coast counterparts, which managed 55.0 billion kilograms of imports and 31.3 billion kilograms of exports, totaling 86.3 billion kilograms in the same year.

This trend marks a significant redirection of the traditional supply chain routes, with East Coast ports increasingly surpassing West Coast ports, which historically served as the primary gateways for imported Asian containerized cargoes. In 2022, East Coast ports had already begun to lead with 70.2 billion kilograms of imports compared to the West Coast's 63.2 billion kilograms—a gap that persisted into 2023. This shift, as shown in Figure 3-7, is not merely incremental but indicative of a larger strategic realignment in U.S. maritime logistics.

Figure 3-7 U.S. East Coast and West Coast Asian Containerized Freight Volumes: 2012–2023



Source: U.S. Department of Commerce, Census Bureau, Economic Indicators Division, accessible at http://usatrade.census.gov as of August 2024.

The data further illustrate how this strategic realignment has unfolded. The compound annual growth rates (CAGRs) between 2012 and 2023 highlight a long-term shift: East Coast ports exhibited a CAGR of 5.5 percent, while West Coast ports declined at −0.3 percent. Postpandemic growth rates show an even more pronounced disparity, with East Coast ports growing at 3.4 percent annually and West Coast ports contracting at −3.6 percent. This clear divergence in growth rates underscores the increasing role of East Coast ports in handling containerized freight from Asia. The shift is also reflected in the export volumes, where East Coast ports are increasingly dominant. The comparative export volumes and the broader dynamics indicate a significant strategic realignment in U.S. maritime logistics, influenced by global changes in shipping routes and port capabilities.

The United Nations Conference on Trade and Development's Liner Shipping Connectivity Index (LSCI) provides additional evidence of this strategic shift. The Port of New York and New Jersey led all U.S. ports with the highest connectivity score in 2023, increasing from 506 in 2022 to 517 in 2023 (Figure 3-8). This improvement reflects the port's growing integration into global shipping networks and its pivotal role in handling a larger share of containerized imports. Ports like Savannah and Norfolk also improved their LSCI scores, further demonstrating the strengthening position of East Coast ports.

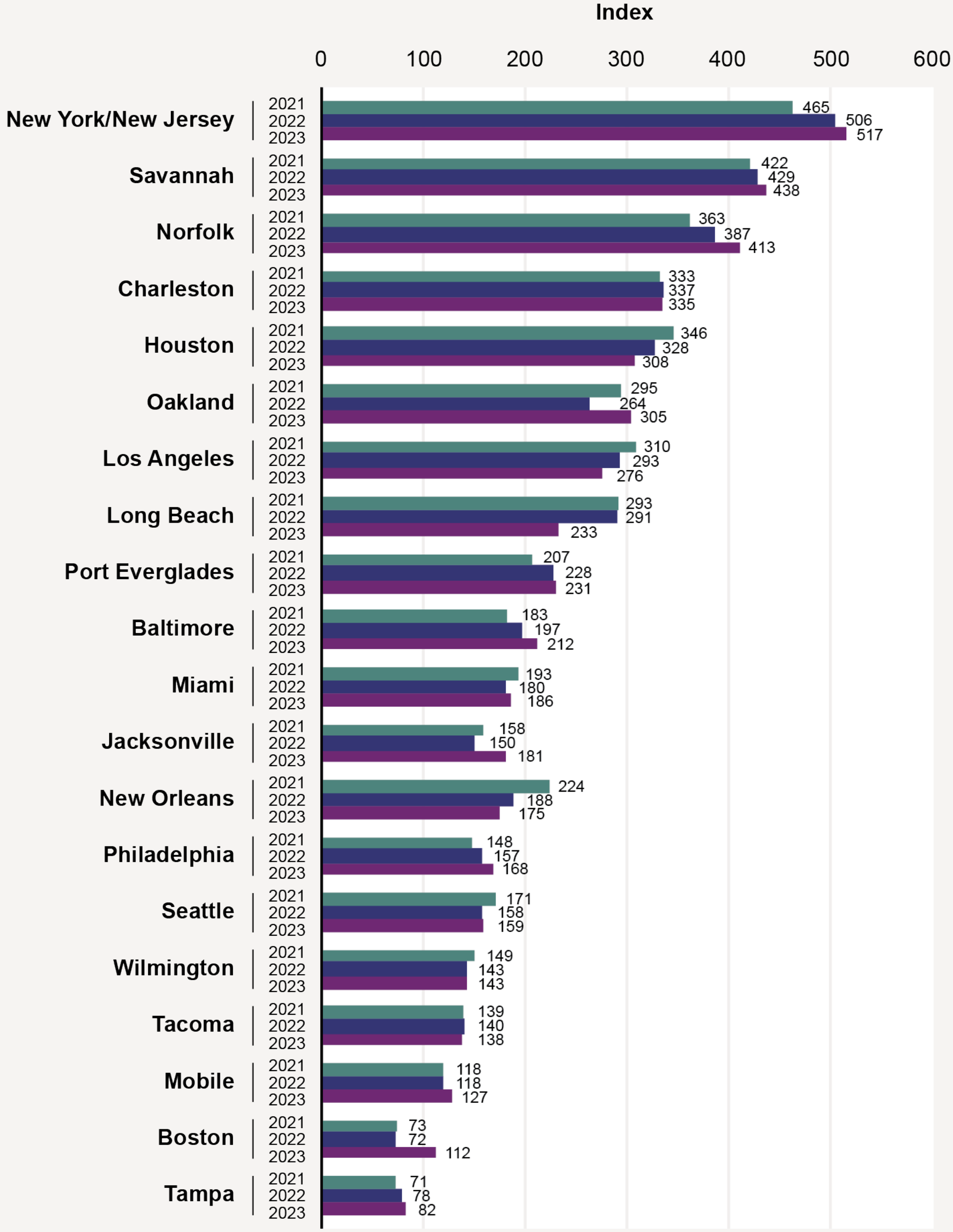
The United Nations Conference on Trade and Development's Liner Shipping Connectivity Index (LSCI), developed in 2004, serves as a critical gauge for assessing the connectivity of global shipping networks among countries and ports. High scores on this index indicate superior connectivity, offering ports competitive advantages in providing diverse and efficient shipping options.

In 2023, as shown in the latest LSCI data from Figure 3-8, reveals that the Port of New York and New Jersey continued to lead with the highest connectivity score among U.S. ports, marking an increase to 517 from 506 in 2022. This progression underscores its robust integration into global shipping networks and its pivotal role in managing an expanding share of containerized imports.

Following the Port of New York and New Jersey, the Ports of Savannah and Norfolk also exhibited growth in their LSCI scores, reflecting enhancements in their connectivity. Savannah's score increased from 429 to 438, and Norfolk's score improved from 387 to 413. These gains demonstrate ongoing developments in their infrastructure and service offerings that bolster their positions in the shipping industry.

Overall, the 2023 LSCI data illustrate a continuing realignment within the U.S. maritime sector, with East and

Figure 3-8 U.S. Top 20 LSCI Ports: 2021–2023



Source: United Nations Conference on Trade and Development (UNCTAD), LSCI, 2024, available at https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=170026 as of July 2024.

Notes: UNCTAD changed its scoring system to better reflect the relationship between trade and transport costs and maritime connectivity. The new system was implemented in 2024 and applied to UNCTAD data back to 2006. Refer to https://unctad.org/news/new-context-calls-changing-how-we-measure-maritime-connectivity for more details.

Gulf Coast ports increasingly enhancing their connectivity to meet the demands of global shipping lines and their customers. This strategic shift suggests a responsive adaptation to the evolving landscape of international trade and logistics, positioning these ports as critical hubs in the global supply chain.

Freight Transportation Performance

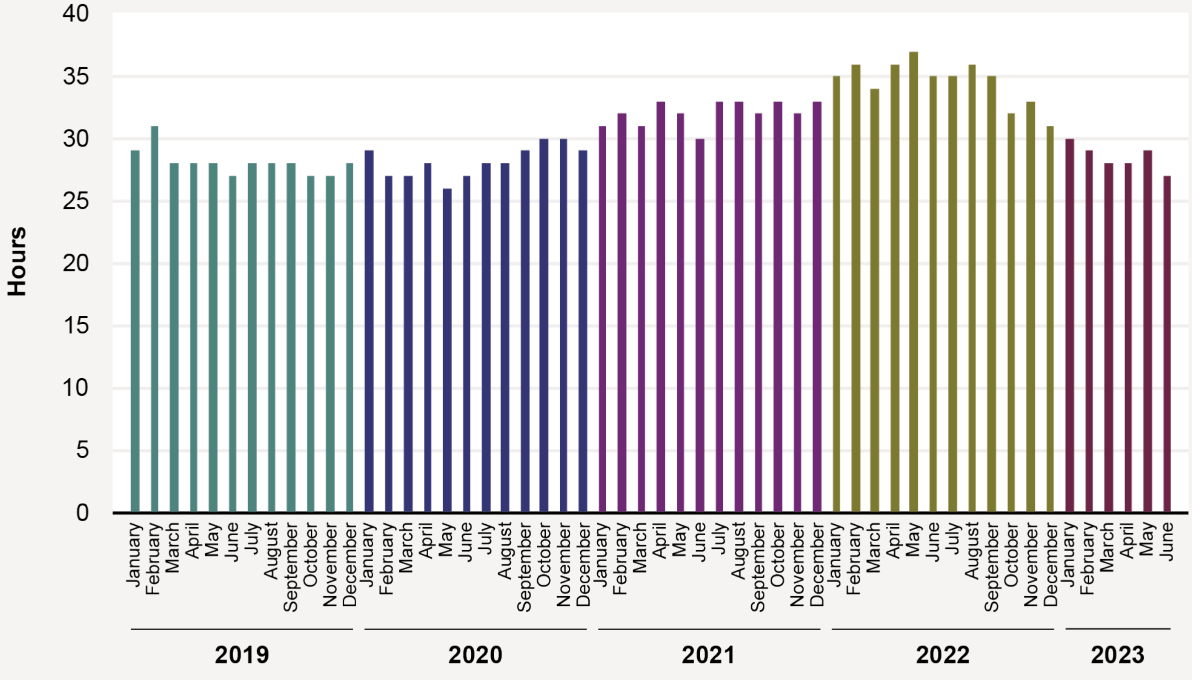
The United States' freight transportation infrastructure is an intricate network consisting of multiple nodes and links, each susceptible to becoming choke points that may hinder overall system efficiency. The COVID-19 pandemic underscored the vulnerability of these supply chain choke points. Monitoring the flow of marine containers through this network offers a clear lens on supply chain efficiency. This flow involves several stages, including transit via ships, trucks, trains, and barges, and passes through critical points, such as marine terminals, customs, border posts, free zones, and distribution centers. In port areas, the movement is particularly complex as container ships maneuver from the entrance buoy to the berths, where containers are handled, stored, and processed. Recent disruptions have significantly strained these components of the network, with some critical areas being monitored by the Bureau of Transportation Statistics (BTS), which employs various indicators to measure freight performance.

Container Port Performance

In the realm of port operations, a suite of performance indicators is important for assessing the efficiency of marine terminal operations. One such critical metric is the container vessel dwell time, which is calculated using the Automatic Identification System (AIS). This system identifies, tracks, and records the speed, direction, and location of vessels, pinpointing which port or terminal a vessel is visiting. BTS utilizes AIS data to monitor the time vessels spend at the berth—known as container-vessel dwell time.

Figure 3-9 tracks the average dwell time for the top 25 U.S. container ports, providing insights from January 2019 to June 2023. Over these years, the average dwell time experienced fluctuations, largely influenced by various factors including

Figure 3-9 Average Container Vessel Dwell Time for Top 25 U.S. Container Ports: 2019–June 2023



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 August 2024.

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. The Top 25 container ports are based on 2018, 2019, and 2020 port rankings published by the U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center.

the vessel's size, measured in twenty-foot equivalent units (TEUs), and the call size, which refers to the container volume loaded or discharged per vessel.

In 2019, average dwell times hovered around 28 hours, with minor variations throughout the year, peaking at 31 hours in February and reaching a low of 27 hours in June. The trend continued in 2020 and 2021, with times slightly increasing to an average of 33 hours by the end of 2021, reflecting the strains imposed by COVID-19-related demands on supply chains.

By the first half of 2022, the average dwell time had climbed to 35.5 hours, marking a noticeable increase due to the ongoing global logistics challenges. This was followed by a reduction in dwell time for the first half of 2023, beginning the year at 30 hours in January and decreasing to 27 hours by June, reaching an average of 28.5 hours in the first half of 2023, suggesting some recovery and optimization in port operations.

The data from Figure 3-9 indicates a gradual adaptation and response to the heightened demands and challenges faced during the pandemic, with average dwell times showing a trend toward stabilization in 2023. This metric serves as a crucial indicator of the efficiency and capacity of U.S. ports to handle international trade and logistics challenges.

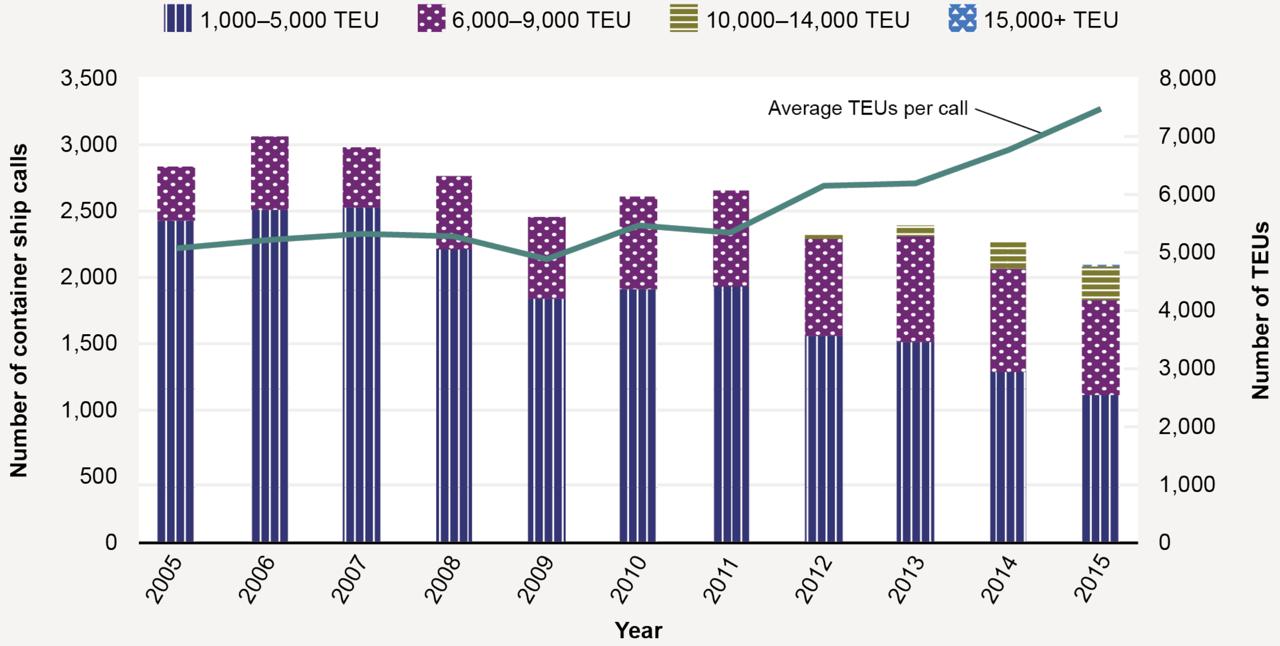
Vessel Size, Efficiency, and Productivity

The relationship between the size of container vessels and operational efficiency at ports is illustrated by historical data from the Ports of Los Angeles and Long Beach. Between 2005 and 2015, these ports demonstrated significant trends in vessel size categories and the corresponding average container throughput per call, as depicted in Figure 3-10.

During this period, there was a noticeable decrease in the total number of ship calls, from 2,817 in 2005 to 2,069 in 2015, indicating a trend toward fewer but larger capacity vessel visits. Concurrently, the average container volume per ship call significantly increased, rising from 5,039 TEUs per call in 2005 to 7,420 TEUs per call in 2015. This trend reflects a shift in operational strategies toward accommodating larger vessels capable of carrying more containers.

Notably, the composition of vessel sizes calling at these ports evolved dramatically. In 2005, the majority of vessels fell into

Figure 3-10 Vessel Size and Call Trends and Average Container Throughput per Call, Ports of Los Angeles and Long Beach: 2005–2015



Source: Vessel call data and size category from San Pedro Bay Ports Clean Air Action Plan, Bay Wide Ocean-Going Vessel International Maritime Organization Tier Forecast 2015–2050, July 2017, p. 3; TEU volume data from the Port of Los Angeles, Annual Container Statistics, available at https://www.portoflosangeles.org/business/statistics/container-statistics and Port of Long Beach, TEUs Archive: 1995 to Present by Year, available at https://polb.com/business/port-statistics#yearly-teus; data at both ports available as of October 2023.

TEU = twenty-foot equivalent unit.

smaller size categories (1,000–5,000 TEU), but by 2015, there was a significant presence of much larger vessels (10,000–14,000 TEU and 15,000+ TEU). The data show that, while ships in the 1,000–5,000 TEU range accounted for 2,409 calls in 2005, this number drastically dropped to 1,103 by 2015. In contrast, vessels larger than 10,000 TEUs, which were nearly nonexistent in 2005, made up to 256 calls in 2015, with the introduction of the 15,000+ TEU category marking a significant milestone in the capabilities of the ports.

This shift toward larger vessels has facilitated increased efficiency in port operations, as larger vessels mean more cargo moved per operation, reducing the relative cost and time per TEU handled. Although the data series ends in 2015, the principle that larger vessels achieve higher productivity due to economies of scale continues to hold true. As discussed below, this led to the World Bank reporting port performance relative to vessel size category. This factor remains a key component of contemporary port strategy, ensuring that the insights drawn from historical data remain relevant and actionable for understanding current and future port operations performance.

U.S. Top 25 Container Ports

Figure 3-11 shows the top 25 U.S. container ports ranked by TEUs for 2022, highlighting the leading positions of the Ports of Los Angeles, Long Beach, and New York and New Jersey. These ports, pivotal in importing activities, emphasize their strategic roles in global shipping. The Port of New York and New Jersey, for instance, handled about 5.4 million TEUs in imports, closely followed by Ports of Los Angeles and Long Beach, showing a significant focus on accommodating large-scale international trade.

Interestingly, the Port of New Orleans stands out for its unique trade balance, handling more exports than imports, which might indicate a specialized market focus. Conversely, the Port of Honolulu serves as a crucial hub for domestic containers, showing its role in supporting interisland transport within Hawaii.

Additionally, the Port of Savannah and the Port of Houston have emerged as significant players, with Savannah processing over 3 million TEUs and Houston more than 2 million TEUs while also showcasing a strong balance between imports and exports. Ports like Tacoma and Jacksonville highlight substantial portions of domestic TEUs, pointing to their strategic roles in facilitating regional trade and distribution networks within the United States. Meanwhile, the Port of Seattle and the Port of Oakland further demonstrate the West Coast's capacity to handle significant volumes, reinforcing its crucial position in trans-Pacific maritime trade.

U.S. Top 10 Container Port Performance Insights

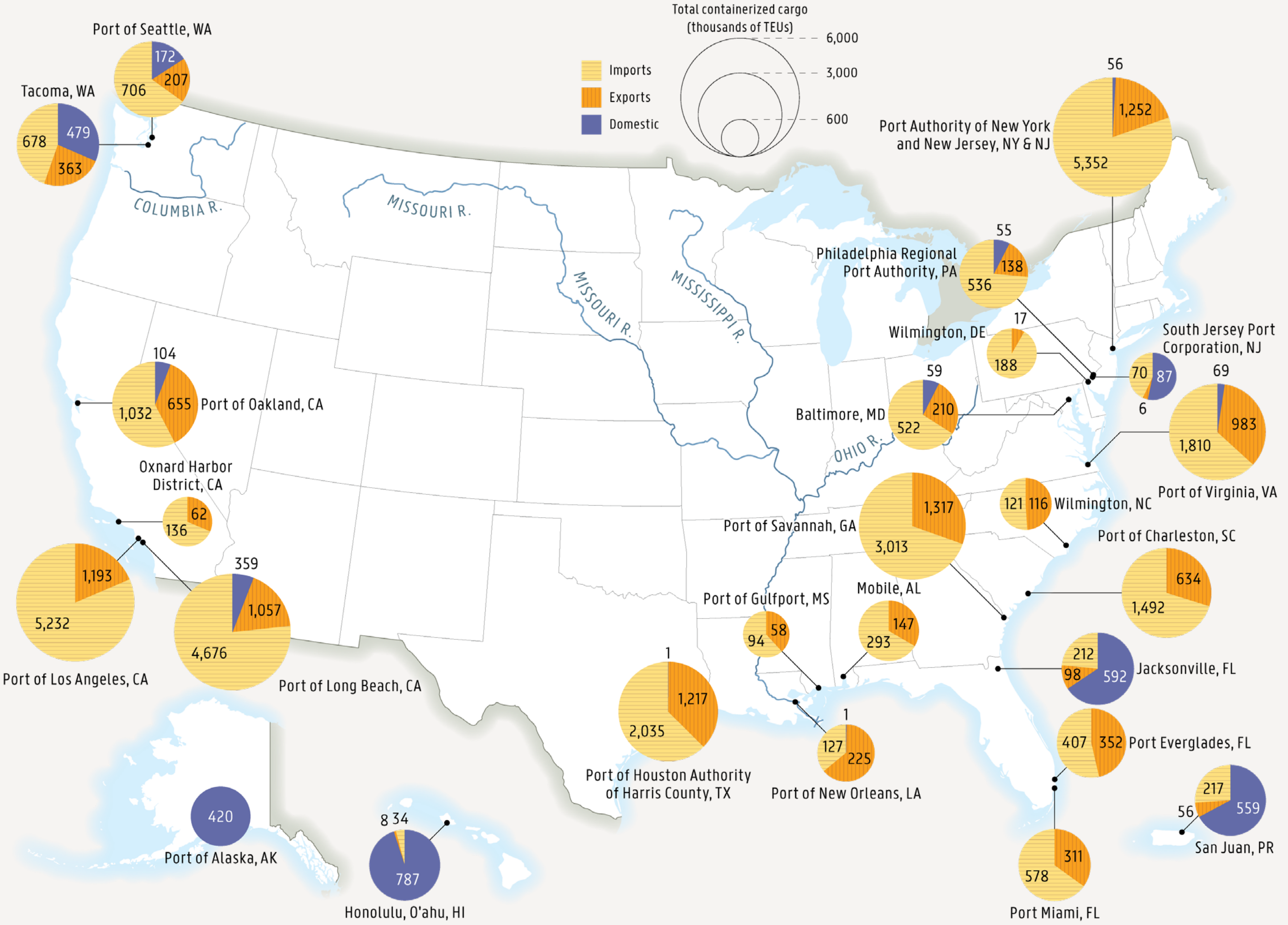
Table 3-8 presents the latest assessment by the World Bank of the top 10 U.S. container ports, highlighting their global rankings based on performance indicators like vessel waiting time, transit time from the entrance buoy to the berth, and berth time. The data provide a nuanced picture of how each port has adapted to changes in shipping dynamics, particularly concerning the management of vessels of varying sizes.

In 2023, the World Bank expanded its evaluation to include 405 container ports, up from 350 in the previous year, offering a broader context for understanding U.S. port performance. Despite this increase in competition, the performance of U.S. ports has shown varied trends. Notably, the Port of New York and New Jersey showed significant improvement, jumping from 309th in 2022 to 99th in 2023. This port performed exceptionally well across different vessel size categories, particularly in managing larger vessels (>13,500 TEU), where it ranked 82nd.

Conversely, other major ports like Los Angeles and Long Beach have declined in the World Bank's performance rankings, with Los Angeles moving from 337th in 2022 to 378th in 2023, and Long Beach from 348th to 376th. Both ports struggled particularly with smaller vessel categories (<1,500 TEU) and saw their best performance in handling the largest vessel categories of 8,501–13,500 TEUs and >13,500 TEUs; Long Beach ranked 92nd in the former category while Los Angeles and Long Beach ranked 103rd and 101st in the latter size category, respectively. The discrepancy across vessel size categories highlights the challenges faced by these ports in balancing efficiency across different vessel sizes, influenced by the challenge in accommodating smaller vessels as the larger vessels take greater berth space over longer periods of time.

The Port of New York and New Jersey performed best among the top-10 ports in the >13,500-TEU category, ranking 82nd worldwide while also ranking best (79th) among the top-10 container ports in the 5,001–8,500 size category. At 86th, Charleston ranked the highest top-10 port in the 8,501–13,500 and 49th in the largest vessel-size category. The performance in these vessel-size categories contributed to the port's dramatic improvement to 60th place in 2023 from 341st in 2022, marking Charleston as 2023's best top-10 performer overall. The Port of Virginia, once the top performer in 2021 ranked at 23rd worldwide, experienced a significant drop to 306th place in 2023 from its 49th rank in 2022, demonstrating the volatility of port-performance metrics under evolving global trade conditions.

Figure 3-11 U.S. Top Container Ports Based on TEUs: 2022



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Loaded TEU by Port, Top 25 Ports by Loaded TEU Quantity, 2022, available at https://data.bts.gov/stories/s/Container-TEU/x3fb-aeda as of August 2024.

TEU = twenty-foot equivalent unit.

The rankings underscore the complexity of port operations, where performance is not uniform across different vessel sizes. Ports generally perform better in handling larger vessels, likely due to improved berth productivity in handling them. However, the challenge remains for ports to enhance their efficiency across all vessel sizes, particularly as they adapt to the shifting demands of global shipping and the pressures of larger vessel calls.

This data illustrates that while some U.S. ports have improved their global standing, others face ongoing challenges. The discrepancies in performance across different vessel size categories highlight the need for continued focus on port infrastructure and technology to ensure that all types of vessels can be accommodated efficiently, maintaining the competitiveness of U.S. ports on the global stage.

Rail and Truck Performance

The average rail terminal dwell time for all railroads in 2023 was 21.7 hours, an increase of 0.7 hours from 2022. Dwell time, an essential performance metric, indicates the average duration a freight car remains within a rail terminal's boundaries. This measure starts with the train's arrival, customer release, or interchange receipt and concludes with its departure, the customer receiving the car, or its transfer to another railway.

Throughout Figure 3-12's reporting period, the rail operators demonstrated varying trends in dwell times. Notably, Norfolk Southern (NS), Burlington Northern and Santa Fe Railway (BNSF), and Chessie System and Seaboard Coast Line Railroad (CSX) experienced peak dwell times around the

Table 3-8 World Bank Container Port Performance Index Rankings of Top 10 U.S. Container Ports: 2021–2023

Port	Overall rank 2021	Overall rank 2022	Overall rank 2023	2023 rank by vessel size ranges by TEU capacity				
				<1,500	1,501–5,000	5,001–8,500	8,501–13,500	>13,500
Los Angeles	370	337	378	—	274	168	163	103
Long Beach	348	328	376	214	304	214	92	101
NY/NJ	251	309	99	180	140	79	94	82
Savannah	367	350	398	255	288	184	174	112
Houston	119	338	327	120	192	171	162	—
Virginia	23	49	306	—	184	149	132	85
Oakland	359	345	396	254	248	190	172	111
Charleston	130	341	60	122	102	91	86	49
Tacoma	345	327	402	—	—	224	176	113
Seattle	336	293	356	—	259	166	155	91

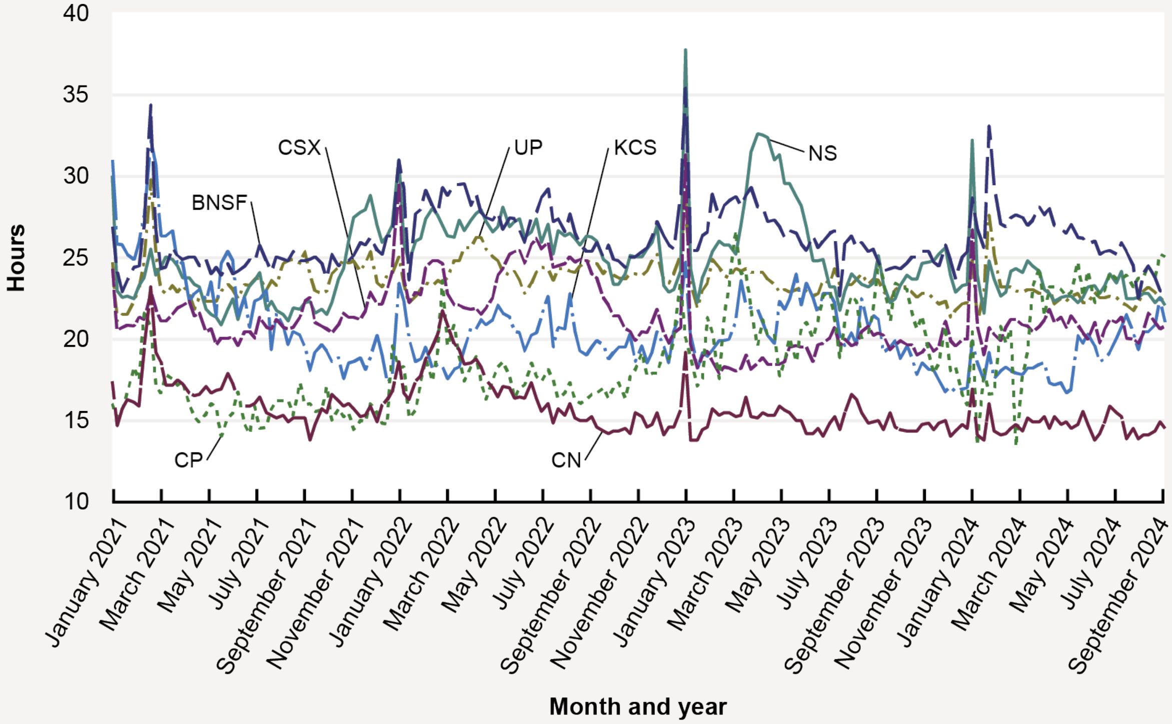
Source: World Bank, Container Port Performance Index 2023, available at https://openknowledge.worldbank.org/entities/publication/87d77e6d-6b7b-4bbe-b292-ae0f3b4827e8 as of July 2024.

Note: The higher the number for the ranking, the poorer the performance.

— Data do not exist.

TEU = twenty-foot equivalent unit.

Figure 3-12 Average Rail Terminal Dwell Time in Hours: January 2021–August 2024



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight Indicators, available at https://www.bts.gov/freight-indicators as of August 2024.

UP = Union Pacific; NS = Norfolk Southern; KCS = Kansas City Southern Railway Company; CSX = Chessie System and Seaboard Coast Line Railroad; CP = Canadian Pacific; CN = Canadian National Railway; BNSF = Burlington Northern and Santa Fe Railway.

end of December 2022, with recorded times of 37.5, 35.2, and 31.2 hours, respectively. Other significant observations include the Kansas City Southern Railway Company (KCS), Union Pacific (UP), and Canadian National Railway (CN) marking their highest dwell times in February 2021, with KCS reaching 32.1 hours, UP peaking at 29.7 hours, and CN at 23.3 hours. Canadian Pacific (CP) recorded its highest dwell time in March 2023 at 26.7 hours, while UP noted a significant dwell time of 29.7 in February 2021.

Table 3-9 details the average system-wide annual dwell times for major U.S. railroad systems from 2020 to 2023, capturing shifts in the performance metrics across different regional rail networks. These data provide insights into the operational dynamics of railroads and their efficiency in freight handling over the 4-year period.

Across the western railroads, BNSF and UP showed a general stability in dwell times with minor fluctuations. BNSF recorded a slight decrease from 27.3 hours in 2022 to 26.2 hours in 2023, indicating an improvement in terminal operations. UP also demonstrated a reduction in dwell time from 24.4 hours in 2022 to 23.4 hours in 2023, reflecting an improvement to their operations.

The central railroads presented a mixed response, with CP showing a significant increase in dwell times, rising from 18.2 hours in 2022 to 20.9 hours in 2023, which could indicate operational challenges or increased freight volumes. Conversely, CN saw a decrease in dwell time in 2023, improving to 15.4 hours from 16.9 hours in 2022. KCS maintained relatively stable dwell times around 20 hours over the years.

Eastern railroads experienced more substantial variations with both CSX and NS reporting decreases in dwell times in 2023 compared to the previous year. CSX improved from 23.4 hours in 2022 to 19.7 hours in 2023 while NS decreased from 26.4 hours in 2022 to 25.7 hours in 2023.

The trend of dwell times across these railroads suggests that geographic location and operational strategies significantly influence railroad performance. Notably, the eastern railroads have historically faced higher dwell times, possibly due to denser network configurations and higher freight traffic, particularly with the shift of some of the container trade to the U.S. East Coast. The improvements in 2023 may indicate effective adaptations to these challenges.

The performance of these railroads over the period also highlights the interconnected nature of rail operations with broader logistical trends, including shifts in shipping patterns and port activities. As U.S. ports have experienced increased congestion due to higher cargo volumes, particularly on the East Coast, rail operators have had to adjust their operations to handle the growing demand.

Table 3-10 reveals the progression of average truck speeds within 5 miles of two significant U.S. ports, highlighting variations that suggest differences in congestion levels and operational efficiencies. Over the 5 year period from 2019 to 2023, the Ports of Los Angeles and Long Beach consistently exhibited higher average speeds compared to the Port of New York and New Jersey, pointing to smoother traffic flows, less traffic congestion, and potentially more efficient cargo handling operations at Los Angeles/Long Beach.

From 2019 to 2023, both the Ports of Los Angeles and Long Beach and the Port of New York and New Jersey displayed a trend of generally increasing truck speeds, with a peak sometimes occurring in the second quarter each year, possibly reflecting seasonal adjustments in port operations

Table 3-9 Average Railroad System-Wide Annual Dwell Time Hours: 2020–2023

Location	Railroad System	Average dwell times (hours) 2020	2021	2022	2023
Western railroads	BNSF	26.6	25.2	27.3	26.2
	UP	22.9	23.7	24.4	23.4
Central railroads	CP	15.3	16.5	18.2	20.9
	CN	17.1	16.7	16.9	15.4
	KCS	20.3	22.5	20.3	20.4
Eastern railroads	CSX	18.3	21.5	23.4	19.7
	NS	18.8	23.8	26.4	25.7

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight Indicators, available at https://www.bts.gov/freight-indicators as of July 2024.

BNSF = Burlington Northern and Santa Fe Railway; UP = Union Pacific; CP = Canadian Pacific; CN = Canadian National Railway; KCS = Kansas City Southern Railway Company; CSX = Chessie System and Seaboard Coast Line Railroad; NS = Norfolk Southern.

and cargo handling. However, the data for 2023 show a noticeable dip in average speeds for the Port of New York and New Jersey in all quarters, which are lower than its 5-year averages for three of four quarters, ending the year with an average speed of 18.95 mph—the lowest in the 5 years. This reduction may indicate rising congestion or operational challenges that have emerged over the year partly as a result of the shift of Asian-related container trades to the U.S. East Coast from the U.S. West Coast.

Conversely, the Ports of Los Angeles and Long Beach not only maintained but slightly increased average speeds across the years, culminating in a higher average of 20.96 mph in 2023. This consistent performance underscores ongoing improvements and possibly better traffic management strategies at Los Angeles/Long Beach compared to New York/New Jersey. The quarter-by-quarter analysis further supports this, showing Los Angeles/Long Beach with a stable or increasing trend in speeds, particularly in the third and fourth quarters, reflecting effective responses to operational demands.

The differences in average speeds between the ports are significant, especially when considering the higher volume of containers typically handled at these locations. The consistent higher speeds at the Ports of Los Angeles and Long Beach compared to the Port of New York and New Jersey could be reflective of the broader infrastructure and operational adaptations that have been implemented, possibly in response to the shifting dynamics of global trade routes and the increasing size of vessels being accommodated.

Disruptions to Supply Chains From Drought and Geopolitical Conflicts

Weather significantly impacts supply chains by disrupting production, particularly in agriculture, and affecting the operation of transportation systems. Waterborne commerce is especially highly vulnerable to disruptions from droughts and extreme weather events. Localized disruptions can also have substantial impacts on trade and supply chains, as illustrated by the recent Francis Scott Key Bridge incident in Baltimore (Box 3-A), which highlights the cascading effects of infrastructure failures on freight flows.

The Mississippi River system remains a crucial artery for transporting goods across the 12 states bordering the Upper Mississippi River system and Louisiana. As reported in the *Transportation Statistics Annual Report 2023*, this vital river faced significant challenges in 2023 due to severe drought conditions, particularly during the summer and early fall [BTS 2023b]. Low water levels severely restricted barge shipments, impacted agricultural outputs, and even threatened drinking

Table 3-10 Average Truck Speed in the Port of New York/New Jersey and the Ports of Los Angeles/Long Beach: 2019–2023

Port	Year	Average speed by quarter				Average annual speed
		1st	2nd	3rd	4th	
New York/ New Jersey	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
	2023	19.70	19.20	18.67	18.23	18.95
	2019–2023 average speed by quarter	19.26	19.32	19.06	18.70	—
Los Angeles/ Long Beach	2019	19.45	19.63	19.39	19.12	17.89
	2020	19.61	20.43	19.88	20.07	19.37
	2021	20.87	20.65	20.28	20.38	19.75
	2022	20.59	20.73	21.03	20.87	19.46
	2023	20.83	20.97	21.13	20.90	20.96
	2019–2023 average speed by quarter	20.27	20.48	20.34	20.27	—

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight Indicators, available at https://www.bts.gov/freight-indicators as of September 2024.

— Not applicable.

BOX 3-A

PORT OF BALTIMORE DISRUPTION: IMPACT OF THE KEY BRIDGE COLLAPSE

The collapse of the Francis Scott Key Bridge on March 26, 2024, has had a profound impact on the Port of Baltimore, one of the Nation's top 20 ports by tonnage and container volume. The incident, caused by a 947-foot containership losing power and striking the bridge's supporting pier, resulted in the bridge's partial collapse and a temporary shutdown of the shipping channel into Baltimore Harbor.

Key facts regarding the bridge's collapse include the following:

- **Port activity:** The Port of Baltimore is a critical hub for dry bulk, motorized vehicle trade, and containerized goods. It ranks 15th in container throughput among U.S. ports and is sixth among U.S. ports on the Shipping Line Connectivity Index.
- **Disrupted traffic:** On March 27, vessel tracking data identified 11 ships—including bulk carriers, general cargo ships, a tanker, and the container ship DALI—stranded in the harbor behind the collapsed bridge. Beyond the bridge, 12 vessels waited at anchorage, further intensifying delays.
- **Cruise ship operations:** Two cruise ships, including one with over 2,000 passengers, were diverted, requiring complex logistics to reunite passengers with vehicles parked at the port terminal.
- **Traffic and safety concerns:** The bridge collapse diverted 34,000 daily vehicles to alternate routes through the congested Fort McHenry and Harbor Tunnels. Hazardous cargo trucks have been diverted around the opposite side of the Baltimore Beltway (I-695). These shifts increased traffic volumes by 18 percent on these routes and exposed over 100,000 residents to greater risk along longer, peak-congested pathways.

Economic and operational implications of the collapse include the following:

- **Supply chain impact:** The temporary closure of the shipping channel disrupted the Port's role in international trade, with an estimated weekly supply chain cost of $1.7 billion during the shutdown.
- **Bridge and port recovery:** While the shipping channel reopened in June 2024, allowing vessel movements to resume, the bridge remains out of service as reconstruction planning progresses.

The incident underscores the vulnerability of critical infrastructure and highlights the cascading impacts disruptions can have on freight, passenger operations, and regional traffic networks.

water supplies in areas such as Louisiana, Mississippi, and Texas.

In 2024, however, the Mississippi River system saw some improvement from the harsh drought conditions of the previous year. Early in the year, river levels returned to near-average, and the risk of spring flooding was below average [NASA, MRIS 2024]. By mid-2024, the Midwest region experienced minimal drought with only 4 percent of the area in moderate to severe drought. These improvements allowed for more reliable barge operations along the river. However, extreme heat and below-normal rainfall in late summer led to the re-expansion of drought conditions, particularly in parts of Ohio and Kentucky [NOAA, NISID 2024]. This underscores the Mississippi River system's continued vulnerability to drought, highlighting the need for regular and frequent rainfall to prevent further issues.

Drought conditions have also significantly impacted the Panama Canal, a critical maritime passageway where 68.6 percent of its freight is tied to U.S. imports and exports, as shown in Table 3-11.

The canal has faced ongoing challenges due to drought, although there have been some improvements compared to 2023. The impacts of low water levels, reduced vessel drafts, and delayed transits underscore the canal's vulnerability to environmental challenges, as detailed in Box 3-B.

In early 2024, the Panama Canal authorities were still forced to impose strict limits on vessel traffic due to critically low water levels. These restrictions caused significant disruptions in global shipping, leading to global supply chain impacts worldwide. By mid-2024, however, as water levels began to normalize, the Panama Canal Authority eased some of these restrictions, allowing for an increase in vessel drafts and daily transits (Figure 3-13).

Efforts to mitigate the impacts of future droughts include the Panama Canal's investment in expanding its water reservoirs and improving water management practices. These measures aim to ensure the canal's continued accommodation of larger vessels and maintain reliable operations even during dry periods. Additionally, the Panama Canal has implemented water conservation practices, including recycling water from the locks, which has led to increased salinity in Lake Gatún—a critical water source for the canal and local communities [Millard, McDonald, Roston 2024].

During the peak of the 2023 drought, the Panama Canal's daily transits were restricted to as few as 24 vessels, a sharp reduction from its typical capacity of handling around 34 to 38 vessels per day; at its maximum sustainable capacity, the canal could accommodate up to 38–40 vessels daily [Labrut 2023]. The restrictions during the drought significantly reduced this number, causing notable disruptions in global shipping.

In response to recent rains in 2024, the canal has been able to ease these restrictions, now accommodating up to the near-normal 36 vessels per day—marking a significant improvement from the height of the drought [The Maritime Executive 2024a]. Nevertheless, the canal's continued vulnerability to fluctuating water levels underscores the

Table 3-11 Panama Canal Cargo Volumes by Principal U.S. Vessel Trade Routes: Fiscal Year 2023

Vessel trade route	Long tons (thousands)
East Coast U.S.–Asia	121,143
East Coast U.S.–West Coast South America	36,620
East Coast U.S.–West Coast Central America	20,610
U.S. Intercoastal, including Alaska and Hawaii	1,929
Europe–West Coast U.S.	5,116
East Coast U.S.–Oceania	3,601
East Coast South America–West Coast U.S.	583
East Coast Central America–West Coast U.S.	433
West Indies–West Coast U.S.	1351
East Coast U.S.–West Coast Canada	621
East Coast U.S.–Pacific World	3,990
TOTAL U.S. vessel trade routes	**195,997**
TOTAL Panama Canal transits tonnage	**285,771**
Percent U.S. transit trade tons	**68.6%**

Source: Statistics and Models Administration, Panama Canal Authority (PCA), available at https://pancanal.com/wp-content/uploads/2023/11/00-Panama-Canal-Traffic-Along-Principal-Trade-Routes.pdf, as of September 2024.

BOX 3-B

PANAMA CANAL DROUGHT DISRUPTIONS

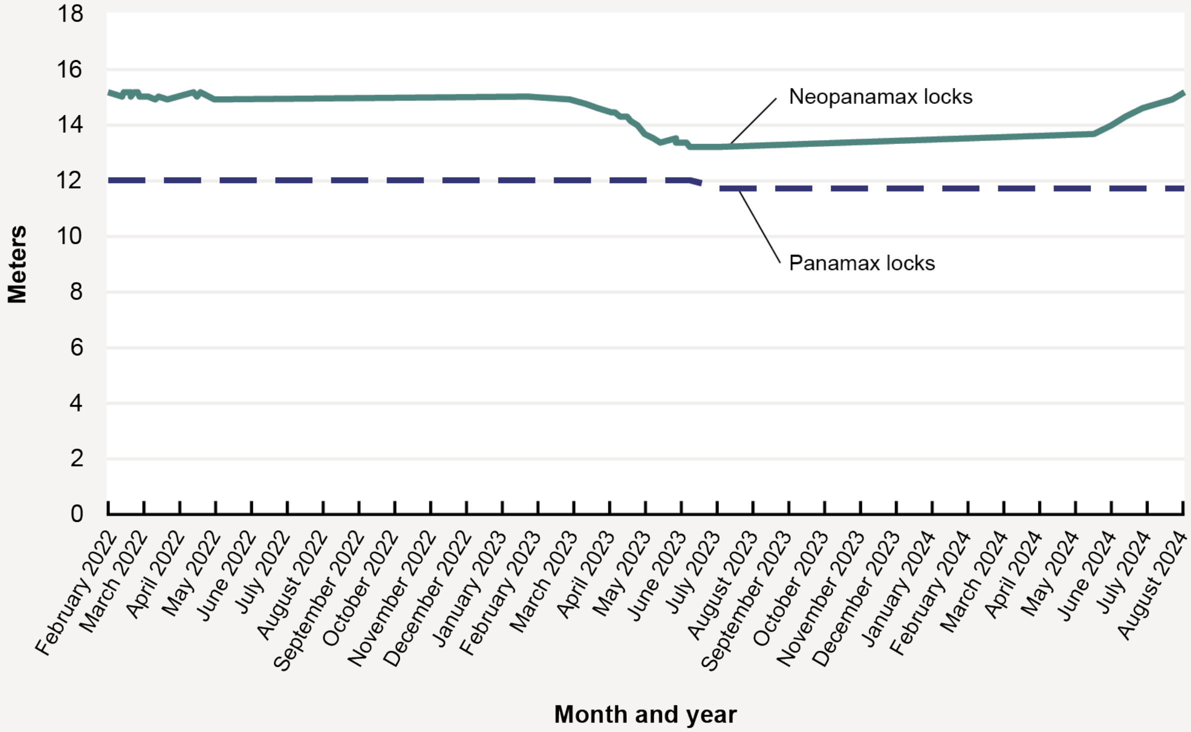
The Panama Canal, a vital artery for global trade and U.S. freight transportation, faced significant operational challenges in 2023 and early 2024 due to severe drought conditions. Gatun Lake, a key water source for the canal's lock operations, experienced water levels well below seasonal norms, forcing the Panama Canal Authority (PCA) to implement strict draft restrictions and limit the number of vessel transits.

Draft restrictions reduced the maximum allowable draft for Neopanamax vessels from the usual 50 feet to 44 feet, requiring ships to reduce cargo loads to meet the new limits. These measures contributed to a 10 percent decline in cargo throughput during the last quarter of fiscal year 2023 compared to the same period in fiscal year 2022. Furthermore, wait times for vessels without reserved transit slots increased significantly, with some ships waiting days or even weeks to transit the canal.

To manage transit delays, some carriers resorted to alternative strategies, including unloading containers onto rail for cross-isthmus transport, participating in PCA auction systems for priority transits, or rerouting ships via the Cape Horn or Suez Canal. These adjustments not only increased shipping costs and transit times but also underscored the canal's vulnerability to water resource challenges.

In response to these disruptions, the PCA has intensified investments in water conservation and management, including reservoir expansions and advanced recycling measures. While such efforts aim to mitigate future drought impacts, the events of 2023–2024 highlight the critical importance of sustainable water management for maintaining the canal's operational reliability.

Figure 3-13 Vessel Draft Restrictions on the Panama Canal by Locks: February 2022–August 2024



Source: Panama Canal Authority, Advisory to Shipping, 2022, 2023, and 2024, available at https://pancanal.com/en/maritime-services/advisory-to-shipping/ as of August 2024.

Note: 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).

TEU = twenty-foot equivalent unit.

importance of ongoing water management and conservation efforts to sustain its critical role in global maritime trade.

Since October 2023, global events have further complicated supply chain dynamics, particularly with the onset of the Hamas–Israeli conflict. The conflict has led to significant vessel diversions, with many shipping companies rerouting their vessels away from the Red Sea route through the Suez Canal to the longer route around the Cape of Good Hope. This shift has resulted in a 43 percent drop in Suez Canal transits and a 60 percent increase in traffic around the Cape from the previous year, leading to longer transit times and higher operational costs for shipping companies and re-routings of U.S.–Asian trades to the trans-Pacific routes [Simon 2024].

The financial impact of these changes is evident in the rising global container freight rates. Before the conflict, the global average freight rate for a forty-foot container was around $1,479 in September 2023; by July 4, 2024, rates continued to rise, reaching an average of $5,868 per forty-foot container, the highest global average ever recorded [Statista 2024]. These increased costs and extended transit times have particularly impacted the availability and pricing of goods, further straining global supply chains.

Emerging Issues

Excess Liner Shipping Capacity

The container shipping industry is navigating a period of potential overcapacity, driven by a wave of new vessel orders initiated during the pandemic's peak, a time when container shipping companies enjoyed record profits due to surging demand and high freight rates. This trend is evident in the extensive orderbook, which amounts to about 28 percent of the current global container fleet's capacity, with notable deliveries expected through 2025—approximately 2.45 million TEUs, for example, were expected to be added in 2023 and another 2.74 million TEUs in 2024, each representing nearly 10 percent of the current fleet's capacity [Miller 2022]. Such rapid expansion in capacity poses a risk, particularly if global trade growth fails to keep pace, which could drive down freight rates and profitability.

Key players in the container shipping industry are particularly active in fleet expansion. Major operators like MSC, ONE, and Evergreen have aggressive order books, adding over 30 percent of their existing capacity (Table 3-12). MSC leads the market with a fleet of 867 ships totaling 6.19 million TEUs, with 31.2 percent of this capacity in newbuilds. Evergreen also has a substantial 36.5 percent of its capacity on order, followed by ONE at 31.5 percent, while the average of the top 10 shipping line orderbook is 20 percent of available capacity. This investment in new vessels reflects not only the industry's bullish outlook but also its shift toward more fuel-efficient, environmentally compliant vessels, anticipating stricter emissions regulations.

However, this level of fleet expansion raises concerns about potential oversupply, especially as newbuild prices have surged by 53 percent since 2020 due to high demand for shipyard slots. Historically, similar capacity expansions have resulted in periods of oversupply, as in the 2010s, when excessive capacity led to prolonged rate depressions [The Maritime Executive 2024b]. The current Red Sea disruption has temporarily mitigated some of the overcapacity, as carriers redeploy excess capacity to serve Asia-Europe trades sailing around the Cape of Good Hope. However, this redeployment involves already idle capacity and does not reduce the long-term risk. Once the Red Sea situation stabilizes and the orderbook capacity is deployed, these vessels will likely exacerbate the oversupply problem. If demand for container shipping does not grow in tandem with this capacity increase, freight rates could face downward pressure, negatively impacting carrier revenues and profitability.

For the United States, this overcapacity poses specific challenges. Lower freight rates due to excess capacity could initially benefit U.S. importers with reduced shipping costs, potentially lowering consumer prices for imported goods. However, the financial strain on carriers may lead to cost-cutting measures that could impact service reliability, especially on less profitable routes. This could affect smaller U.S. ports and regional trade routes, where service frequency and options might be reduced if carriers focus on consolidating high-demand routes to maintain profitability.

Vessel Diversions from Middle East Conflict

The ongoing Israel–Hamas conflict has had a profound impact on shipping through the Suez Canal, with a precipitous decline in vessel transits, from 2,286 in October 2023 to 998 transits in June 2024 (Figure 3-14). Heightened risks of attacks in the Red Sea have prompted shipping companies to reroute container ships around the Cape of Good Hope. This diversion, while avoiding security risks, extends transit times by about 10 days on Asia–Europe routes, leading to higher operational costs, increased fuel consumption, and delays in delivery schedules. Consequently, freight rates and insurance

Table 3-12 Liner Shipping Capacity and Orderbook in TEUs of Top 10 Shipping Lines

	TOTAL		Owned		Chartered		Orderbook		
Operator	TEU	Ships	TEU	Ships	TEU	Ships	TEU	Ships	Percent of chartered and owned capacity
MSC	6,191,591	867	3,221,745	575	2,969,846	292	1,930,530	131	31.2
Maersk	4,393,446	713	2,541,002	333	1,852,444	380	491,164	35	11.2
CMA CGM	3,800,171	650	2,080,726	289	1,719,445	361	1,034,473	73	27.2
COSCO	3,292,106	507	1,946,646	195	1,345,460	312	918,963	58	27.9
Hapaq-Lloyd	2,273,765	296	1,320,466	128	953,299	168	176,126	12	7.7
ONE	1,941,587	247	783,644	92	1,157,943	155	611,708	47	31.5
Evergreen	1,726,419	221	1,100,963	138	625,456	83	629,877	56	36.5
HMM	881,593	79	729,806	54	151,787	25	109,653	12	12.4
Zim	760,449	129	65,700	12	694,749	117	36,515	5	4.8
Yang Ming	695,799	93	300,354	57	395,445	36	77,500	5	11.1

Source: Alphaliner Top 100, available at https://alphaliner.axsmarine.com/PublicTop100/ as of October 29, 2024.
TEU = twenty-foot equivalent unit.

premiums for these longer routes have risen, reflecting the elevated risks and added expenses.

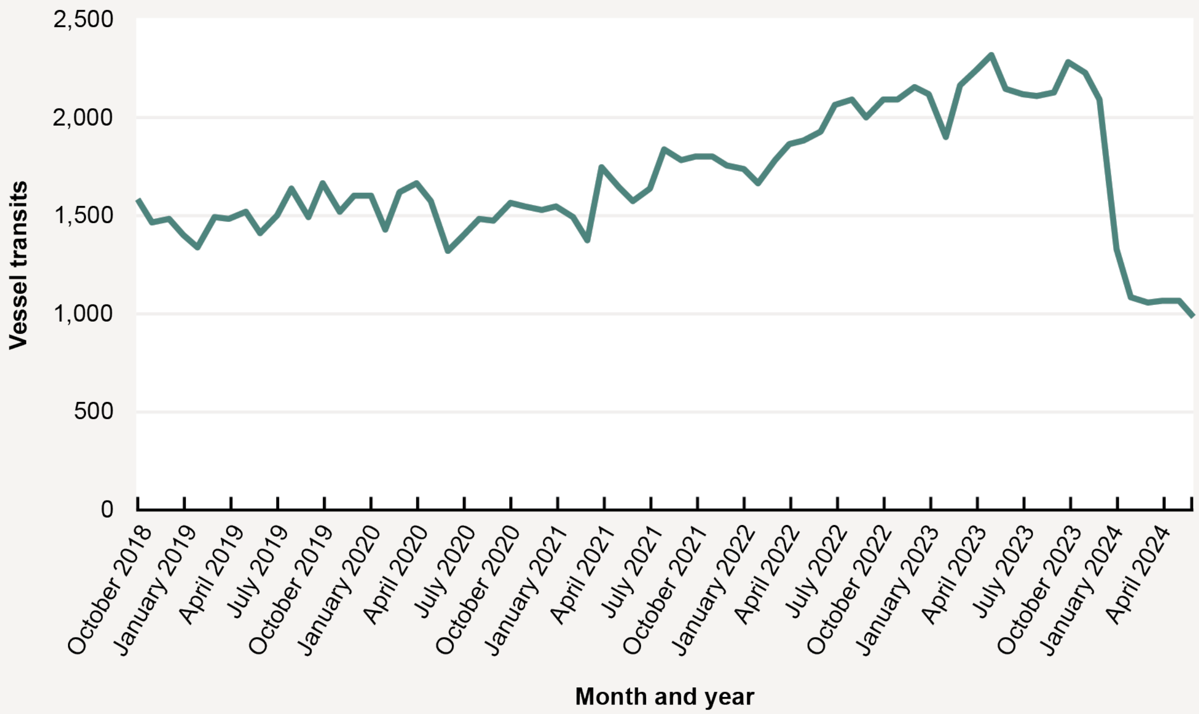
Shipping companies have responded by adding extra vessels to maintain service frequencies, increasing logistics costs further. These reroutings have significant downstream implications for U.S. importers and exporters reliant on the Suez Canal for timely shipments, impacting inventory management and raising costs for U.S. businesses. Moreover, the extended transit times and increased fuel use present challenges to sustainability efforts in the shipping industry, counteracting emissions reduction initiatives.

As the situation unfolds, carriers serving the Asia–Europe and Asia–U.S. markets might re-evaluate their route strategies, particularly for services to the U.S. East Coast via the Suez Canal. This reevaluation could lead to a shift of capacity from Asia–U.S. East Coast routes to trans-Pacific routes, where carriers avoid the Suez Canal and rely on U.S. West Coast ports as entry points. While this could bring short-term benefits to U.S. West Coast importers due to increased shipping line capacity and potentially stabilized rates, it may also introduce complications for East Coast-oriented customers.

For East Coast customers, the shift to trans-Pacific routes increases demand for intermodal and trucking services to transport goods cross-country from West Coast ports to certain U.S. East Coast port markets, which may result in higher shipping costs and longer delivery times. Increased demand for rail and truck transport across the country could further strain U.S. inland logistics networks, creating potential bottlenecks and higher rates for cross-country deliveries.

The increased cargo volumes at U.S. West Coast ports also carry the risk of renewed congestion. Ports like Los Angeles, Long Beach, and Seattle–Tacoma have limited capacity, and an influx of diverted shipments could strain existing resources, especially during peak seasons. However, West Coast ports are better prepared now than they were during the pandemic peak, having made significant infrastructure improvements and operational adjustments to handle higher volumes. Ports and logistics providers would likely need to closely coordinate to manage these increased volumes effectively and mitigate the risk of congestion, but the improved preparedness could help manage the influx more smoothly.

Figure 3-14 Suez Canal Vessel Transits: October 2018–June 2024



Source: UNCTAD, "Navigating Troubled Waters: Impact to Global Trade of Disruption of Shipping Routes in the Red Sea, Black Sea and Panama Canal," UNCTAD Rapid Assessment, February 2024, available at https://unctad.org/publication/navigating-troubled-waters-impact-global-trade-disruption-shipping-routes-red-sea-black#anchor_download; and UN Office for the Coordination of Humanitarian Affairs (OCHA)/Humanitarian Data Exchange (HDX), "Red Sea crisis: Suez Canal traffic impacts," Panama and Suez Canal Transits dataset, available at https://data.humdata.org/dataset/the-red-sea-suez-canal-traffic.

Foreign Direct Investment

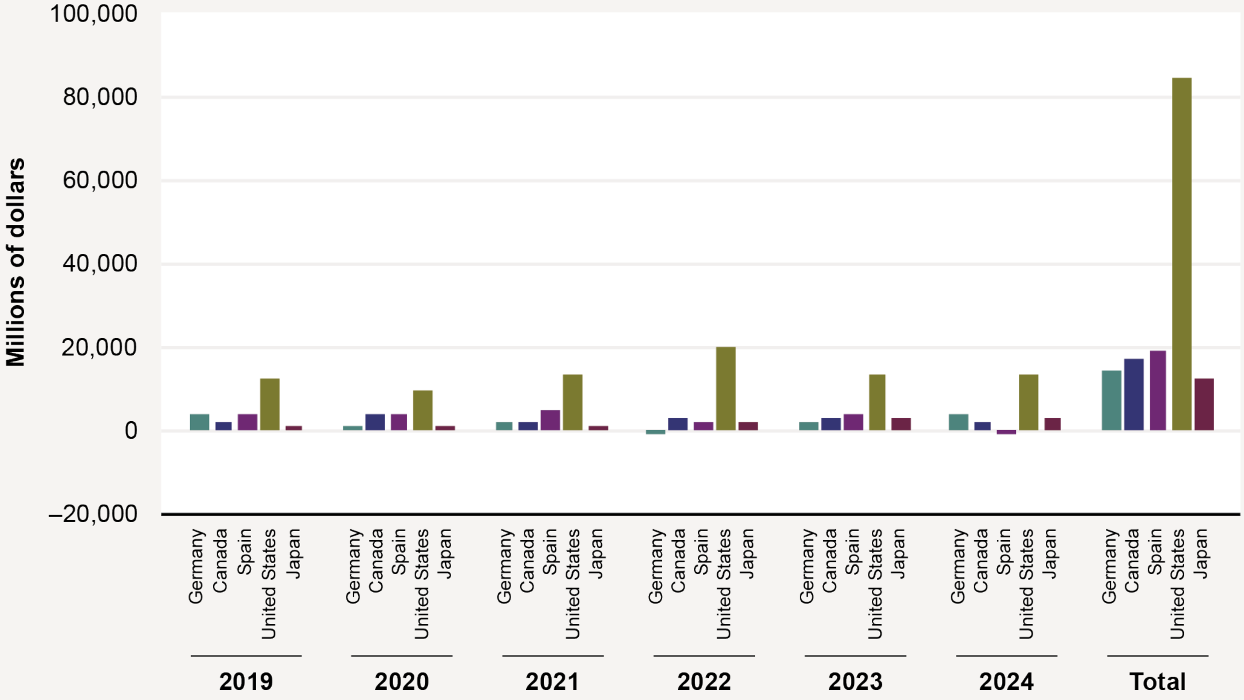
As Figure 3-15 shows, the data on foreign direct investment (FDI) in Mexico from 2019 to the first two-quarters of 2024 highlights the country's strategic emergence as a manufacturing and trade hub within North America, particularly for the top five investing countries—Germany, Canada, Spain, the United States, and Japan. The United States stands out with consistently high investment levels, peaking at $20.2 billion in 2022, and accumulating over $83 billion across the period. Further, the first two quarters of U.S. FDI in Mexico match the total U.S. FDI of 2023. This sustained inflow reflects a shift by U.S. companies toward reshoring production to Mexico to leverage proximity, reduced logistics costs and supply chain risks, and favorable trade terms under the United States–Canada–Mexico Agreement (i.e., the USMCA). Additionally, Mexico's lower labor costs provide U.S. companies with an economically viable way to keep production costs competitive, balancing cost efficiency with supply chain resilience.

For other major economies, including Canada, Germany, Spain, and Japan, the FDI data suggests that Mexico is also a preferred base for accessing the U.S. market. Canada's steady investment reflects its continued focus on Mexico's manufacturing sectors as cost-effective export points to the United States, while Germany and Spain, despite some fluctuations, collectively contributed over $33 billion between 2019 and 2024. Japan's growing investment, especially in recent years, underscores a commitment to high-tech manufacturing and automotive production targeting North American markets.

Annual FDI fluctuations reveal specific dynamics. The spike in U.S. investment in 2022 likely aligns with reshoring efforts as companies seek to mitigate supply chain risks, capitalize on tariff benefits, and reduce transit times to the U.S. market. Concurrently, the increased Canadian and German investments from 2020 to 2023 reflect strategic moves to leverage Mexico's cost advantages in North American trade. Spain's negative FDI in early 2024 may indicate capital adjustments or profit repatriations, though its overall investment remains substantial.

These FDI trends have profound implications for cross-border transportation, especially by truck, given the dominance of

Figure 3-15 Top Five FDI Countries in Mexico: 2019–2023 and First Two Quarters of 2024



Source: Gobierno de México, "Información Estadística de la Inversión Extranjera Directa," Información estadística general de flujos de IED hacia México desde 1999, available at https://www.datos.gob.mx/busca/dataset/informacion-estadistica-de-la-inversion-extranjera-directa as of October 28, 2024.

FDI = foreign direct investment.

land transport between the United States and Mexico. As manufacturing activities increase in Mexico to serve U.S. and broader North American markets, cross-border trucking demand will likely surge. This will put added pressure on infrastructure at key border crossings, such as those in Laredo, TX, and Nogales, AZ, as well as on highways and inspection facilities.

Data Gaps

The growing complexities in freight transportation require a more robust and comprehensive dataset to analyze system performance and respond to emerging challenges. The most recent developments—such as shifting supply chains, advancements in e-commerce, and efforts to address port congestion—highlight the critical need for more granular and timely freight transportation data.

Shipment Routing Data

Existing data sources focus mainly on collecting information on the origins and destinations of shipments. However, there is a critical gap regarding the distribution or routing of goods between origin and destination. For example, many shipments use multiple modes, such as containerized shipments that use truck–rail intermodal, which requires moving vehicles from truck to train, typically at an intermodal yard. Additionally, even when goods transport uses only one mode, carriers may transfer goods between trucks at less-than-truckload terminals, or from one train to another train at a rail classification yard. Existing sources do not reveal these details of shipment paths. This gap limits the ability of stakeholders to evaluate the impacts of potential facility disruptions and assess overall freight system performance. Data on shipment routes and transfer points would give freight operators insight into benefits of their operational improvements, and allow them to understand impacts of these facilities on system resilience.

Ports: Performance and Utilization Data

A critical gap persists in the availability of real-time data related to freight system performance, particularly at the port level. Although the massive pandemic-related port bottlenecks are over, disruptions (either realized or potential) continue to occur. Therefore, these data gaps are as important for preparedness as they were in 2021–2022. A comprehensive analysis of freight transportation requires more granular data points that capture port activity, such as the following:

- **Vessel waiting time:** Measuring the time container vessels wait for an available berth, categorized by vessel type and size, is essential for monitoring port congestion and for vessel operators to optimize vessel calls.
- **Truck turn time:** Understanding how long trucks spend entering and exiting a terminal, accounting for factors like empty hauls, double hauls, and whether containers are full or empty, is key to improving terminal performance. Double hauls—where trucks drop off and pick up containers in a single trip—can significantly reduce truck trips, lowering both operational costs and emissions.
- **Truck queue time:** The time trucks spend waiting to reach the gate impacts both operational efficiency and environmental outcomes. Reducing these wait times improves throughput and reduces fuel consumption and emissions.

Tracking these performance metrics helps identify inefficiencies and the underlying causes of delays, providing the foundation for solutions that can enhance port performance and reduce emissions. By collecting data on vessel waiting times, truck turn times, and truck queue times, ports and marine terminals can better evaluate the environmental benefits of their operational improvements.

Additionally, data on underutilized port assets is essential for planning for available capacity during disruptions. Developing a dataset that identifies the TEU capacity of all U.S. ports capable of handling sea-going container vessels would enable stakeholders to quickly identify excess capacity and strategically deploy resources during periods of congestion or unforeseen disruptions. Such data would provide a valuable tool for managing port and terminal performance, ensuring that available capacity is fully leveraged when disruptions occur.

Other Logistics Nodes: Capacity and Infrastructure Utilization Data

Supply chain performance metrics require more comprehensive data collection to effectively manage capacity and infrastructure utilization. This gap encompasses both transportation-specific facilities and storage and distribution facilities. Transportation facilities, such as intermodal yards and less-than-truckload terminals, are critical to freight system performance, as are warehouses and distribution centers. While data on their locations are available, information on their capacity and utilization remains scarce. Such data is essential for understanding system congestion, resilience, and the potential benefits of improvements to these facilities.

For instance, warehouse capacity utilization is a critical measure—ideally, utilization should not exceed 85 percent to prevent bottlenecks. Comprehensive data on warehouse capacity availability and utilization, the capacity and utilization of other logistics nodes, as well as chassis and vehicle availability and truck queue and waiting time data at distribution centers, can help industry stakeholders anticipate and mitigate bottlenecks and congestion-related risks.

First-Mile and Last-Mile Freight Movements

Freight transportation analysis has increasingly emphasized the “last mile” of deliveries, particularly as e-commerce has introduced new challenges for freight transportation infrastructure. The rise of e-commerce has led to a growing frequency of smaller delivery vehicles, such as vans and light trucks, sharing road space with larger freight trucks. This increased road congestion is particularly notable in urban areas and impacts the efficiency of freight truck movements, causing delays in transporting goods to and from ports. Delivery vehicles frequently stopping in residential and commercial areas contribute to traffic bottlenecks, which create additional challenges for larger freight trucks.

However, a critical data gap exists in understanding e-commerce shipments that originate directly from retail stores rather than warehouses. Many retailers, such as PetSmart, Ulta, Target, and Walmart, now offer shipping and delivery services from their stores. This trend introduces additional complexities in freight logistics and creates challenges in quantifying the scale and impact of these shipments, as no authoritative data source currently tracks these operations. Efforts to address this gap, such as ongoing work from the Commodity Flow Survey (CFS), are essential for providing a clearer picture of e-commerce freight dynamics.

It is also important to consider the “first mile” of freight movements, particularly in agricultural regions during harvest seasons. Trucks transporting agricultural products to grain elevators and terminals often face significant congestion with bottlenecks forming at these collection points. Similar to marine terminals, agricultural sites can experience long truck queues and extended truck turn times, leading to increased emissions from idling vehicles and inefficiencies in the supply chain.

The focus on first-mile operations, alongside last-mile challenges, highlights the need for data collection across both ends of the freight transportation spectrum. Key data points—such as truck queuing time and truck turn time—should be gathered not only at marine terminals but also at agricultural sites and distribution centers to monitor congestion and improve operational efficiency. Reducing congestion and optimizing truck movements in both the first and last mile can lead to emissions reductions and enhance overall supply chain performance.

Moreover, data related to delivery density, missed deliveries, and the utilization of alternative delivery methods (e.g., cargo bikes or delivery lockers in the case of e-commerce) will help improve the efficiency of last-mile logistics. By broadening the focus to include the first mile, especially in rural and agricultural contexts, stakeholders can take a more comprehensive approach to optimizing freight movements and reducing the environmental impact of inefficiencies across the entire freight system.

Shipping Freight Cost

While BTS has made significant strides in providing cost indicators for specific freight routes, a more extensive dataset is still needed to capture freight costs across the supply chain. These costs include not just freight rates, but also tariffs and fees from shipping lines, ports, airports, trucking companies, and distribution centers.

Detailed freight cost data are crucial for stakeholders to monitor cost trends, understand the impact of market disruptions, and make informed decisions regarding freight planning. More expansive cost data would also support policy decisions aimed at improving the competitiveness and sustainability of U.S. transportation networks.

Similarly, companies have monetized the value of time and hence incorporate time and reliability as additional factors for route planning and delivery. Data relative to delivery time and the extent to which delivery schedules are met fills out a more holistic view of freight system performance from a company’s perspective.

Conclusion: Addressing Data Gaps for a Resilient Freight System

The ongoing evolution of global trade, domestic production, and e-commerce highlights the urgent need for more granular and real-time data across the U.S. freight transportation network. Access to accurate, timely data is critical for improving the resilience of the freight system, optimizing both operational efficiency and environmental performance.

Crucial data gaps remain in the areas of port congestion, vessel and truck waiting times, and infrastructure utilization. Addressing these gaps is essential for improving port and terminal performance, reducing emissions, and ensuring efficient use of resources during periods of disruption or high demand. Additionally, as sustainability-linked loans become more widely adopted, tracking environmental performance data at the port and terminal level will allow operators to achieve emissions reduction targets and access more favorable loan terms.

The need for a better understanding of the e-commerce impacts on transportation is clear. Urban, suburban, and even rural streets and roads are being used by different vehicles in different ways. E-commerce has facilitated the limited introduction of sidewalk robots and may do the same for aerial drones. Transportation planners need to determine how to cope with these changes or even whether coping is necessary.

Equally important is the need to collect and analyze data on the first and last mile of freight movements. While e-commerce has brought renewed focus to last-mile logistics, the first mile, particularly in agricultural contexts, also presents significant challenges related to congestion and emissions. Understanding the dynamics of freight movements at both ends of the supply chain will allow for a more comprehensive approach to reducing inefficiencies, optimizing truck operations, and mitigating the environmental impacts of freight transportation.

Moreover, shipping freight costs, delivery time, and reliability metrics are critical components for monitoring cost trends, route optimization, and overall system performance from a company's perspective. Expanding these datasets will not only empower stakeholders to make better decisions, but also support policy efforts aimed at enhancing the competitiveness and sustainability of the transportation sector.

Ultimately, these diverse aspects of data collection—port performance, shipping costs, and delivery metrics—tie together into a cohesive strategy for improving the freight transportation network. By gathering and analyzing more detailed data on port performance, supply chain capacity, and first- and last-mile movements, stakeholders will be better equipped to navigate the challenges of a rapidly changing marketplace, ensuring that the U.S. transportation system remains competitive, responsive, and environmentally responsible.

References

Bureau of Transportation Statistics (BTS)

——2023a. Freight Transportation and the Economy: Freight-related fixed assets. Available at https://data.bts.gov/stories/s/Freight-Transportation-the-Economy/6ix2-c8dn.

——2023b. *Transportation Statistics Annual Report 2023*. Available at https://rosap.ntl.bts.gov/view/dot/72943.

Bureau of Transportation Statistics (BTS), Federal Highway Administration (FHWA). n.d. Freight Analysis Framework (FAF), version 5. Available at https://www.bts.gov/faf.

Labrut, M. 2023. "Panama Canal to reduce daily vessel transits due to drought," *Seatrade Maritime News* July 27, 2023. Available at https://www.seatrade-maritime.com/panama/panama-canal-reduce-daily-vessel-transits-due-drought.

Millard, P., M. McDonald and E. Roston. 2024. "The Panama Canal averts a crisis for now—but at a cost to drinking water," *Phys.org* March 18, 2024. Available at https://phys.org/news/2024-03-panama-canal-averts-crisis.html.

Miller, G. 2022. "Container-ship building spree not over yet; new orders still rising," *FreightWaves* June 27, 2022, available at https://www.freightwaves.com/news/container-ship-building-spree-is-not-over-yet-new-orders-still-rising.

National Aeronautics and Space Administration (NASA), Moderate Resolution Imaging Spectrometer (MRIS). 2024. "March 11, 2024 - Mississippi River Level Struggles to Recover from Record Lows." Available at https://modis.gsfc.nasa.gov/gallery/individual.php?db_date=2024-03-11.

National Oceanic and Atmospheric Administration (NOAA), National Integrated Drought Information System (NIDIS). 2024. "July 25, 2024 - Drought Status Update for the Midwest." Available at https://www.drought.gov/drought-status-updates/drought-status-update-midwest-2024-07-25.

Simon, C. 2024. "Looking at causes, measuring effects of Israel-Hamas war," The Harvard Gazette February 15, 2024. Available at https://news.harvard.edu/gazette/story/2024/02/looking-at-causes-measuring-effects-of-israel-hamas-war/.

Statista. 2024. "Global container freight rate index from the 12th January 2023 to the 15th August 2024," data as of August 20, 2024. Available at https://www.statista.com/statistics/1440707/global-container-freight-index/.

The Maritime Executive

——2024a. "Panama Canal Continues Progress Toward Normal Operations." *The Maritime Executive* July 31, 2024. Available at https://maritime-executive.com/article/panama-canal-continues-progress-toward-normal-operations.

——2024b. "Newbuilding Prices Reach Highest Level in 16 Years Driven by Strong Orders," *The Maritime Executive* June 12, 2024. Available at https://maritime-executive.com/article/newbuilding-prices-reach-highest-level-in-16-years-driven-by-strong-orders.

CHAPTER 4

TRANSPORTATION ECONOMICS

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.
- 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.

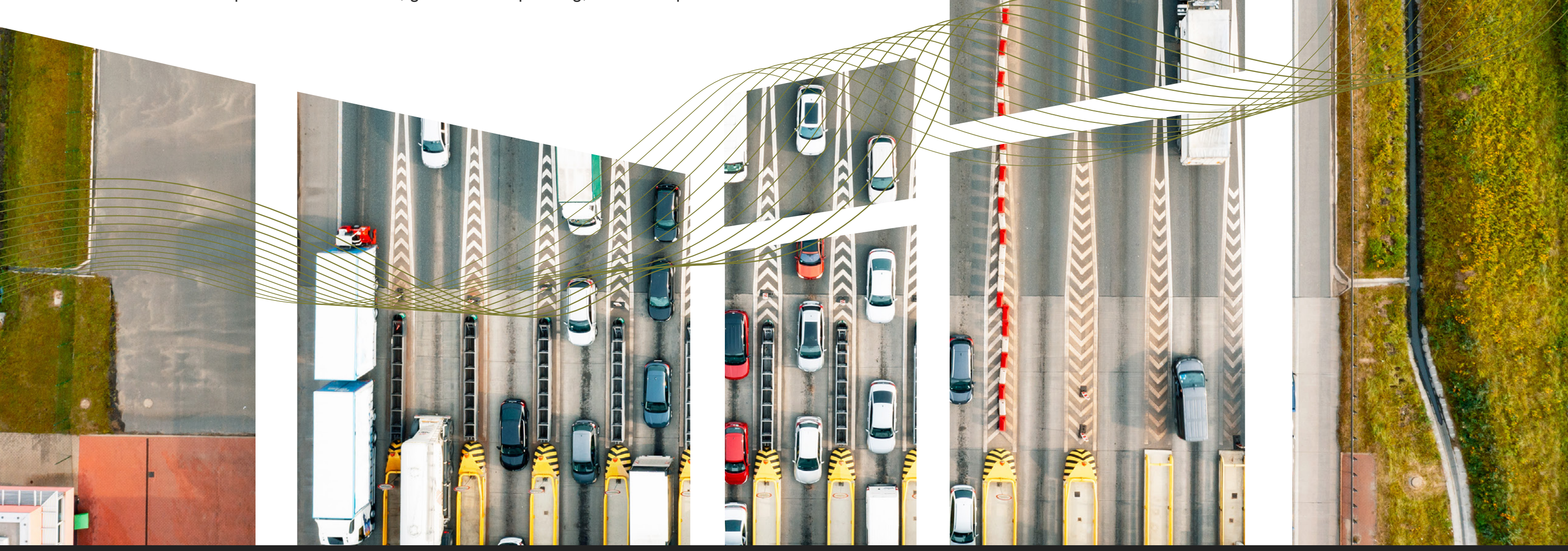
The average overall inflation rate reached its lowest level in August 2024 (2.5 percent) in over two years, falling below the March 2021 level (2.6 percent), but remaining above the federal target of 2.0 percent [BLS 2024a; Federal Reserve 2024]. Inflation can spur growth, but unchecked, inflation can 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,

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.



HIGHLIGHTS

Transportation accounted for 9.0 percent of U.S. gross domestic product in 2022, up from 8.4 percent in 2021 and 7.7 percent in 2020.

In 2022, the wholesale and retail trade sector continued to require more transportation services than any other sector to produce one dollar of gross output.

Transportation and transportation-related industries employed 16.0 million people (10.3 percent of the U.S. labor force) in 2023—up 1.7 percent from 2022.

Employment in transportation and warehousing (e.g., warehousing and storage, truck and air transportation, and school and city buses) declined slightly from 2022 to 2023, while employment in transportation-related industries (e.g., automotive manufacturing) grew (–0.6 and 3.3 percent, respectively).

The unemployment rate in the transportation and warehousing sector has fallen since the May/July 2020 all-time high. Nevertheless, the transportation and warehousing unemployment rate was 5.7 percent in July 2024; up from 4.2 percent in July 2019.

The number of job openings in the transportation, warehousing, and utilities sector reached an all-time high in December 2021, growing 114.8 percent from December 2020 to December 2021—the largest 12-month gain over the past decade. The number of job openings fell 53.6 percent from the December 2021 high to July 2024 (the latest available data). Despite the decline in openings, hirings grew 12.9 percent from July 2023 to July 2024.

Adjusted for inflation, total investment in new transportation infrastructure and new and used transportation equipment increased 21.1 percent from 2022 to 2023 (from $352.6 to 427.0 billion in 2017 dollars).

Businesses purchasing transportation services saw freight transportation rates fall in 2023 as seen through inland waterway transport rates returning to their prepandemic levels. From December 2023 to August 2024 (the most recent data available), ocean freight rates from the United States to Shanghai also returned to prepandemic levels, while rates from Shanghai to the United States increased 206.9 percent.

Per the National Highway Construction Cost Index, highway construction costs rose 13.9 percent in 2023 (the most recent data available) but by less than in 2022 when costs rose by the largest amount on record (26.5 percent). Higher costs reduce what can be bought with the $673.8 billion allocated by the Bipartisan Infrastructure Law for transportation by potentially 30 to 40 percent.

Increases in manufacturers' shipments as well as industrial production create demand for freight transportation services that, in turn, caused the Freight Transportation Services Index, which measures the volume of freight transportation, to rise to a new postpandemic high in February 2023.

Investment in new transportation infrastructure and new and used transportation equipment was $509.2 billion in 2023.

In 2023, the costs for rail, air, and water transportation services, as shown by the Producer Price Index (PPI), reached their all-time high, suggesting an increase in the prices businesses face when purchasing these transportation services. Contrastingly, truck transportation prices, as measured by the truck PPI, fell 5.2 percent from 2022 to 2023.

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).

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 2022, transportation services' (for-hire, in-house, and household) total contribution to GDP was $1.7 trillion (6.7 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 $911.8 billion (3.5 percent) to an enhanced U.S. GDP of $26.2 trillion.[4] In-house transportation services (air, rail, truck, and water) provided by nontransportation industries for their own use contributed an additional $364.1 billion (1.4 percent) to enhanced GDP. Household transportation, measured by the depreciation cost associated with households owning motor vehicles, contributed $471.1 billion (1.8 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 services. In 2022, the wholesale and retail trade sector required the most transportation services, 9.9 cents (4.7 cents of in-house transportation operations and 5.2 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 [BTS 2024a]. 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 observed 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 June 2022 due to significant economic growth observed through a 60.2 percent increase in new manufacturing orders from April 2020 (COVID-19 low) to June 2022 and a 5.9 percent increase in real GDP from Q1 of 2020 through Q3 of 2022 [FRED 2024a]. Increases in manufacturers' shipments as well as industrial production create demand for freight transportation services that, in turn, caused the Freight TSI to rise and reach a new postpandemic high in February 2023. In 2024, the Freight TSI fluctuated but increased 3.0 percent from January 2024 to July 2024 (the latest available data). However, the Freight TSI was down 1.3 percent in July 2024 from the post pandemic February 2023 high and down 1.7 percent from the August 2019 all-time high.

BTS research shows that changes in the TSI occur before changes in the economy, making the TSI a potentially useful economic indicator [BTS 2024h]. 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'

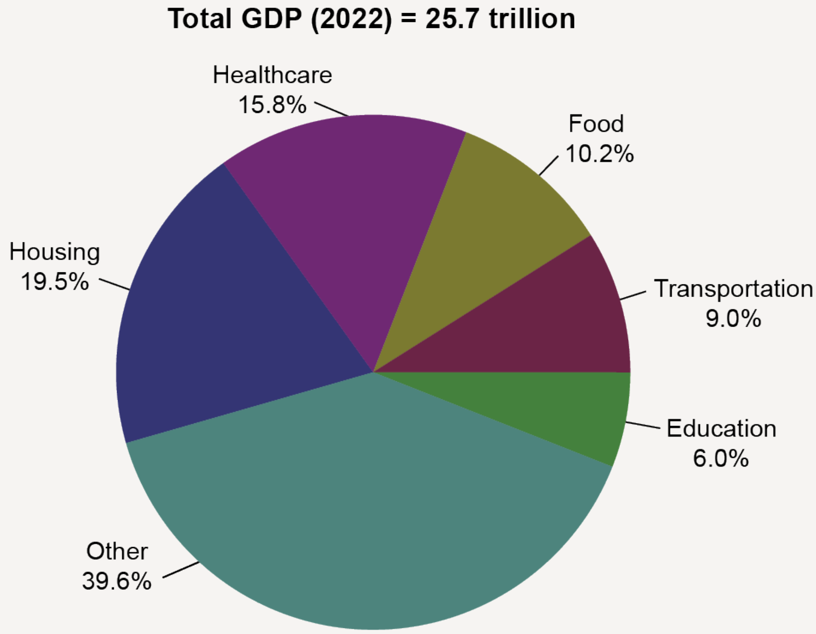
---

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 September 2024.

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), refer to U.S. Department of Transportation, Bureau of Transportation Statistics, *Transportation Economic Trends*, chapter 2, available at https://data.bts.gov/ stories/s/smrm-36nv/ as of September 2024.

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

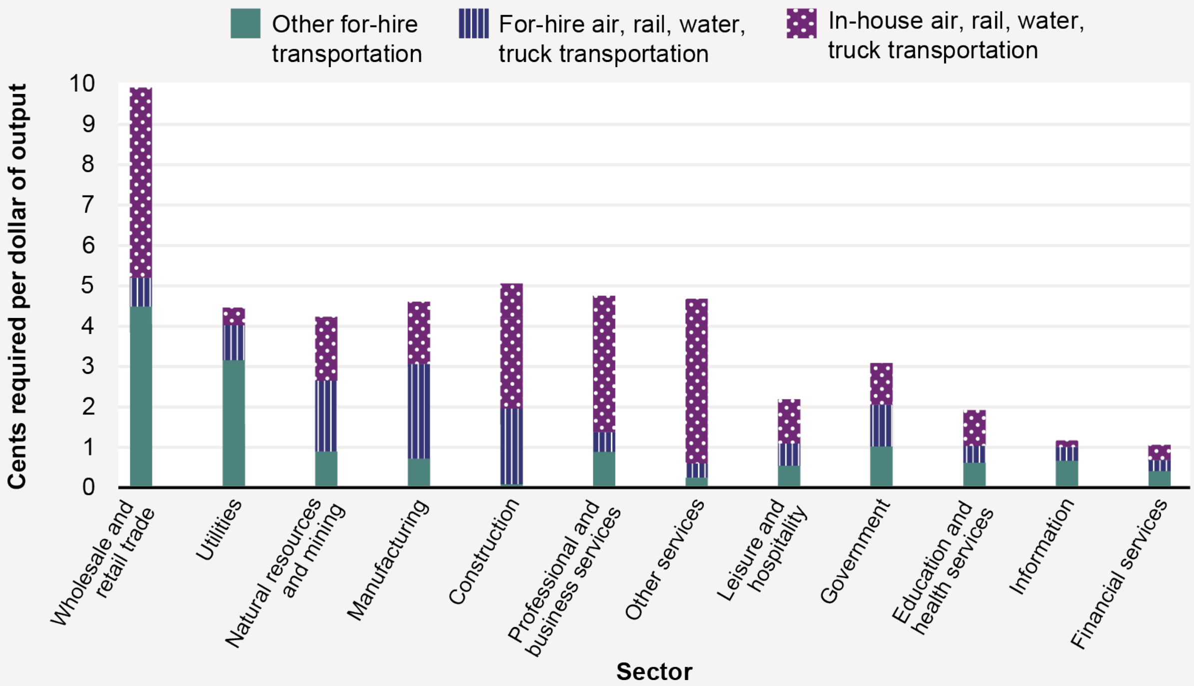


Source: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts Tables, tables 1.1.4, 2.4.4, 3.11.4, 3.15.4, 4.2.4, 5.4.4, 5.5.4 and 5.7.4B (price deflators); 1.1.5, 2.4.5, 3.11.5, 3.15.5, 4.2.5, 5.4.5, 5.5.5 and 5.7.5B (current dollars); 1.1.6, 2.4.6, 3.11.6, 3.15.6, 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 September 2024.

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

GDP = gross domestic product.

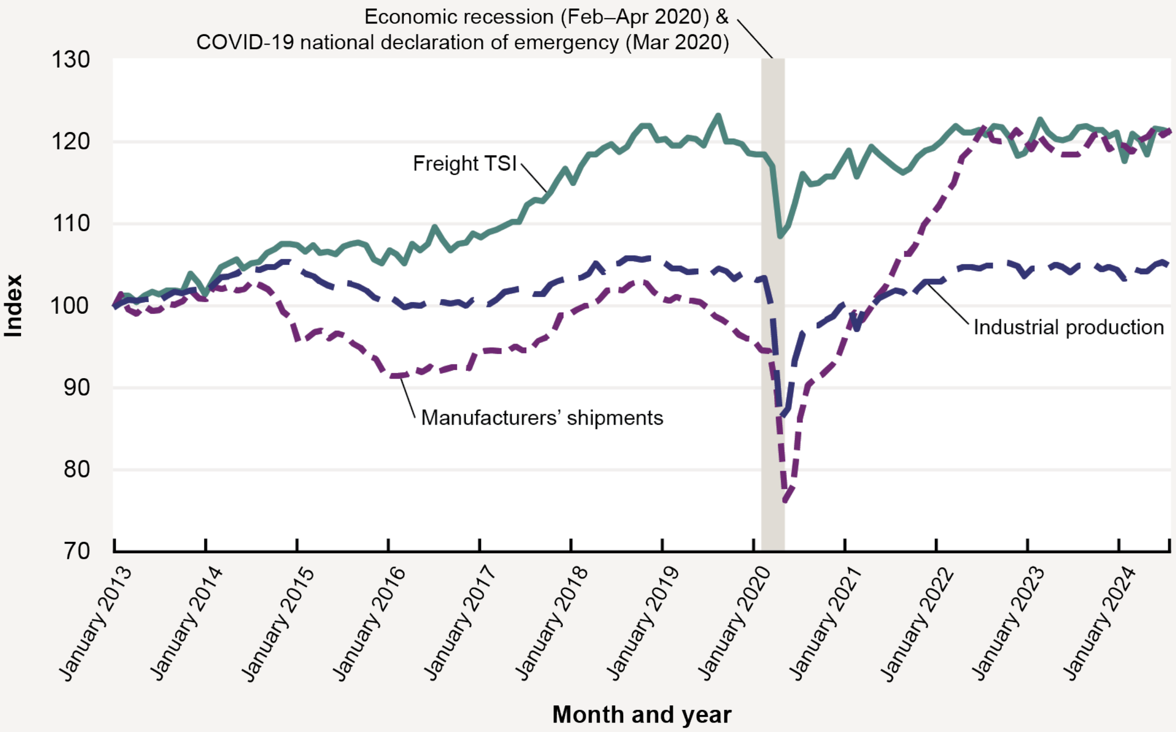
Figure 4-2 Transportation Services Required to Produce One Dollar of Output by Sector: 2022



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Satellite Accounts, available at http://www.bts.gov/satellite-accounts as of September 2024.

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.

Figure 4-3 Industrial Production, Manufacturers' Shipments, and Freight Transportation Services Index (Seasonally Adjusted): January 2013–July 2024



Source: 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 September 2024. 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 September 2024. Freight TSI: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Services Index, available at www.transtats.bts.gov/OSEA/TSI/ as of September 2024.

TSI = Transportation Services Index.

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 2024. 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 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 whether May 2022 marks an economic slowdown or a slight reduction in economic activity during a period of economic growth like that seen between May 1991 and December 1994.

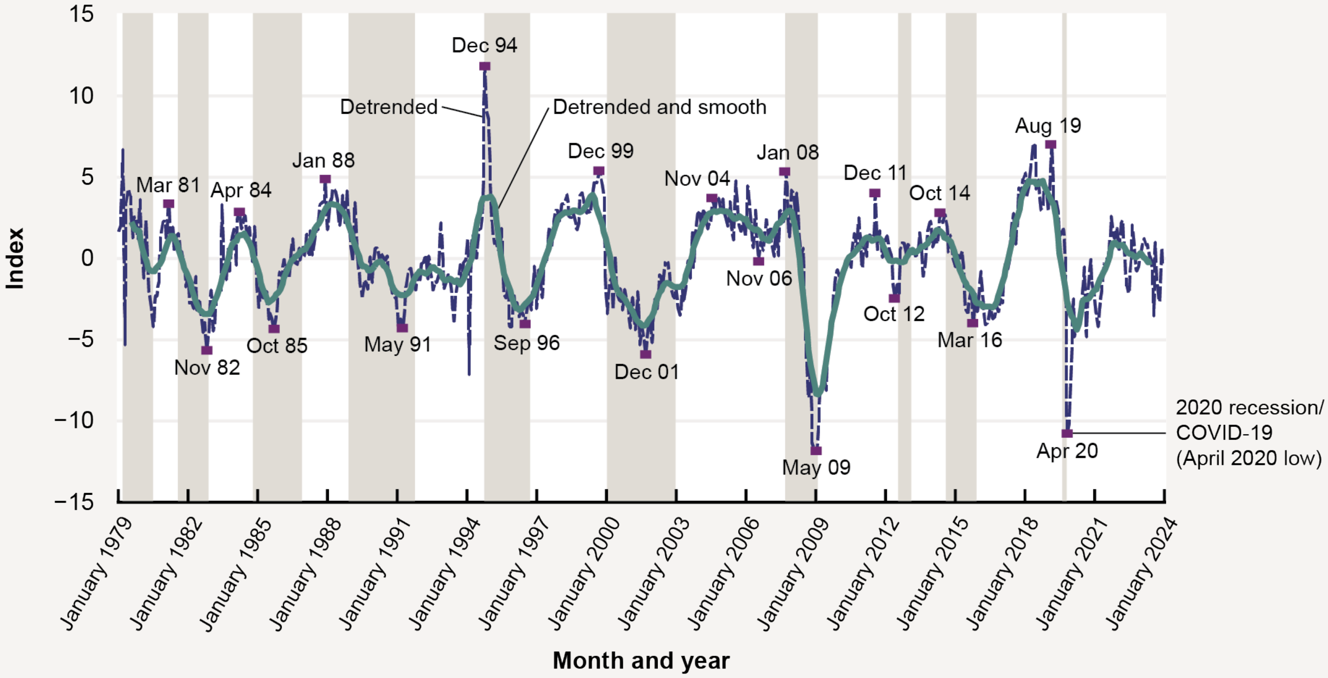
Transportation-Related Employment, Wages, Job Turnover, and Unemployment

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 16.0 million people (10.3 percent of the U.S. labor force) in 2023 in a variety of roles, from driving buses to manufacturing cars, to building, operating, and maintaining ports and railroads [BTS 2024b]. 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 through 2023, increasing 4.3 percent in 2021, 4.7 percent in 2022, and 1.7 percent in 2023.

The transportation and warehousing sector directly employed 6.6 million U.S. workers in 2023—a decrease of 0.6 percent from 2022. The 6.6 million workers comprised

Figure 4-4 Freight Transportation Services Index and the Economic Growth Cycle: January 1979–June 2024



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 September 2024.

Note: 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.

4.2 percent of the U.S. labor force (Figure 4-5), up from 4.0 percent in 2020 but down from 4.3 percent in 2022 [BTS 2024b]. Employment in transportation-related industries (e.g., automotive manufacturing) increased from 2022 to 2023 (by 0.3 million)—a 3.3 percent increase, unlike the 0.6 percent employment decline in the transportation and warehousing sector. Employment in transportation-related industries rose above the pre-COVID-19 level in 2023, climbing 0.1 million above 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 2023.

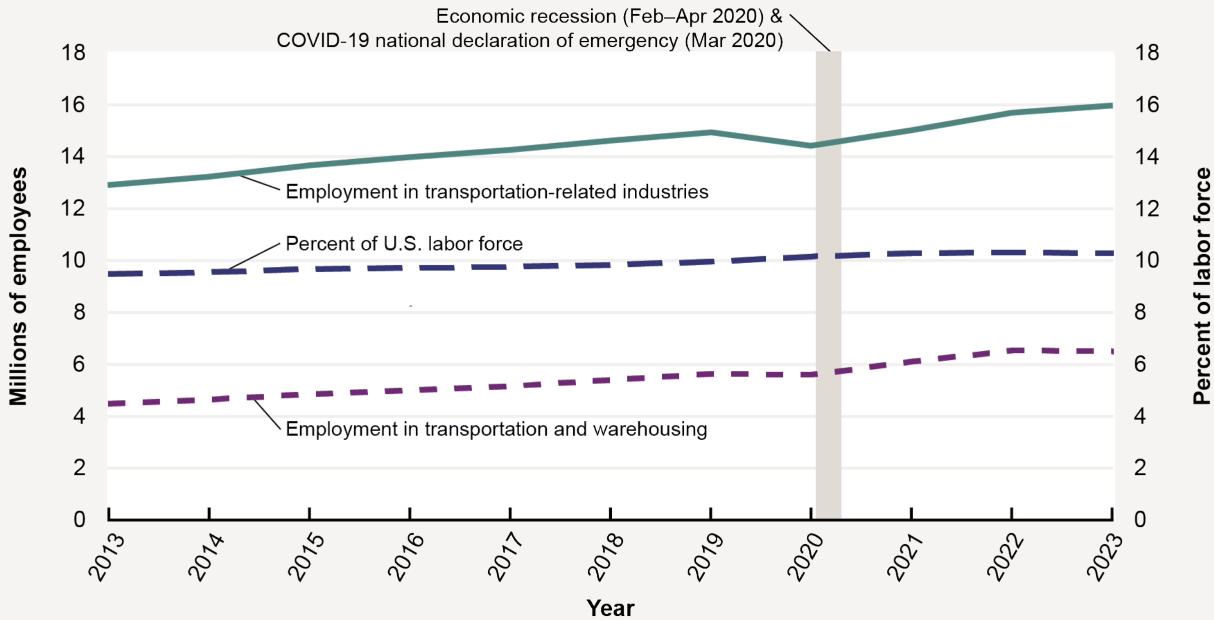
The total count of workers in the transportation industry includes all occupations, such as administrative staff employed by the trucking industry. Some workers holding transportation occupations work outside of the transportation and warehousing sector, such as truck drivers employed by retail stores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

Transportation Wages

Workers with transportation occupations earned a lower average hourly compensation ($34.89) than workers in all occupations ($45.42) in Q1 2024 [BLS 2024b]—the largest difference on record. Notably, wages for all occupations increased 5.5 percent from Q1 2023, rising from $43.07 to $45.42, while transportation occupations experienced a 3.8 percent increase in their wages from $33.60 in Q1 2023 to $34.89 in Q4 2023. Figure 4-7 shows annual median wages for the largest, lowest, and highest-paid and the fastest growing transportation occupations in the United States in 2023.

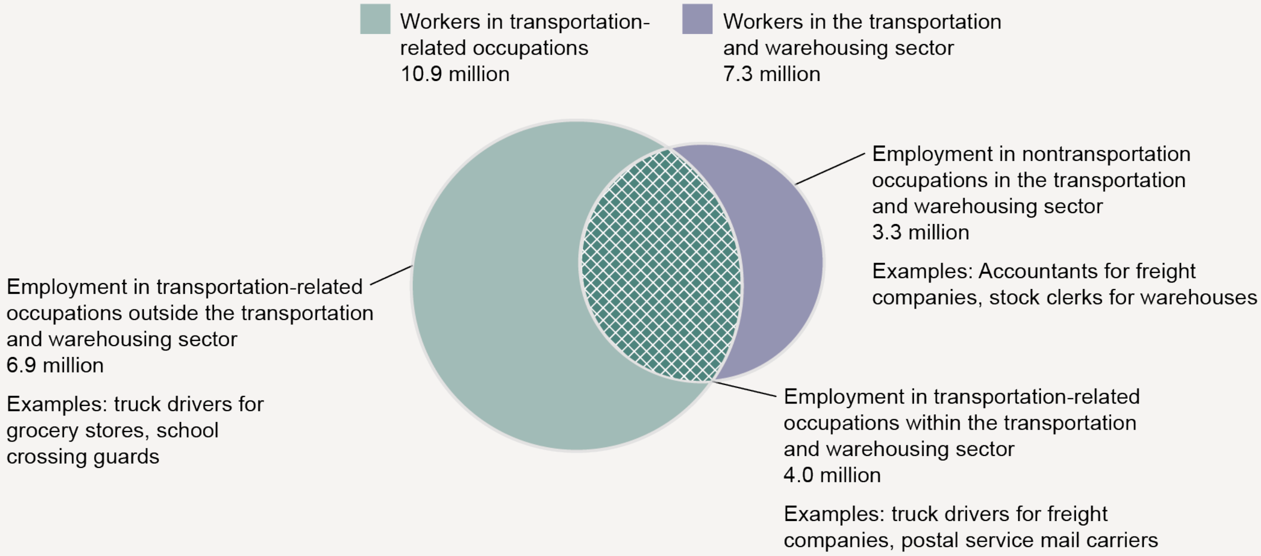
Annual wages vary widely, from a median annual wage of more than $219,000 for airline pilots and more than $137,000 for air traffic controllers to a median annual wage of just more than $32,000 for ambulance drivers and attendants. The 5 lowest-wage transportation-related occupations collectively employed about 605,000 workers, while the 5 highest-wage occupations employed about 245,000 workers in 2023.

Figure 4-5 Transportation-Related Labor Force Employment in the United States: 2012–2023 (Millions)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Economic Trends, Employment in Transportation and Related Industries, available at https://data.bts.gov/stories/s/caxh-t8jd as of September 2024.

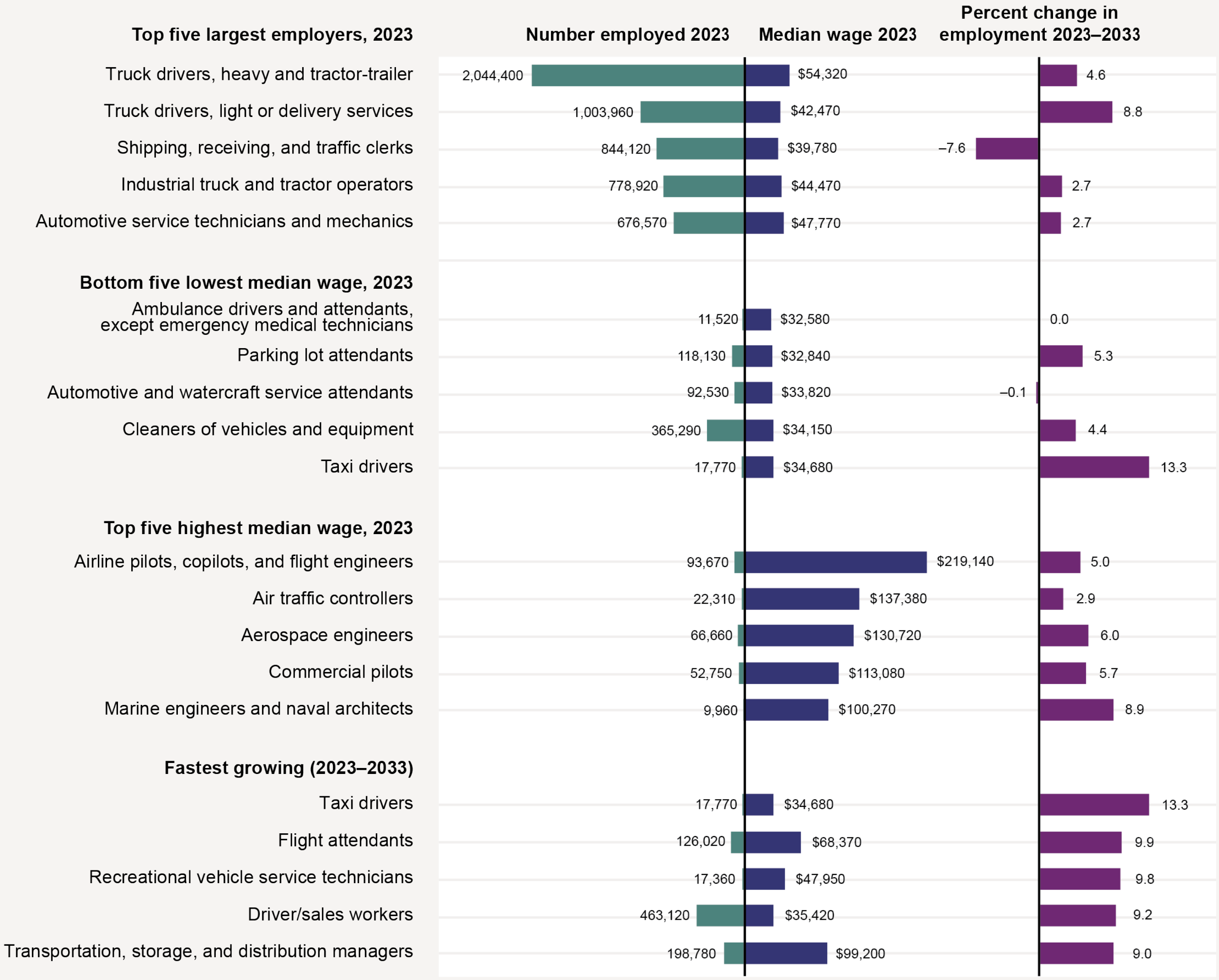
Figure 4-6 Relationship Between the Transportation and Warehousing Sector and Transportation-Related Occupations: 2023



Source: Bureau of Labor Statistics, Occupational Employment Statistics, available at https://bls.gov/oes/ as of September 2024.

Note: 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 includes 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.

Figure 4-7 Employment and Wages in Select Transportation Occupations: 2023



Source: 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 https://bls.gov/oes/. Projected growth rate: U.S. Department of Labor, Bureau of Labor Statistics, Employment Projections, available at https://www.bls.gov/emp/tables.htm as of September 2024.

Note: Airline pilots on scheduled air carrier routes typically transport passengers and cargo, while commercial pilots on nonscheduled air carrier routes typically transport passengers. “Commercial pilots” includes charter pilots, air ambulance pilots, and air tour pilots. Ambulance drivers excludes emergency medical technicians.

Automation of transportation and technological changes affect which transportation occupations will gain or lose employment. From 2023 to 2033, the number of taxi drivers and chauffeurs, which includes drivers working for ride-hailing services, such as Uber and Lyft, is expected to be the fastest growing transportation occupation at 13.3 percent—the 51st fastest growing occupation out of the 832 occupations identified by the Bureau of Labor Statistics [BLS 2024c].[5]

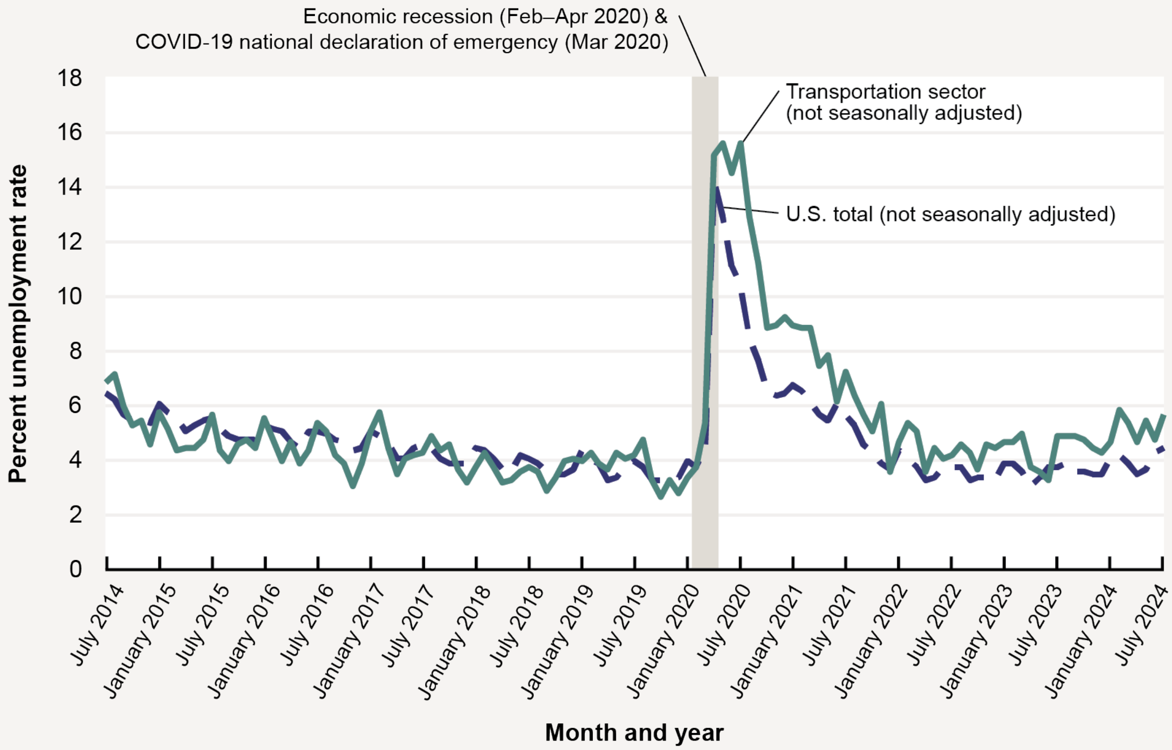
Job Openings and Labor Turnover

The number of job openings in the transportation, warehousing, and utilities sector reached an all-time high in December 2021 after growing 114.8 percent from December 2020 to December 2021—the largest 12-month gain over the past decade (Figure 4-8). The number of job openings fell 53.6 percent from the December 2021 high to July 2024 (the latest available data). Despite the decline in openings, hirings increased. Over the most recent 12-month period for which complete data are available, hiring grew 12.9 percent from July 2023 to July 2024 and increased month-over-previous month in 7 of those 12 months. After reaching an all-time high in November 2022, quits dropped 20.5 percent from November 2022 to July 2024. However, the number of those who quit their job steadily rose (18.1 percent) from March to July 2024. Layoffs and discharges remain stable after the combined effects of the February to April 2020 economic recession, and the COVID-19 pandemic caused a 415.3 percent increase in layoffs and discharges from January 2020 to March 2020—the highest level reached in the past decade.

Layoffs and discharges caused unemployment in the transportation and warehousing sector to reach an all-time high in May 2020—a level matched again in July 2020 (Figure 4-9). Since then, the unemployment rate in the transportation and warehousing sector has recovered substantially, but it is not yet back to prepandemic levels. In 43 out of the 49 months since July 2020, the unemployment rate in the transportation and warehousing sector exceeded the 2019 prepandemic level for the same month, and it has been higher than the 2019 levels in every month of 2024

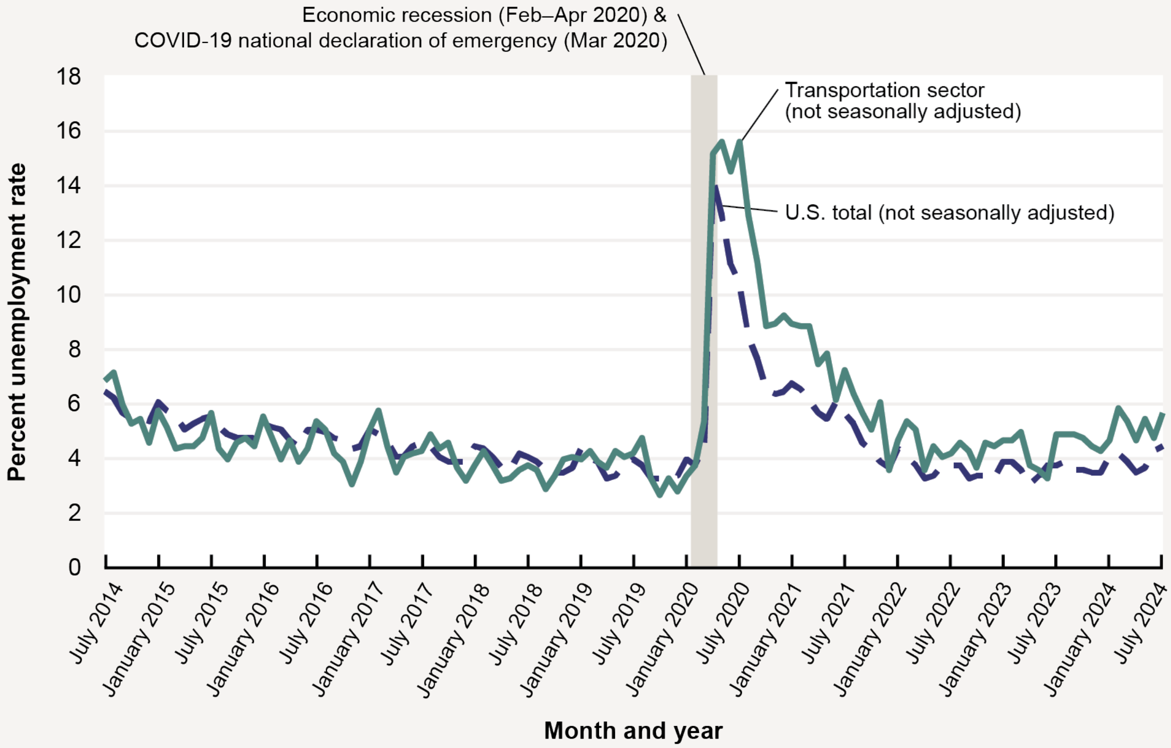
5 Summary occupations excluded from count.

Figure 4-8 Job Openings and Labor Turnover: Transportation, Warehousing, and Utilities Sector (Seasonally Adjusted): January 2013–July 2024



Source: U.S. Department of Labor, Bureau of Labor Statistics, Job Openings and Labor Turnover, available at https://www.bls.gov/jlt/ as of September 2024.

Figure 4-9 Transportation Sector and U.S. Total Unemployment Rate: July 2014–July 2024



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 September 2024.

thus far (as of July 2024). 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 they still experience higher rates of unemployment (Figure 4-10) [BTS 2024i].

Transportation Expenditures and Revenues

This year, BTS released a new compendium of transportation public finance statistics, known as Transportation Public Finance Statistics (TPFS). It replaced the previous product 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. TPFS is the only statistical compilation of government financial statistics covering all modes of transportation at all levels of government. The new financial statistics program releases preliminary statistics, allowing the data to be available to the public 6 months earlier, and will publish the actual data once they are available later in the year. This allows stakeholders and current TPFS users to access the data when they are more relevant. TPFS also expands on the level of detail provided in GTFS. The data expands on the categories of revenues and expenditures separating expenditures as capital and noncapital expenditures; revenues are broken out by own-source, including user-based and other, and supporting revenues. The data also denotes which data are from trust funds and shows Amtrak funds.

Public and Private Sector Expenditures and Revenue

Expenditures

The most recent data show that federal, state, and local governments spent $423.3 billion on transportation in 2022. 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 2022, state and local governments spent $375.7 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 $41.5 billion directly on transportation, excluding federal transfers to states (Figure 4-11), and Amtrak, which is considered a nonfederal cash flow, spent $6.1 billion [BTS 2024c].

Government transportation expenditures rose in 2020 due to the passage of three appropriation bills providing emergency funding in response to COVID-19.[6] The Infrastructure Investment and Jobs act was signed into law in 2021 with disbursements from fiscal year 2022 through 2026.

Revenue

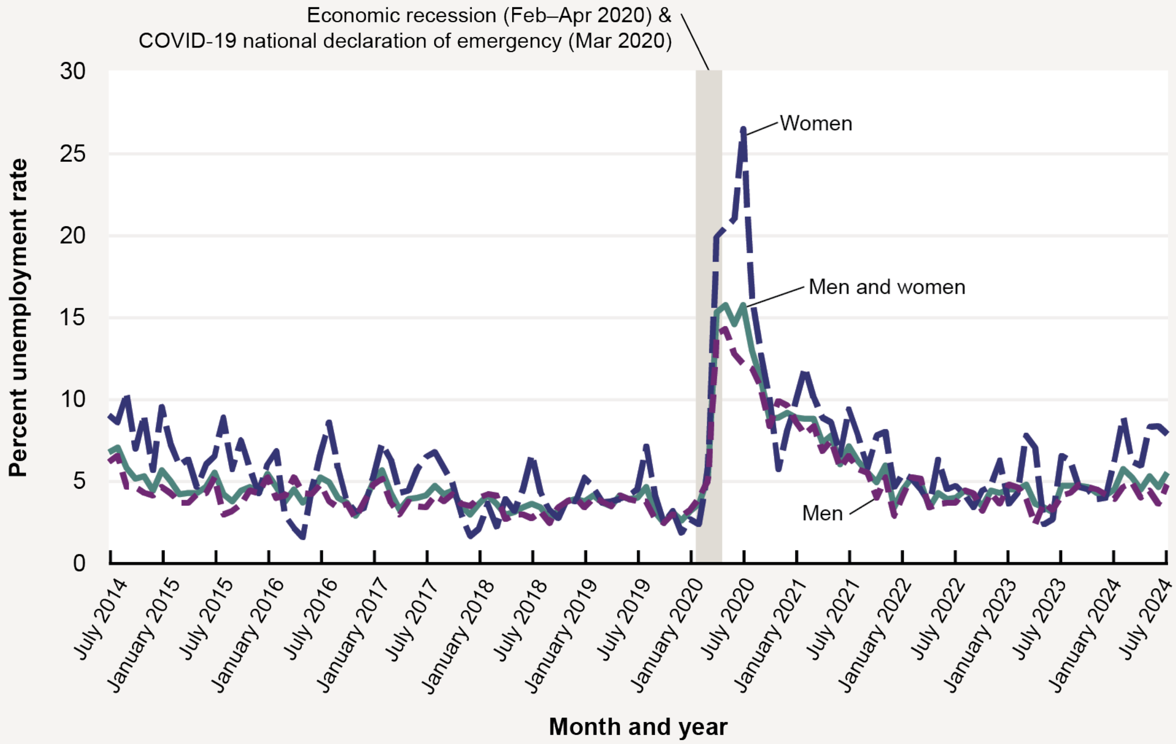
Government transportation revenue comes from user taxes and fees, such as gasoline taxes and tolls, air ticket taxes, and general revenues as well as income from investing transportation funds and receipts from fines and penalties. In 2022, federal, state, and local government revenue collected and dedicated to transportation programs totaled $555.2 billion (in 2022 dollars) (Figure 4-12) [BTS 2024c]. Less than half of the revenue ($228.2 billion, or 41.1 percent) came from taxes and charges levied on transportation-related activities (own-source revenue) [BTS 2024c]. The remaining $327.1 billion (58.9 percent) came from nontransportation-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, in inflation adjusted dollars, 4.6 percent between 2019 to 2020, but in 2021 revenue increased 2.2 percent before jumping to 22.8 percent in 2022.

Total government transportation expenditures increased from 2021 to 2022 (from 411.6 billion to 423.3 billion current dollars), at the same time, government transportation revenues also increased (from 417.1 billion in 2021 to 555.2 billion current dollars in 2022). In 2022, total (own-source and supporting) transportation revenues ($555.2 billion) outpaced total transportation expenditures ($423.3 billion) by $131.9 billion [BTS 2024c].

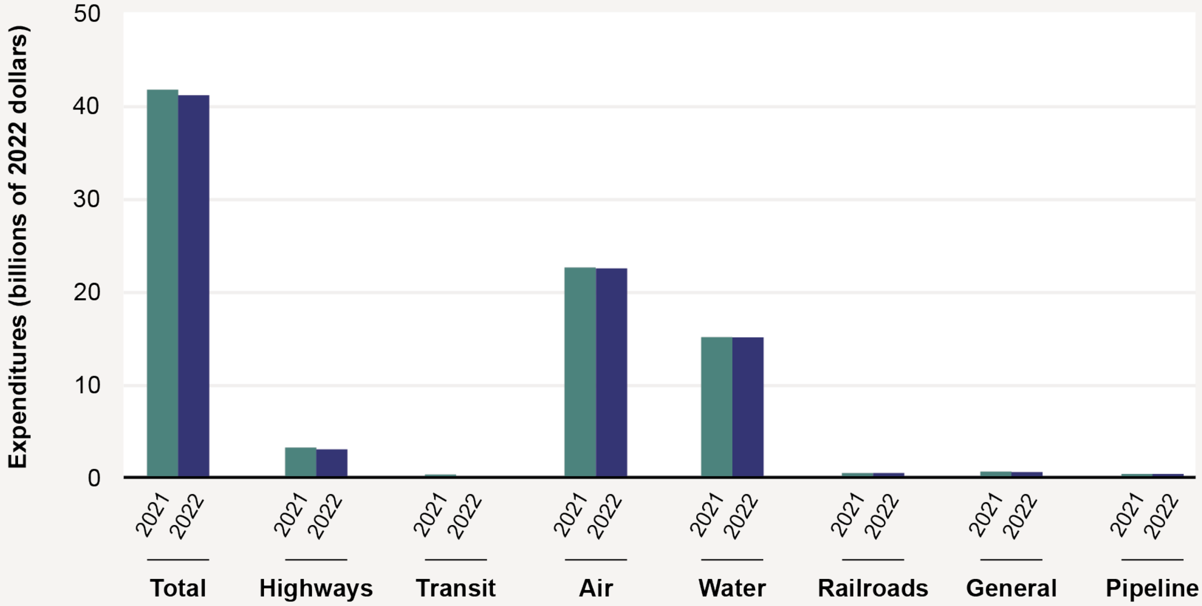
6 For more information on these bills, refer to U.S. Department of Transportation, Bureau of Transportation Statistics, "COVID-19 Stimulus Funding for Transportation in the CARES Act and Other Supplemental Bills," Transportation Economic Trends, available at https://data.bts.gov/stories/s/2cyr-4k8j.

Figure 4-10 Transportation Sector Unemployment Rate for Men and Women: July 2014–July 2024



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 September 2024.

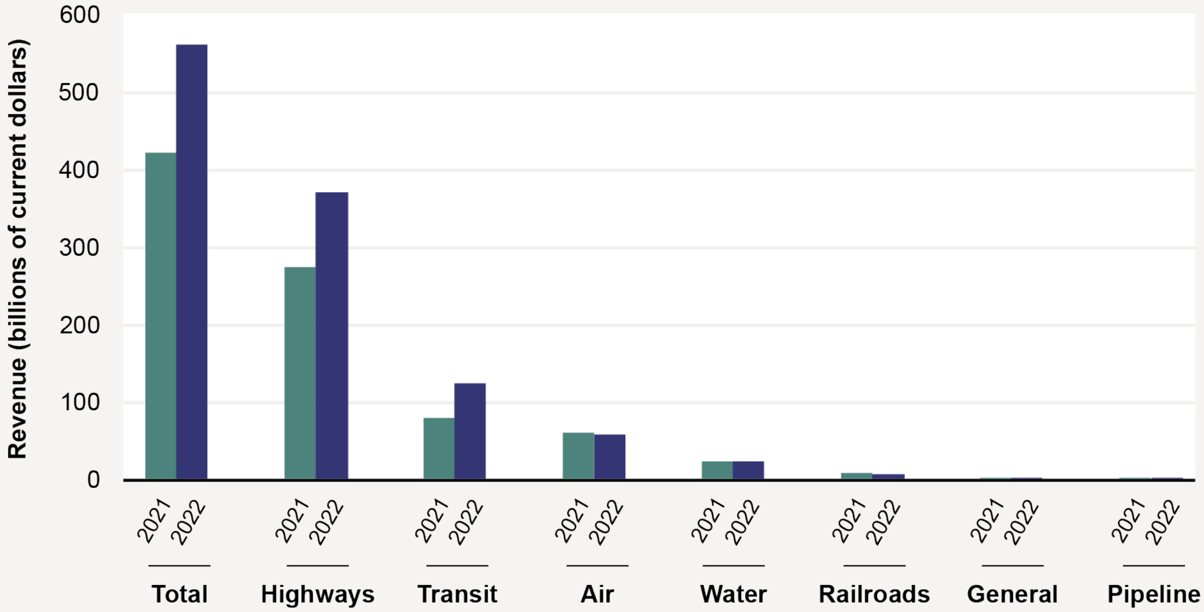
Figure 4-11 Federal Transportation Expenditures by Mode: 2021 and 2022 (Billions of Current Dollars)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at https://www.bts.gov/tpfs as of September 2024.

Note: Federal expenditure includes direct federal spending, excluding grants to state and local governments. Percents may not add to 100 due to rounding

Figure 4-12 Federal, State, and Local Transportation Revenue by Mode: 2021 and 2022 (Billions of Current Dollars)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Government Transportation Financial Statistics, available at https://www.bts.gov/tpfs as of September 2024.

Note: Highways includes user-based-transit revenue but is excluded from the total, which already contains these transit revenues, to avoid double counting.

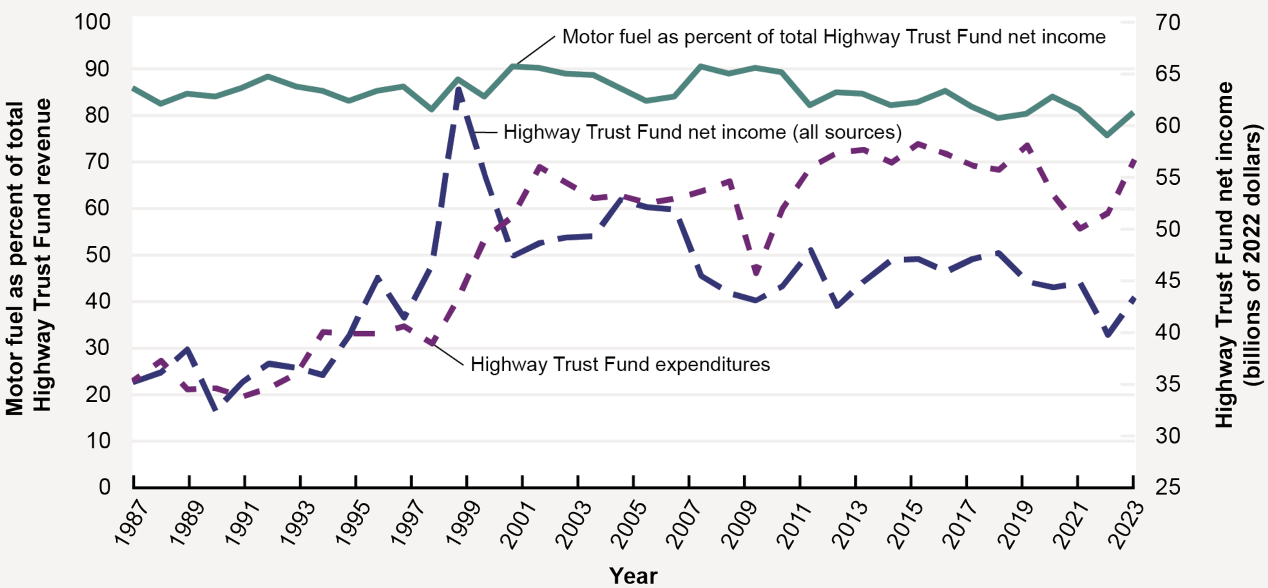
Trust Fund Revenue and Expenditure

Motor fuel taxes are a major contributing factor to the highway trust fund (Figure 4-13). At its peak in fiscal year 2010, motor fuel taxes accounted for 91 percent of the highway trust fund's net income, but by fiscal year 2024 that share had fallen to 81 percent. And while the highway trust fund's share of net income from motor fuel taxes diminished markedly from fiscal year 2010 to 2024, net income from motor fuel and all other sources changed marginally during that period, annually fluctuating between 40.0 and 44.6 billion dollars (adjusted for inflation). Fluctuating fuel prices, vehicle miles traveled, the fuel efficiency of vehicles, and the tax levied contribute to changes in the revenue collected from motor fuel sales. The regular price of gasoline and diesel fuel reached an all-time high in 2022 and then fell in 2023. The latest monthly fuel price data show that the regular price for motor gasoline rose 2 percent in October 2024 from January 2024 [BTS 2024g]. Reduced travel and greater vehicle fuel efficiency combined with lower fuel prices reduce highway trust fund revenue from motor fuel sales. Annual vehicle miles traveled remained 2.0 percent below the pre-COVID-19 level in 2022 but rose to 1.6 billion miles (0.05 percent) above 2019 levels in 2023 [FRED 2024b]. In September 2024 (the latest available data), vehicle miles traveled were 0.1 percent below the September 2023 level but 6 percent above September 2019 [FRED 2024b]. Greater vehicle fuel efficiency offset the potential revenue gains from increased travel. Vehicle fuel efficiency for light-duty vehicles increased 2 by percent from 2019 to 2022 (the latest available data) [BTS 2024d]. At the same time, the federal fuel tax on fuel remained unchanged.

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 Nov. 15, 2021. The BIL provides $1.2 trillion in funding, which includes $673.8 billion for transportation. Expenditures from disbursed BIL funds contributed to the 28 percent increase in government transportation expenditures from 2021 to 2022 [BTS 2024c]. 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. Higher costs reduce what can be bought with the money allocated by transportation spending bills. Should highway construction costs rise above their level when BIL was signed in 2021, what can be bought with the funds in each fiscal year will decline (Figure 4-14).

Figure 4-13 Motor Fuel Revenue as Percent of Total Highway Trust Fund Net Income and Expenditures (2024 Dollars): Fiscal Years 1987–2024



Source: 1987–2022: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2022, available at https://www.fhwa.dot.gov/policyinformation/statistics.cfm as of September 2024; 2023–2024: U.S. Department of the Treasury, Highway Consolidated Reports, Treasury Direct, available at https://treasurydirect.gov/government/funds-management-program-reports/monthly-financial-reporting/highway/ as of November 2024 and U.S. Department of Transportation, Federal Highway Administration, Status of the Highway Trust Fund, available at https://www.fhwa.dot.gov/highwaytrustfund/ as of November 2024; 1987–2024: U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index, all items in U.S. city average, all urban consumers, not seasonally adjusted, available at https://www.bls.gov/cpi as of September 2024.

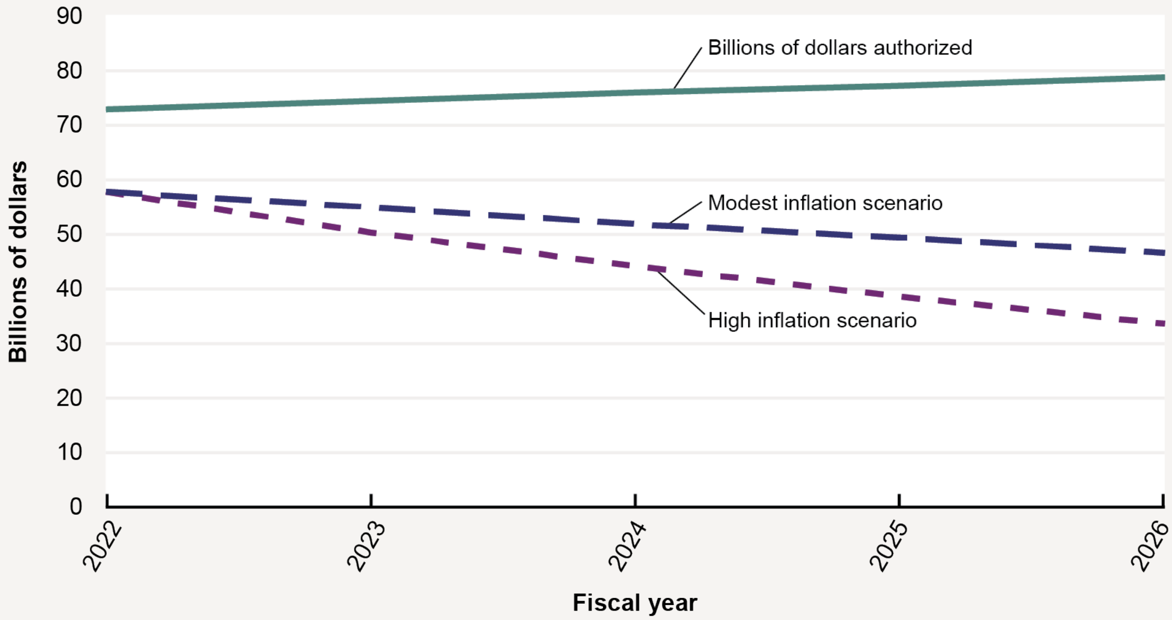
Figure 4-14 looks at two different scenarios for BIL funds allocated for highways. The first scenario assumes construction costs continue to rise at their current rate using the average annual growth from the last two years (2021 and 2022), called the High Inflation Scenario. Under this scenario, only $224.2 billion can be bought with the $379.3 billion allotted for highways. In other words, only 60 percent of what could have been bought in 2021, when BIL was signed, can be bought over the 5 years from 2022 through 2026—a 40 percent reduction. The second scenario, the Modest Inflation Scenario, assumes a more modest growth in construction costs equal to the average annual growth in 2019 and 2021. Under this more modest growth scenario, $260.5 billion can be bought with the $379.3 billion allocated for highways due to increased highway construction costs, which amounts to a 30 percent reduction in what can be bought.

Transportation Investment

Transportation assets consist of infrastructure and equipment taking more than 1 year to consume, such as bridges, roads, and vehicles. Investment in transportation assets includes spending on new structures as well as new and used equipment. It excludes spending on maintenance and repair of existing structures and equipment. Transportation investment represents a small but important share of public and private investment in transportation and nontransportation infrastructure, equipment, and intellectual property products like software, which economists collectively refer to as fixed assets, in the United States.

In 2023, public and private investment in transportation assets totaled $509.2 billion, or 8.6 percent of total national investment in transportation and nontransportation fixed assets (Figure 4-15). The percentage of national investment attributed to transportation was 1.5 percentage points higher in 2023 than in 2022, but the 2023 share was 2.1 percentage points lower than the 2018 all-time high [BTS 2024e]. Public and private investment in new transportation infrastructure accounted for $187.5 billion (5.2 percent), and private transportation new and used equipment accounted for $321.7 billion (8.9 percent) of the $5,929.6 billion national investment in all fixed assets. Adjusted for inflation, total

Figure 4-14 Infrastructure Investment and Jobs Act (IIJA) Funds Authorized for Highway by Fiscal Year and Amount Reduced by Construction Cost Inflation: 2012–2026



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, "Increases in Highway Construction Costs Could Reduce BIL Funding Allocated to Transportation Up to 40% Over the Next Five Years," available at https://www.bts.gov/data-spotlight/increases-highway-construction-costs-could-reduce-bil-funding-allocated as of September 2024.

Note: The IIJA is also known as the Bipartisan Infrastructure Law (BIL). A "high inflation scenario" is the amount that could be bought with allocated BIL funding for transportation assuming construction costs continue to grow at the average of the 2019 and 2021 annual growth. A "modest inflation scenario" is the amount that could be bought with allocated BIL funding for transportation assuming construction costs continue to grow at the average of the 2021 and 2022 annual growth. For more information about IIJA and funds allocated, refer to https://data.bts.gov/stories/s/cvki-zubk as of September 2024.

investment in new transportation infrastructure and new and used equipment increased 21.1 percent from 2022 to 2023 (from $352.6 to 427.0 billion in 2017 dollars) [BTS 2024e].

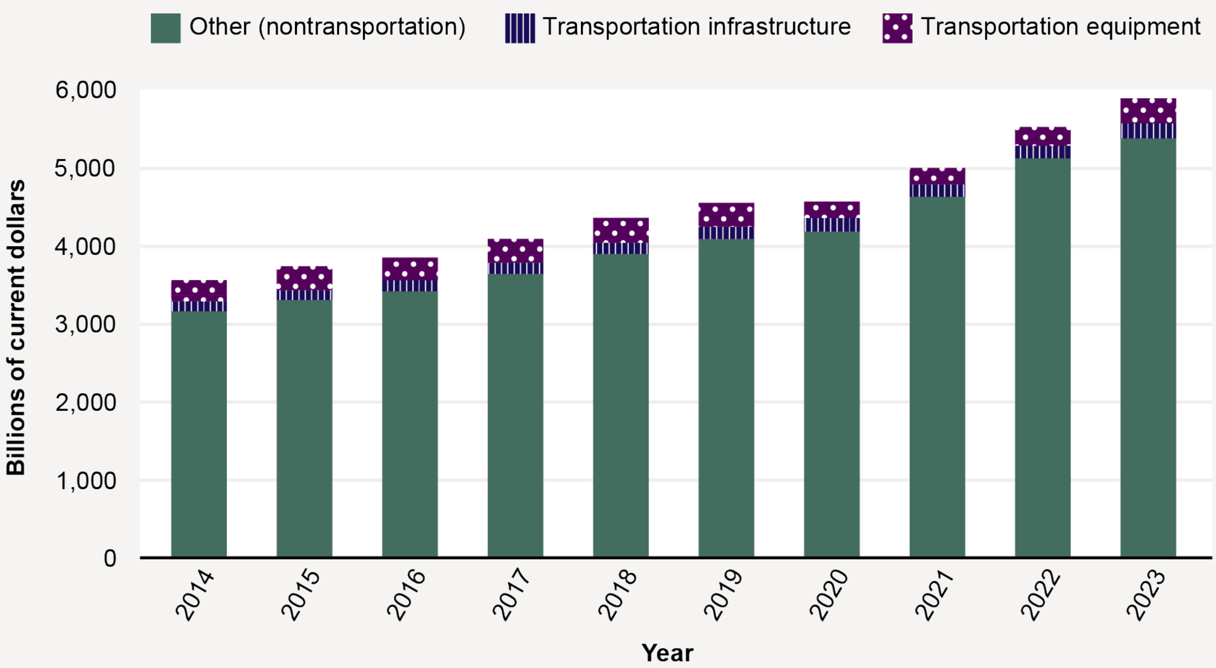
Cost of Transportation

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 decline. The goods and services that 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 all-time high of $3.95 per gallon in 2022 after increasing year-over-year by the second largest amount (31.3 percent). The price of gasoline in 2022 was 9.2 percent higher than the previous all-time high reached in 2012. In 2023, average gasoline prices dropped by 10.9 percent to $3.52 (Figure 4-16). On-highway diesel also reached a new average high in 2022 of $4.99 per gallon and then fell in 2023 by 15.5 percent to $4.21. The latest jet fuel and railroad diesel data are for 2021. Jet and railroad diesel fuel increased by the second largest amount between 2020 and 2021 (51.1 and 50.3 percent, respectively) but in 2021 remained below the all-time high reached in 2012 by 37.0 and 32.4 percent, respectively.

Figure 4-15 Total Investment and Transportation Investment in Fixed Assets (New Structures, New and Used Equipment, and Intellectual Property Products): 2014–2023 (Current Dollars)



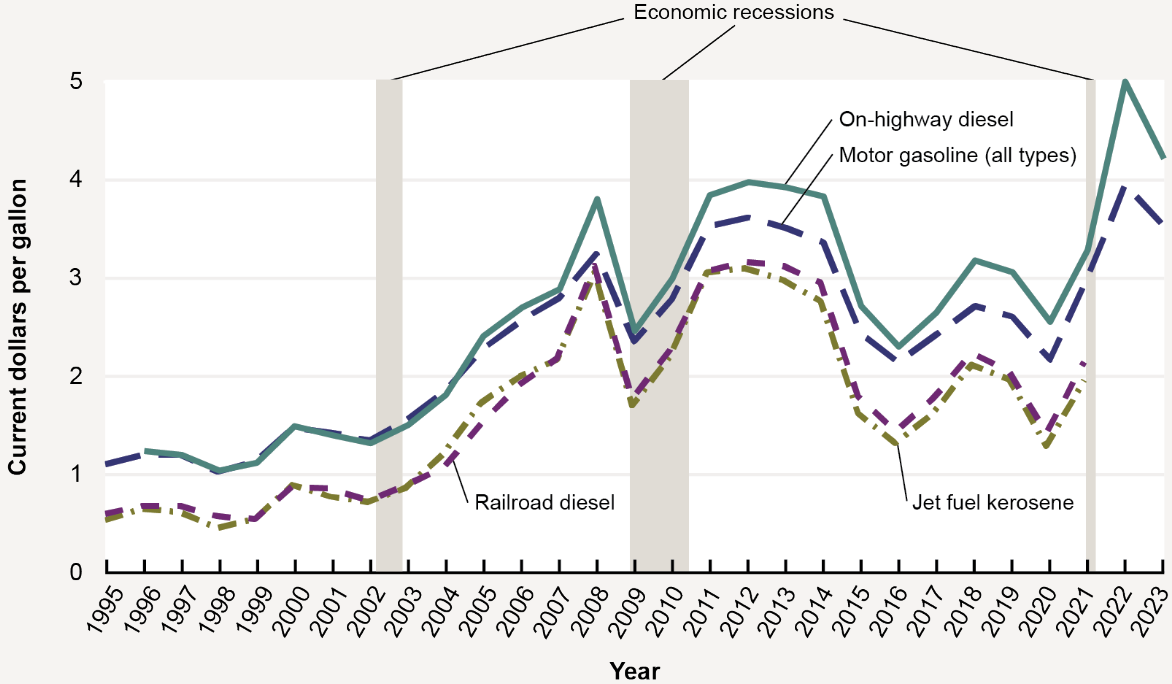
Source: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts, National Income and Product Account Tables, Private Fixed Investment in Structures by Type, table 5.4.5 (millions), Private Fixed Investment in Equipment by Type, table 5.5.5 (millions), and Gross Government Fixed Investment by Type, table 5.9.5 (millions), available at https://apps.bea.gov/iTable/index_nipa.cfm as of September 2024.

Note: 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.

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 Producer Price Index (PPI) measures the average change over time in the amount 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 price for air, rail, and water transportation services each reached an all-time high, suggesting an increase in the costs businesses face when purchasing these transportation services. Water transportation services increased the most, at 4.6 percent, from 2022 to 2023, followed by air (4.4 percent), and rail (2.1 percent) (Figure 4-17). The price for truck

Figure 4-16 Sales Price of Transportation Fuel to End-Users (Current Dollars/Gallon): 1994–2023



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 September 2024.

Note: 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.

transportation services fell for the first time since 2020, falling from an all-time high in 2022 by 5.2 percent. As 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.

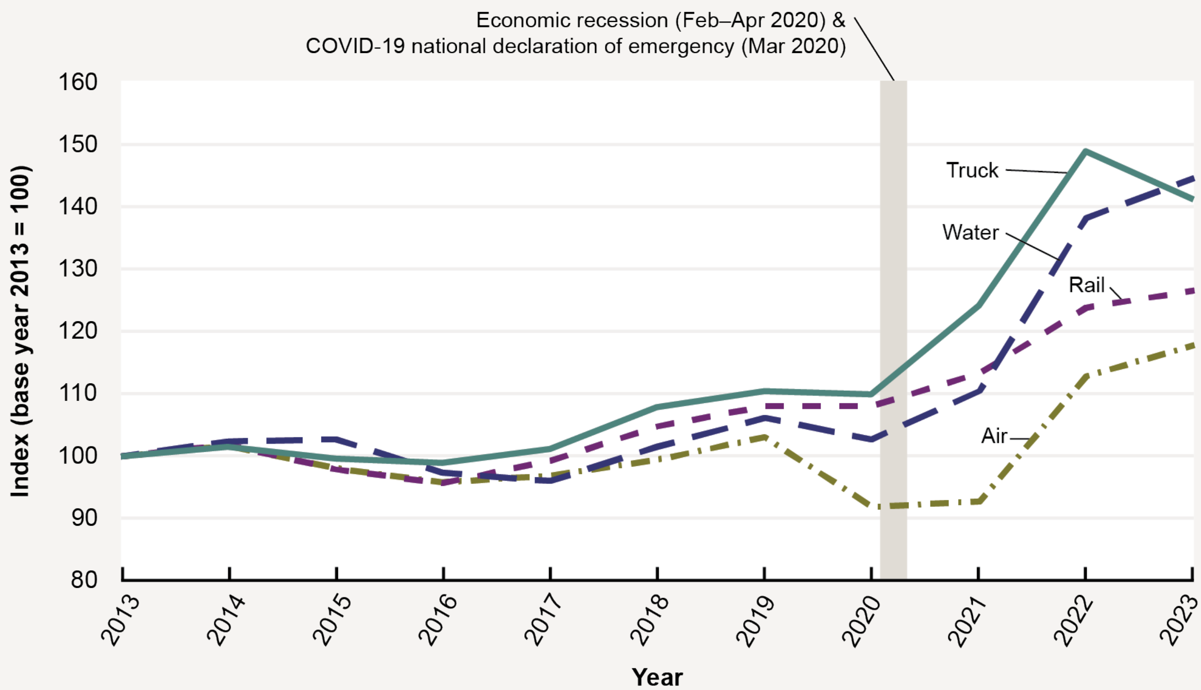
Highway Construction Costs

Per the National Highway Construction Cost Index, highway construction costs rose 13.9 percent in 2023 (the most recent data available) but by less than in 2022 when they rose by the largest amount on record (26.5 percent). Highway construction costs have risen steadily since the fourth quarter of 2020, increasing 68.3 percent from that quarter to the fourth quarter of 2023. During this period, highway construction costs grew the most, month-over-month, from the fourth quarter of 2021 through the first quarter of 2023. Nine of the top 10 largest monthly increases in highway construction costs occurred from the fourth quarter of 2021 through the first quarter of 2023. Supply chain issues, such as factory closures and transportation delays lead to supply shortages, caused an increase in the price for construction materials and contributed to the growth in highway construction costs since 2020 [FHWA 2024].

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 CPI for items such as motor vehicles, gasoline, and airfares. It also includes the transportation costs, as measured in the 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.

Figure 4-17 Producer Price Indices for Producers of Selected Transportation and Warehousing Services: 2013–2023



Source: U.S. Department of Labor, Bureau of Labor Statistics, Producer Price Index Industry Data, available at http://www.bls.gov/ppi as of September 2024.

Note: Producer Price Index data come from the Bureau of Labor Statistics.

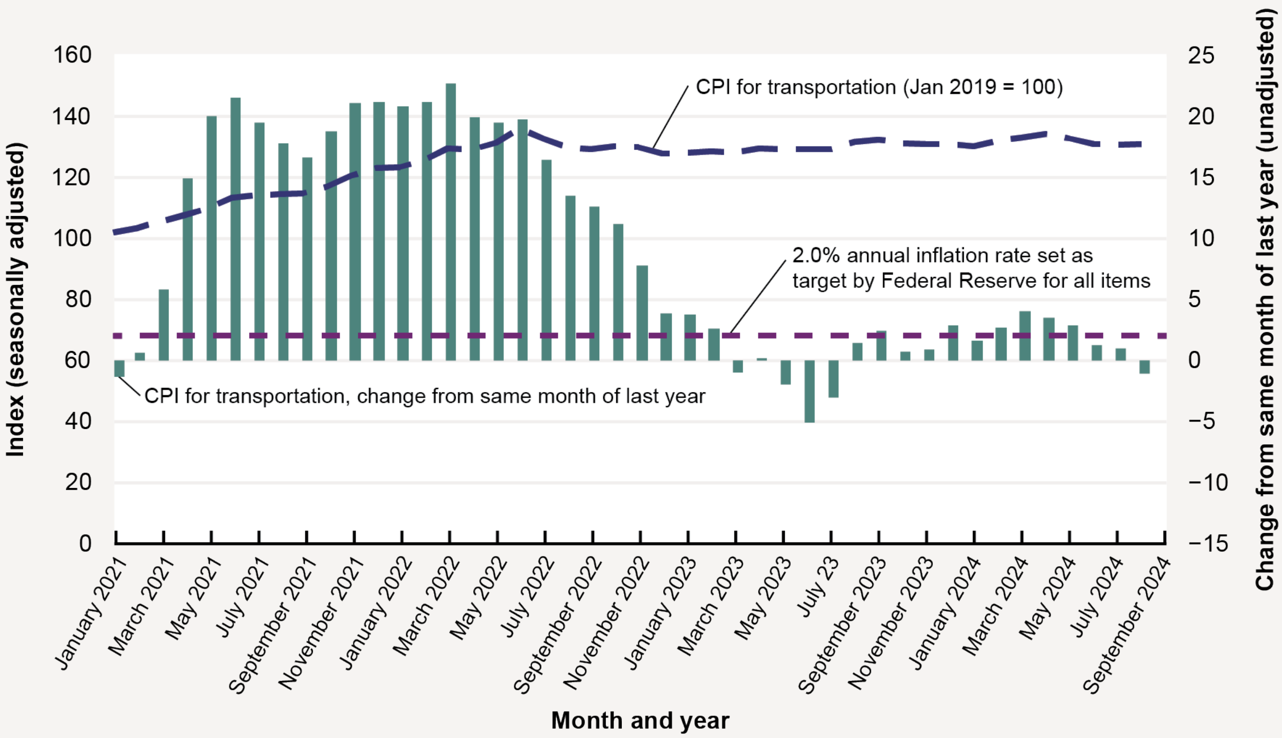
Contribution of Transportation to Overall Inflation

The transportation CPI is the official measure of the prices paid by consumers for transportation goods and services. When prices for transportation goods and services rise, the transportation CPI rises, and it contributes to the overall increase in prices (inflation) reported by the media. Conversely, when prices for transportation goods and services fall, the transportation CPI falls, and it dampens overall inflation.

Steadily increasing from June 2020 to a new all-time high in June 2022, the seasonally adjusted transportation CPI began to decline July 2022—as observed in Figure 4-18 in the steady decline of the red line starting in July 2022. The transportation CPI fell month-over-previous month in 14 of the 26 months from June 2022 to August 2024 (the latest available data). In August 2024, the seasonally adjusted transportation CPI was 3.6 percent below the June 2022 high. Figure 4-18 depicts the month-over-previous month change. Bars with a value less than zero are months where the transportation CPI fell from the value in the previous month and hence are months where transportation inflation declined.[7] The transportation CPI fell due to declines in fuel and used car and truck prices and, as a result, dampened year-over-year price increases in all goods and services from March to July 2023, but due to increases in motor vehicle insurance, the transportation CPI positively contributed to year-over-year prices increases from August 2023 to July 2024 (Figure 4-19). While transportation contributed to overall inflation in 2024, it contributed less than its all-time high contribution of 58.6 percent reached in June 2021 [BTS 2024f].

7 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 4-18 Consumer Price Index for Transportation, Change from Same Month of the Previous Year (Unadjusted) and Seasonally Adjusted Value: January 2021–August 2024



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 September 2024.

In 2023, 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 for transportation services declined in 2023 across multiple modes.

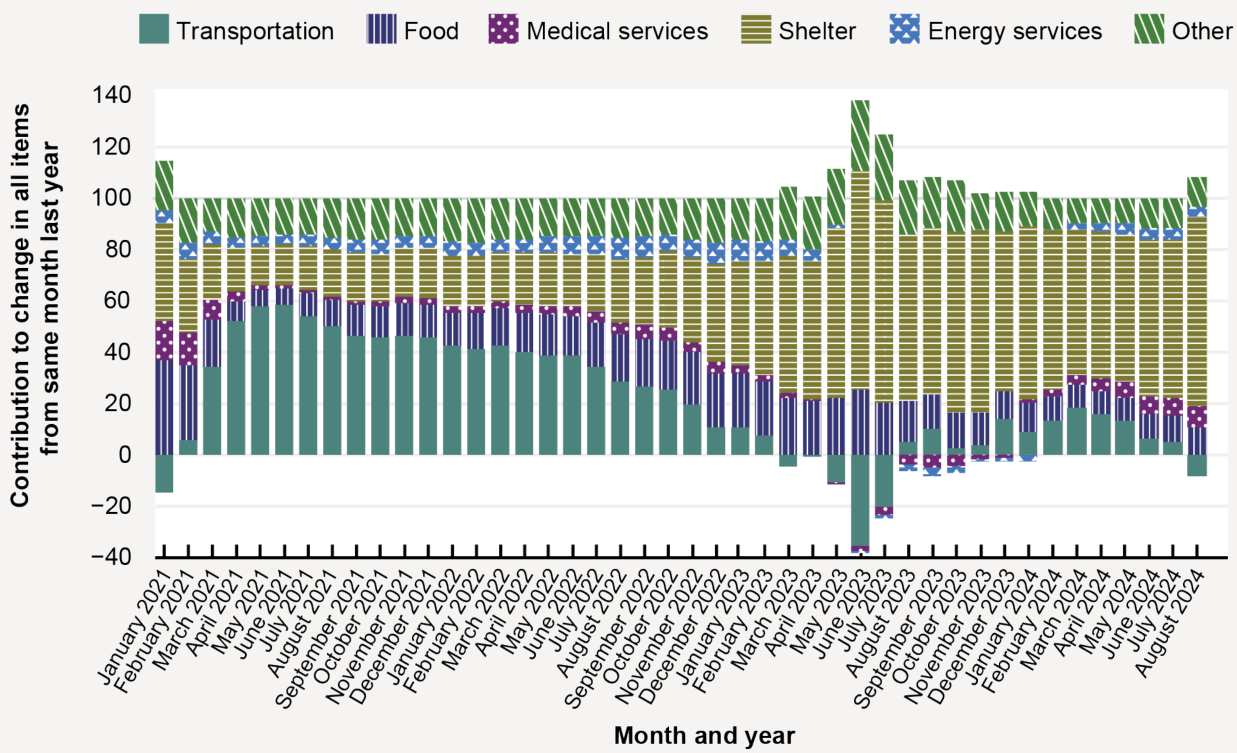
Downbound barge rates are seasonal, falling in the spring and summer when water levels are higher and rising in the fall and winter as water levels decline. However, downbound barge rates reached an all-time high in the fall of 2022 (Figure 4-20) when the water levels in the Mississippi reached a new record low, but despite falling to an even lower level in the fall of 2023, the downbound barge rates remained well below the 2022 all-time high. 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 fell in 2023 from their 2022 levels but have begun to rise again. Freight rates from Shanghai to the U.S. west coast increased 206.9 percent from December 2023 to August 2024 (the most recent data available), but rates from the west coast to Shanghai fell 15.7 percent over that same time period, from $886 per forty-foot container in December 2023 to $747 in August 2024 (Figure 4-21).

The PPI for transportation services measures the prices faced by producers purchasing the services. When the PPI for transportation services increases, producers purchasing transportation services face higher prices and transportation contributes to the price increases (inflation) faced by producers. Transportation dampens the inflation faced by producers when freight rates fall, as seen through a decline in the PPI for transportation services.

Declines in freight rates caused transportation's contribution to year-over-year price increases faced by producers to fall from the August 2022 high. Since August 2022, transportation and related services, such as freight forwarding, contributed a decreasing or negative share to the year-over-year increase

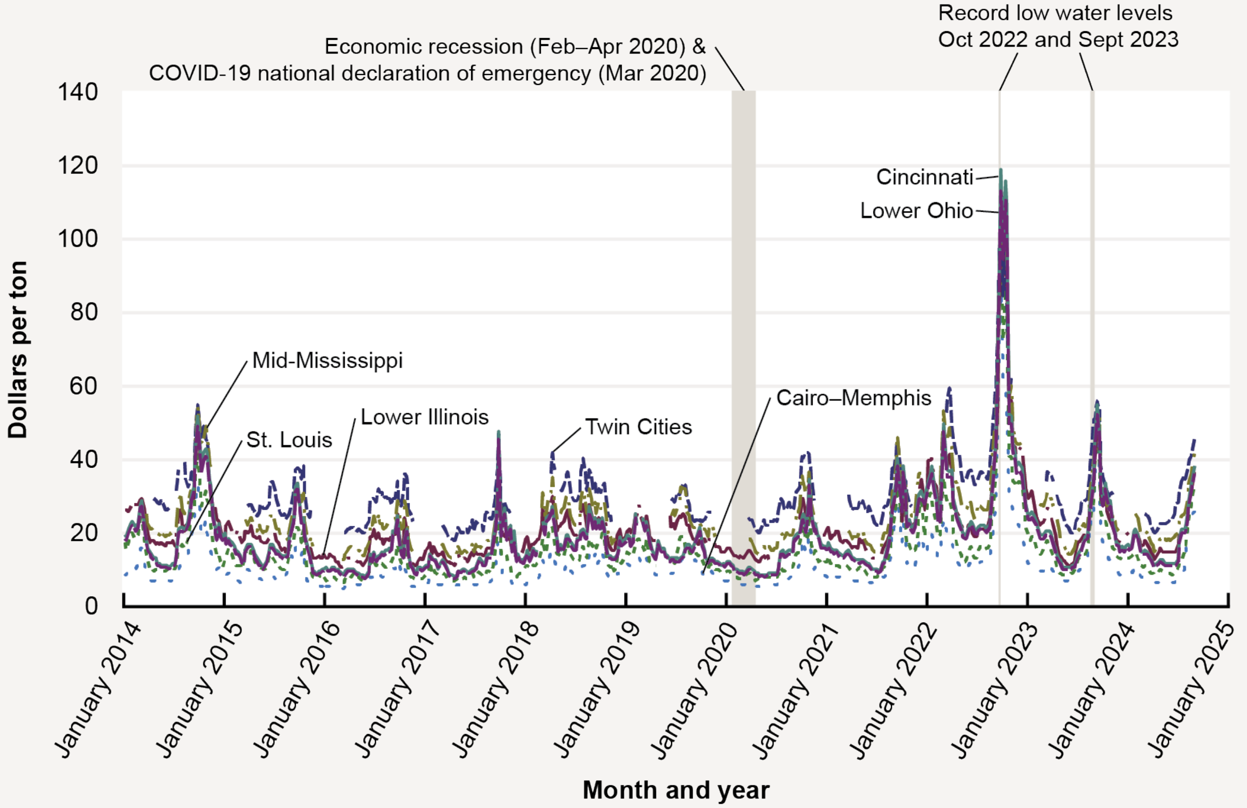
Figure 4-19 Contribution of Transportation to Inflation Compared to Food, Shelter, and Medical Services: January 2021–August 2024



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 September 2024.

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

Figure 4-20 Downbound Grain Barge Rates (Dollars per Ton): January 2014–September 2024



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 September 2024.

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). 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.

in the price for all goods and services faced by producers in 18 of the 24 months. Figure 4-22 shows the contribution of transportation and related services to the year-over-year change in the price for all goods and services purchased by producers. Transportation dampened the increase in the price for all goods and services (inflation) purchased by producers in the months where the bar was less than zero. The trend changed in March 2024 when transportation once again contributed positively and an increasing amount to the inflation faced by producers (Figure 4-22).

Data Gaps: Needs for the Future

As the economy adapts to issues and changes spurred by COVID-19, such as price increases, hybrid work, and supply chain issues, the following data needs have arisen:

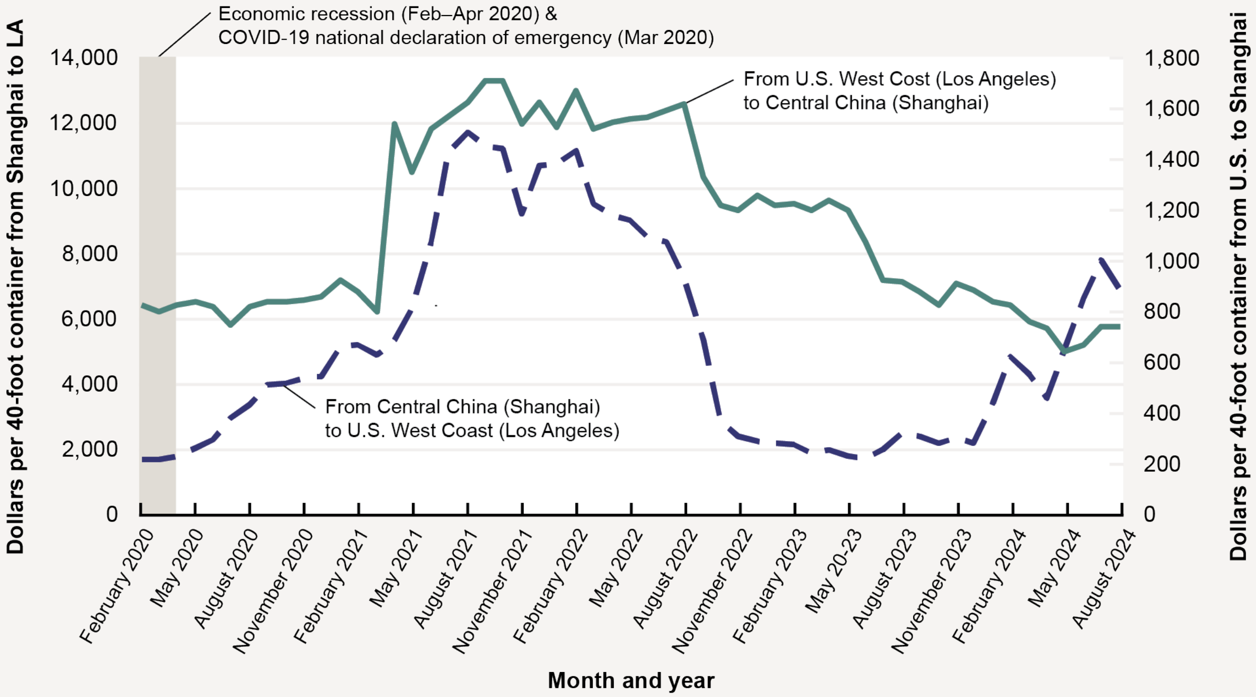
- Timely data on the volume of transportation services to better gauge the current supply and demand for freight transportation services.
- Granular employment data to measure unmet transportation labor needs.

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.

In 2024, BTS expanded on its transportation financial data series to lessen the above data gap in transportation financial statistics and released the Transportation Public Finance Statistics (TPFS) data series. The TPFS provides more detailed information about federal trust fund cash flows and the split between capital and noncapital expenditure than the previous government financial data series. TPFS also includes more granular revenue data, including user-based, own-source, and supporting revenue categories.

Figure 4-21 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–August 2024



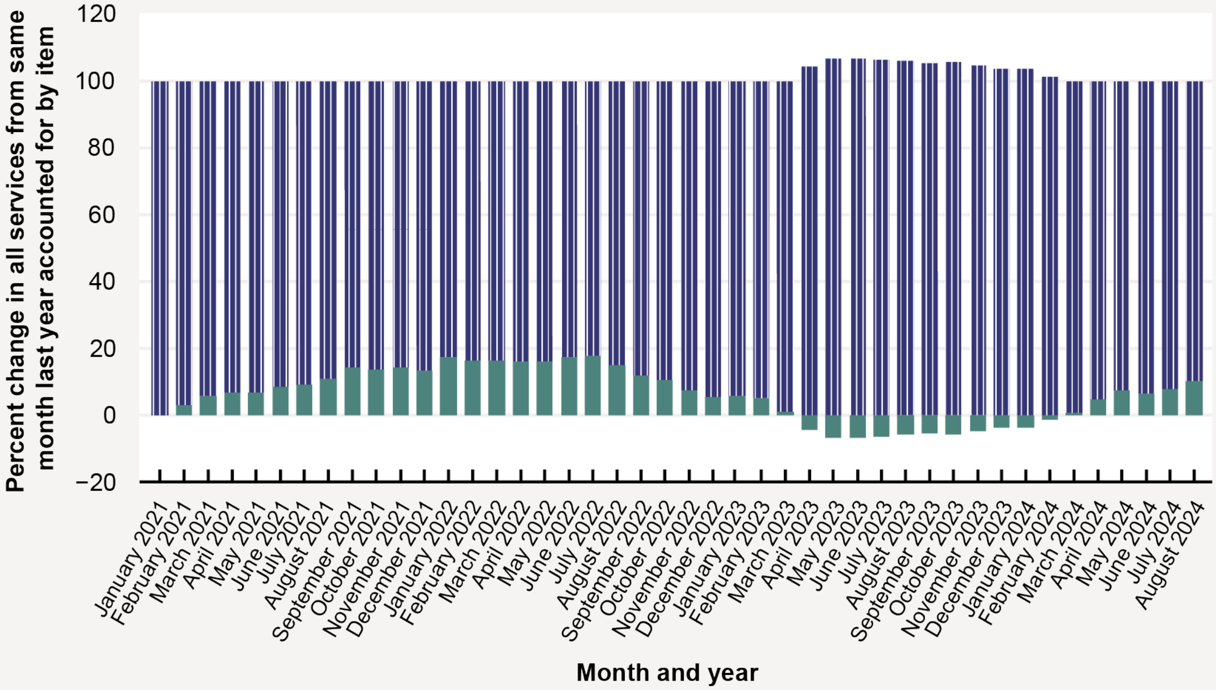
Source: U.S. Department of Agriculture, Agricultural Market Service, Container Ocean Freight Rates from Drewry Supply Chain Advisors' Container Freight Rate Insight as of September 2024.

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

BTS identified additional data needs and opportunities for the Federal Government to implement improved data, analysis tools, and technical assistance for evidence-based local infrastructure investment decision-making in the *Work Plan to Provide Federal Support for Local Decision-Making* [BTS 2023]. The work plan is a response to the Infrastructure Investment and Jobs Act section 25003, which requires BTS to determine the data and analysis tools that would assist planning and infrastructure decision-making officials in units of local government. In the work plan, BTS noted data analysis challenges raised by the local decision-making officials and the need for 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 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.

Figure 4-22 Contribution of Transportation and Related Services to Inflation Faced by Producers of Goods and Services: January 2021–August 2024



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 September 2024.

Note: Data include 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.

References

Bureau of Labor Statistics (BLS)

——2024a. Consumer Price Index for All Urban Consumers: All Items in U.S. City Average. Available at https://www.bls.gov/cpi/.

——2024b. Employer Costs for Employee Compensation for Total Civilian compensation for All occupations and Total Civilian compensation for Transportation and material moving occupations. Available at https://www.bls.gov/eci/home.htm.

——2024c. Employment Projections, Occupational Projections and Worker Characteristics, 2023–2033, available at https://www.bls.gov/emp/tables/occupational-projections-and-characteristics.htm.

Federal Highway Administration (FHWA). National Highway Construction Cost Index. Available at https://www.fhwa.dot.gov/policy/otps/nhcci/.

Bureau of Transportation Statistics (BTS)

——2023. *Federal Support for Local Decision-Making*. Available at https://www.bts.gov/local-outreach.

——2024a. Transportation Services Index. Available at https://data.bts.gov/Research-and-Statistics/Transportation-Economic-Trends-TET-data/tcq5-4pgu.

——2024b. Transportation Economic Trends, Employment in Transportation and Related Industries. Available at https://data.bts.gov/stories/s/caxh-t8jd.

——2024c. *Transportation Public Finance Statistics*. Available at http://www.bts.gov/tpfs.

——2024d. *National Transportation Statistics*, Average Fuel Efficiency of U.S. Light Duty Vehicles (Table 4-23). Available at https://www.bts.gov/nts.

——2024e. Transportation Economic Trends, Investment in Transportation. Available at https://data.bts.gov/stories/s/435g-4p74/.

——2024f. Transportation Economic Trends, Inflation and Transportation: Consumer Price Index. Available at https://data.bts.gov/stories/s/Transportation-and-Inflation-CPI/jrb8-y6mq/.

——2024g. Transportation Economic Trends, Inflation and Transportation: Monthly Motor Fuel Prices. Available at https://data.bts.gov/stories/s/gxhw-fwdh.

——2024h. 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.

——2024i. 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.

Federal Reserve. 2024. Economy at a Glance – Inflation (PCE). Available at https://www.federalreserve.gov/economy-at-a-glance-inflation-pce.htm.

Federal Reserve Bank of St. Louis (FRED)

——2024a. Manufacturers' New Orders: Total Manufacturing (AMTMNO), U.S. Census Bureau, available at https://fred.stlouisfed.org/series/AMTMNO, and Real Gross Domestic Product (GDPC1), U.S. Bureau of Economic Analysis, available at https://fred.stlouisfed.org/series/GDPC1.

——2024b. Vehicle Miles Traveled, Millions of Miles, Annual, Not Seasonally Adjusted (TRFVOLUSM227NFWA), U.S. Federal Highway Administration. Available at https://fred.stlouisfed.org/series/TRFVOLUSM227NFWA.

CHAPTER 5

TRANSPORTATION SAFETY

Although safer today than a generation or two ago, transportation remains 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 for all modes claimed 44,546 lives in 2022, of which all but 2,049 involved highway motor vehicles.

After rising dramatically in 2020 and 2021, fatalities involving highway motor vehicles declined in 2022 and again in 2023, when an estimated 40,990 people died. A further 3.2 percent decline was projected by the National Highway Traffic Safety Administration (NHTSA) for the first half of 2024 [NHTSA 2024b]. It appears that the increase in road deaths fueled by risky behaviors during the COVID-19 pandemic, with fatalities rising by nearly 7,000 over their 2019 level to a high of 43,230 in 2021, has abated. The declaration of the COVID-19 public health emergency in the United States began in March 2020 and formally ended on May 11, 2023 [CDC n.d.a].

As for nonhighway transportation modes, rail and transit rail, air, water, and pipelines collectively averaged over 2,000 fatalities each year between 2019 and 2022.

This chapter discusses recent transportation fatality and injury statistics, focusing especially on 2021 and 2022 (and partial 2023 data as available). It thus illuminates changes in transportation safety during and in the immediate aftermath of the COVID-19 pandemic. It also examines 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 and/or preliminary for 2023.

Fatalities and People Injured by Mode

Transportation is the number two cause of unintentional deaths in the United States [CDC n.d.b]. Figure 5-1 shows the transportation fatalities by mode in 2022, with 44,563 total fatalities, and Table 5-1 shows deaths from 2016–2023 (note that 2023 data are incomplete). About 2.4 million people were injured in transportation crashes and accidents in 2022, with roughly 99.5 percent of injuries attributable to highway motor vehicles (Table 5-2). Injury estimates are only given for 2016 and onward 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.

HIGHLIGHTS

Transportation incidents for all modes claimed 44,546 lives in 2022, of which all but 2,032 involved highway motor vehicles. Preliminary estimates for 2023 suggest a further decline in fatalities.

Highway deaths fell in 2016–2019 but then jumped during the pandemic. NHTSA analysis showed that more drivers engaged in risky behaviors such as speeding, drinking, and not wearing seatbelts. In 2022, 38 percent of speeding drivers in fatal crashes were alcohol-impaired compared to just 18 percent of nonspeeding drivers. Fatal crashes for speeding passenger vehicles not wearing seat belts were 52 percent, whereas only 22 percent for the nonspeeding passenger vehicle drivers. NHTSA data also suggested that these risky behaviors may be abating somewhat as the pandemic recedes.

The current level of deaths arising from risky driving behavior remains well above prepandemic levels. It is not clear whether these behaviors will continue to decline or whether a higher “new normal” of willingness to engage in risky driving behaviors will occur.

Not since the 1980s have so many people died in large truck crashes as in 2022; this trend applies to the truck occupants (over 1,000 in 2022) as well as the people in other vehicles and nonoccupants. Every year, most people dying in crashes involving large trucks are people outside the truck—4,839 of the 5,936 in large truck crashes in 2022.

Transportation incidents were the most frequent cause (37.7 percent) of the 5,486 on-the-job fatalities in 2022.

Among the more than 2,000 deaths in nonhighway modes in 2023:

- Railroad deaths were just under 1,000 (998) and the highest number since 1998, with trespasser deaths at 718, the highest since at least 1975.

- Boating deaths jumped in the first year of the pandemic but have fallen in each subsequent year to 564 in 2023.

- There were no deaths from crashes on large commercial airlines in 2023, but several hundred deaths occurred in crashes in general aviation, commuter air, and air taxi services.

More than 7,500 pedestrians died in traffic incidents in 2022, which is the most since 1980.

Transportation injuries in 2022 fell by about 120,000 to 2.4 million, with nearly all (i.e., 99.6 percent) involving highway motor vehicles.

In 2022, 891 people died in work zones, down from 961 in 2021, a 15-year high.

Highway Motor Vehicles

Highway motor vehicles[1] were involved in 95.4 percent of U.S. transportation fatalities in 2022 (Figure 5-1) and about 99.4 percent of the people injured in transportation crashes and incidents (Table 5-2). Both the number and rate of highway fatalities have decreased notably since the 1960s, with deaths decreasing from a yearly rate of more than 5 per 100 million vehicle miles of travel (VMT) to 1.08 per 100 million VMT in 2014, which was a historic low point. The fatality rate subsequently fluctuated before jumping from 1.11 in 2019 to 1.34 in 2020—the largest annual increase on record. After a further increase to 1.38 in 2021, the rate fell to 1.33 in 2022 and is projected to fall to 1.26 in 2023 [NHTSA 2024b].

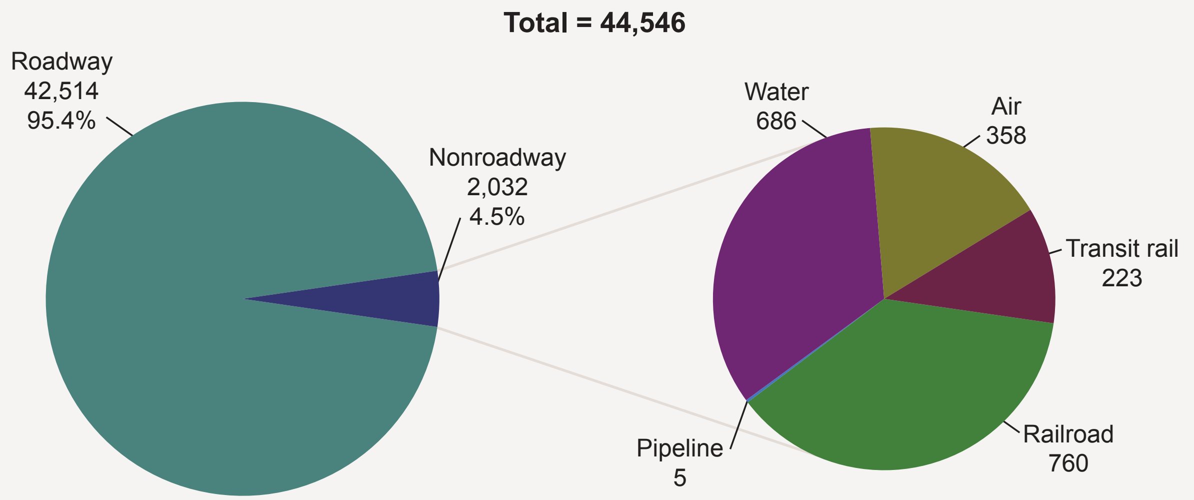
As for the number of deaths, motor vehicle-related fatalities reached their lowest number in six decades in 2011—32,479—and then rose by about 5,300, reaching 37,806 in 2016. As shown in Table 5-1, deaths then declined in 2017, 2018, and 2019 to 36,355 but were still 12 percent more than that in 2011. In March 2020, a national health emergency was declared due to the COVID-19 pandemic. With fewer people driving, one might have expected highway fatalities to decline in 2020. Instead, fatalities rose dramatically, with an unprecedented increase that was followed by an even greater rise in 2021, with road fatalities reaching 43,230—a level not observed since 2005 [NHTSA n.d.a]. Deaths in 2022 fell by 716, a decrease of 1.7 percent from 2021. A further decline of 3.6 percent (to 40,990) is projected by NHTSA for 2023 [NHTSA 2024b].[2]

Figure 5-2 shows the change in motor-vehicle fatalities in relation to VMT before and during the pandemic. The rise in fatalities from 2019–2021 partly arose from risky behaviors by vehicle occupants (Box 5-A), as suggested by double-digit percentage increases in deaths involving the following:

- **Speeding-related fatalities:** Increased by 19 percent from 2019 to 2020, increased further by 9 percent from 2020 to 2021, and decreased by 3 percent in 2022.
- **Alcohol-impaired driving fatalities:** Increased by 15 percent from 2019 to 2020, increased further by 16 percent from 2020 to 2021, and decreased by 0.7 percent in 2022.
- **Ejections from passenger vehicles in fatal crashes (largely due to passenger vehicle occupants not wearing restraints):** Increased by 22 percent from 2019 to 2020, increased further by 7.9 percent from 2020 to 2021, and decreased by 7.6 percent in 2022.

1 Highway-Rail Grade crossing crashes are discussed in the Ignoring Risks and Warnings section of this chapter.
2 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.

Figure 5-1 Transportation Fatalities by Mode: 2022



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, Table 2-1, available at www.transportation.gov as of July 2024.

Table 5-1 Transportation Fatalities by Mode: 2016–2023

Category	Mode	2016	2017	2018	2019	2020	2021	2022	2023	Change from 2022 to 2023
Fatalities	**TOTAL**	**39,753**	**39,364**	**38,755**	**38,424**	**41,038**	**45,250**	**44,546**	—	—
	Air	413	347	396	454	355	373	358	—	—
	Highway	37,806	37,473	36,835	36,355	39,007	43,230	42,514	40,990*	↓
	Railroad[1]	631	677	661	723	632	724	760	876	↑
	Transit rail[2]	150	151	174	173	176	197	223	210	↓
	Water	737	709	682	707	853	715	686	—	—
	Pipeline	16	6	7	11	15	11	5	15	↑
Other counts, redundant with modal counts	U.S. air carrier[3]	0	0	1	4	0	0	1	—	—
	On-demand air taxi and commuter carrier	27	16	16	34	26	27	18	—	—
	General aviation	386	331	379	416	329	346	339	—	—
	Railroad, trespasser deaths not at highway–rail crossing	468	505	499	533	504	578	605	718	↑
	Railroad, killed at public crossing with motor vehicle	130	140	132	129	94	128	146	122	↓
	Rail, passenger operations	254	307	254	262	188	200	280	272	↓
	Rail, freight operations	507	510	539	589	539	647	626	726	↑
	Transit, nonrail	109	98	86	95	113	124	117	117	→
	Recreational boating	701	658	633	613	767	658	636	564	↓
	Commercial waterborne	36	51	49	94	86	57	50	—	—

Source: Various sources as cited by the U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Statistics, table 2-1, available at www.bts.gov as of August 2024. Highway-2023: U.S. Department of Transportation, National Highway Traffic Safety Administration, Early Estimate of Motor Vehicle Traffic Fatalities in 2023, DOT HS 813 561, availabe at https://crashstats.nhtsa.dot.gov as of August 2024.

Note: Highway-2023 is a statistical projection of fatalities. For more information, refer to the complete notes from the source. Pipeline fatalities include those resulting from asphysiation, fire, and explosions, which include causes such as excavation, natural or outside forces, and other causes of damage or failure. Other counts, redundant with above help eliminate double counting in the Total fatalities. Refer to NTS table 2-1 in source for adjustments to avoid double counting, complete source notes, and an expanded time-series.

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

[2] Includes transit employees, contract workers, passengers, revenue facility occupants, and other fatalities for all modes reported in the National Transit Database.

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

* Early estimate based on statistical projection.

— Data not available at time of publication or not applicable.

Table 5-2 Transportation Injuries by Mode: 2016–2022

Category	Mode	2016	2017	2018	2019	2020	2021	2022	Change from 2021 to 2022
Injuries by mode	**TOTAL**	**3,079,613**	**2,763,144**	**2,727,510**	**2,757,464**	**2,295,151**	**2,511,102**	**2,396,490**	↓
	Air	241	229	271	261	205	244	259	↑
	Highway[1]	3,061,885	2,745,268	2,710,059	2,740,141	2,282,209	2,497,869	2,382,771	↓
	Railroad	8,027	8,212	7,728	7,377	5,057	5,429	5,936	↑
	Transit rail	6,015	6,319	6,370	6,648	4,097	4,473	4,927	↑
	Water	3,357	3,084	3,004	3,002	3,546	3,054	2,576	↓
	Pipeline	88	32	78	35	37	33	21	↓
Other counts, redundant with modal counts	U.S. Air Carrier[2]	18	19	26	17	8	13	20	↑
	On-demand air taxi and commut-er carrier	9	4	18	14	11	5	27	↑
	General aviation	199	206	227	230	188	219	212	↓
	Railroad, injured at public crossing with motor vehicle	675	680	620	671	508	529	579	↑
	Transit, nonrail	17,589	16,515	16,468	16,714	11,324	12,093	13,858	↑
	Recreational boating	2,903	2,629	2,511	2,559	3,191	2,641	2,222	↓
	Commercial waterborne	454	455	493	443	355	413	354	↓

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

[1] 2016–2020 estimates are not comparable as of July 2024; Highway-2022: U.S. Department of Transportation National Highway Traffic Safety Administration, Overview of Motor Vehicle Crashes in 2022, DOT HS 813 560, available at https://crashstats.nhtsa.dot.gov as of July 2024.

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

Box 5-A highlights how these three risky behavioral factors overlap among passenger vehicle drivers in fatal crashes.

Given the declines between 2021 and 2022 and projected overall decline for 2023, it appears that these risky behaviors may be abating somewhat as the pandemic recedes. However, the absolute number of deaths in each of these categories is well above prepandemic numbers in 2019 [NHTSA 2024a]. 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 [NHTSA 2023].

A 2024 study by the American Automobile Association (AAA) Foundation for Traffic Safety analyzed three different periods during the COVID-19 pandemic, comparing them to prepandemic traffic safety trends. The study found that these trends likely would have elevated highway deaths even without the pandemic. It estimated that the number of deaths during the pandemic increased by 17 percent compared to what would have happened if the pandemic had not occurred [AAA 2024]. During the pandemic, crash fatalities were more likely to be males and people not wearing seatbelts. Also, fatal incidents were more likely to happen late at night in vulnerable communities as defined by the CDC.

In recent decades, and also during the pandemic, many economically comparable countries achieved notably greater reductions in highway fatalities on a per-capita basis than the United States. The 27 countries of the European Union (EU) (excluding the United Kingdom, which left the EU in early 2020) reduced their road fatalities by 16 percent between 2013 and 2023. The EU also fared better during the pandemic: EU road deaths in 2023 were 10 percent fewer than their prepandemic number in 2019, while U.S. road deaths were an estimated 17 percent more [EU 2024; NHTSA 2024a].

BOX 5-A

HOW RISKY BEHAVIORIAL FACTORS—SPEEDING, ALCOHOL USE, AND FAILURE TO USE SEAT BELTS AMONG PASSENGER VEHICLE DRIVERS—OVERLAP IN FATAL CRASHES

The following diagram portrays the overlap of speeding, alcohol impairment, and failure to wear a seat belt among passenger vehicle drivers involved in fatal traffic crashes in 2022.

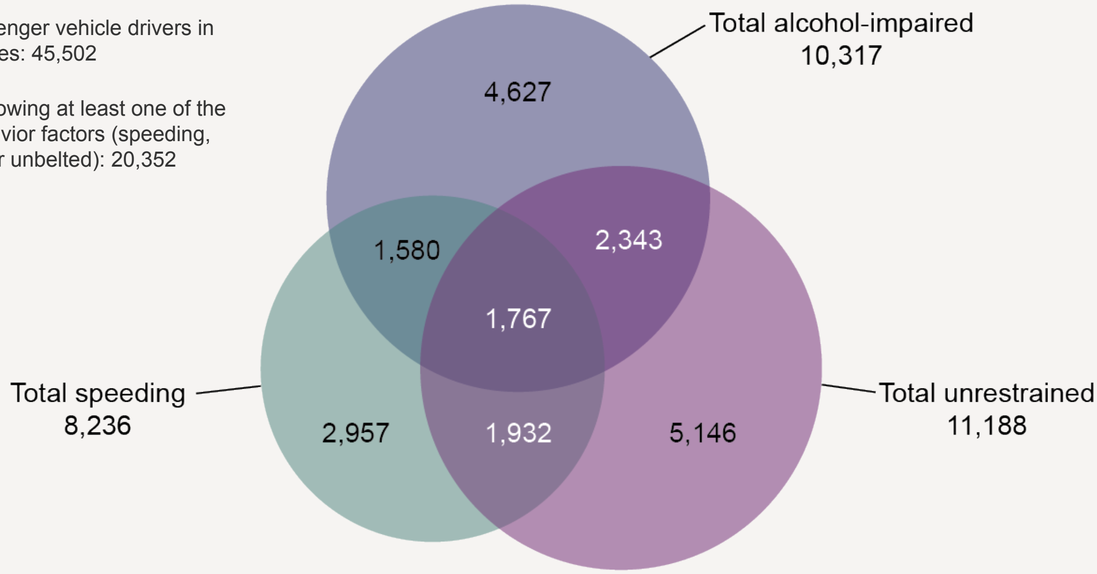
Of the 45,502 passenger vehicle drivers involved in fatal crashes that year, 55 percent (25,150) were wearing seat belts, were not speeding, and were not alcohol impaired.

The remaining 45 percent of drivers (20,352) had at least one of these three behavioral factors, and many showed more than one factor as follows:

- **Alcohol-impaired and unrestrained:** 5.1 percent (2,343 drivers)
- **Speeding and unrestrained:** 4.2 percent (1,932 drivers)
- **Speeding and alcohol-impaired:** 3.5 percent (1,580 drivers)
- **Speeding, alcohol-impaired, and unbelted:** 3.9 percent (1,767 drivers)

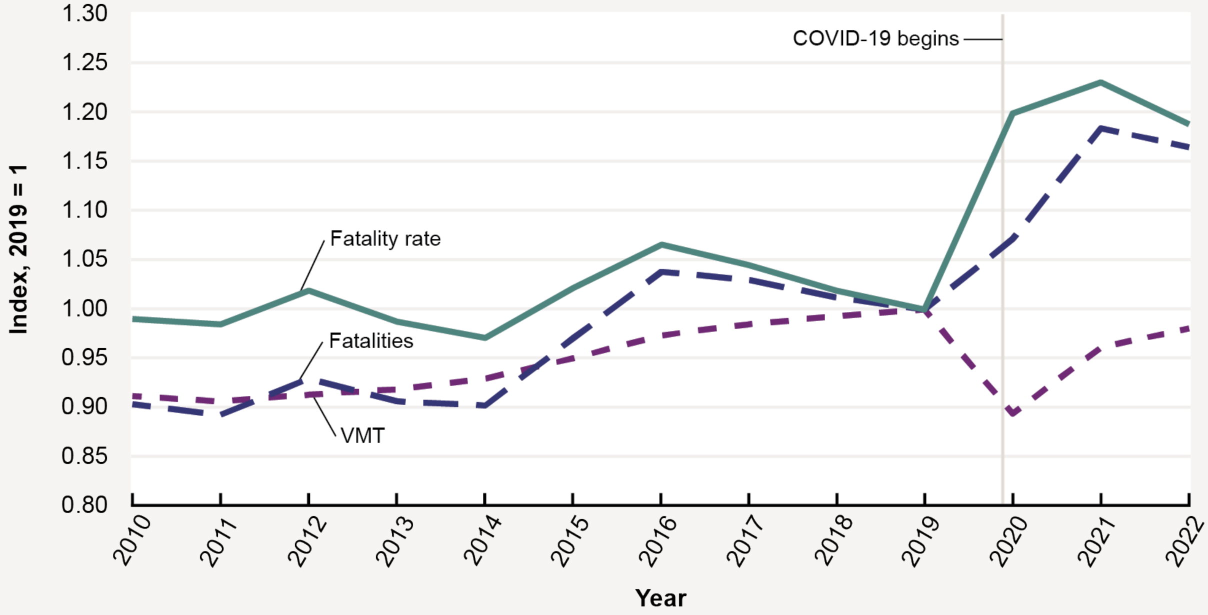
Total passenger vehicle drivers in fatal crashes: 45,502

Drivers showing at least one of the three behavior factors (speeding, drinking, or unbelted): 20,352



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, Passenger Vehicles. 2022 Data. July 2024. DOT HS 813 592.

Figure 5-2 Indices of Motor Vehicle–Related Fatalities, VMT, and Fatality Rates Before and During COVID-19: 2010–2022



Source: 2019–2022: U.S. Department of Transportation, National Highway Traffic Administration. Overview of Motor Vehicle Crashes in 2022. June 2024 (Revised) DOT HS 813 560. 2010–2018: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, tables 1-35, 2-1, and 2-7.

When looking at safety data, analysts often find it helpful to examine two categories of people: those inside the vehicle (i.e., occupants) and those outside the vehicle (including motorcycle riders/passengers). From 1996–2022, the share of fatalities of people inside vehicles decreased from 80 to 64 percent, while the share of fatalities for those outside vehicles rose from 20 to 36 percent [NHTSA 2024a]. Figure 5-3 shows the changing ratio in occupant and nonoccupant fatalities since NHTSA began collecting these data in 1975. Pedestrian, bicyclist, other cyclist,[3] and other/unknown nonoccupant fatalities increased from 5,110 in 2010 to 8,952 in 2022 [NHTSA 2024a]. However, pedestrian deaths (i.e., the largest category of nonoccupant deaths) remained below the high point of 8,096 in 1979 at 7,522 in 2022 [BTS n.d.].

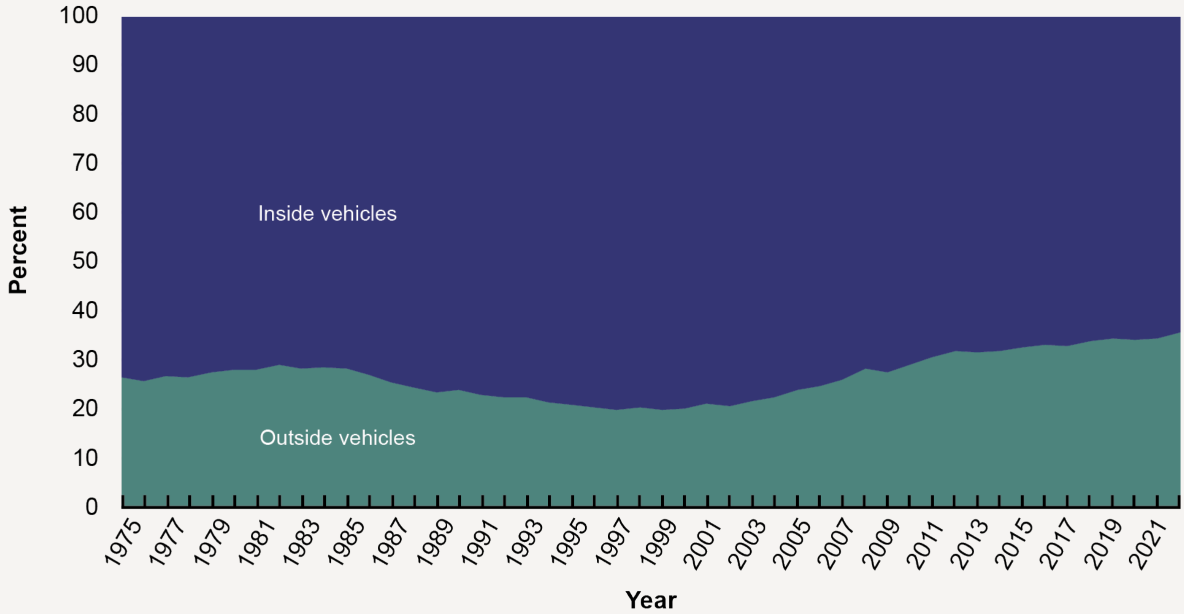
In 2022, 6,218 motorcyclists died, an increase of 75 people from 2021 and the highest number since NHTSA began collecting statistics in 1975.[4] This toll was nearly 1,200 more deaths than in 2019. Some of the factors contributing to the increase over the decades include the increasing age of riders, reduced helmet usage, speeding, and alcohol impairment [NHTSA 2024c]. The number of motorcyclist deaths per 100 million VMT (26.16) was about 22 times greater than that for passenger car occupants (1.20) and 36 times that for light truck occupants (0.76) [NHTSA 2024c].

The number of motorcyclist deaths per 100 million VMT (26.16) was about 22 times greater than that for passenger car occupants (1.20) and 36 times that for light truck occupants (0.76) [USDOT NHTSA 2024c]. Also in 2022, 34 percent of people dying in motorcycle crashes were 50 years old or more, compared to just 7 percent in 1993 [Insurance Institute for Highway Safety (IIHS) n.d.]. The average age of motorcycle riders who died in crashes increased from 40 in 2008 to 42 in 2022 [USDOT NHTSA 2024c].

Large-truck occupant fatalities increased by 8.5 percent in 2022, the only category of vehicle-occupant fatalities other than motorcyclists (here considered occupants) to increase that year. This increase followed a notable 23 percent increase in 2021. Large truck occupant deaths have exceeded 1,000 in 2021 and 2022. 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

3 Bicyclists and other cyclists include riders of two-wheel, nonmotorized vehicles; tricycles; and unicycles powered solely by people pedaling.
4 The 2020 tally of 5,506 was the prior record.

Figure 5-3 Proportion of Traffic Fatalities Inside/Outside Vehicles: 1975–2022



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration. Overview of Motor Vehicle Crashes in 2022. June 2024 (Revised). DOT HS 813 560. Available at www.nhtsa.gov/ as of August 2024.

subsequently increased, exceeding 3,500 every year after 2016. In 2022, there were 4,839 deaths of people in other vehicles or nonoccupants in crashes involving large trucks, 29 more than in 2021 [NHTSA 2024a].

As for injuries in 2022, there was a 4.6 percent decrease in people injured in highway motor vehicle crashes compared to 2021—from 2.5 million people 2.38 million people, respectively. There was also a 2.8 percent decline in the number of police-reported crashes—from 6.10 million to 5.93 million [NHTSA 2024a].

About 28 percent of the crashes involved injuries to an occupant or person outside an involved vehicle. Less than 1 percent of the crashes (0.7 percent) were fatal crashes. However, fatal crashes increased by 30 percent from 2013–2022.

In addition to deaths and injuries on public trafficways, thousands of people die and many thousands more are injured each year in motor vehicle incidents that do not occur on public roadways. Examples of nontraffic incidents include people dying when vehicles collide on private roads, children or other people accidentally run over by cars or SUVs in residential driveways, and pedestrians struck by cars in parking lots. NHTSA began to collect information on these nontraffic incidents in 2007 and has released several subsequent reports on its findings, called nontraffic surveillance [NHTSA 2024d]. In its most recent report, NHTSA found that 3,990 people died in these nontraffic incidents in 2021, an increase of 26 percent over 2020. Pedestrians, bicyclists, and other nonoccupants comprised just over one-fourth of the deaths, with the rest motor vehicle occupants. NHTSA estimated that just under 65,000 people were injured in these nontraffic motor vehicle incidents. While NHTSA does not include these nontraffic fatalities and injuries in its annual estimate of roadway motor vehicle fatalities and injuries, if they were included, the combined annual fatality total in 2021 would be 8.5 percent more. As is discussed in Appendix D, some organizations like the National Safety Council do include these off-roadway incidents in their published motor vehicle totals, which may create an impression of inconsistency but is actually a reflection of different coverage.

Differences in Highway Fatalities by Sex and Age

There are great differences in the number of highway fatalities depending on the sex and age of the victims. 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 2022. Statistically expressed, about 2.6 males died in highway crashes to every 1 female that year—30,669 males versus 11,737 females [IIHS n.d.]. The number of males killed in 2022 was up 18.7 percent from 2019 versus 11.8 percent for females.

Males drive about 5 more miles per day than females on average—about 31.0 versus 26.2 miles in 2022 [FHWA 2024]. 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 the following percentages in 2022:

- 71 percent of pedestrian fatalities
- 87 percent of bicycle fatalities
- 92 percent of motorcycle fatalities

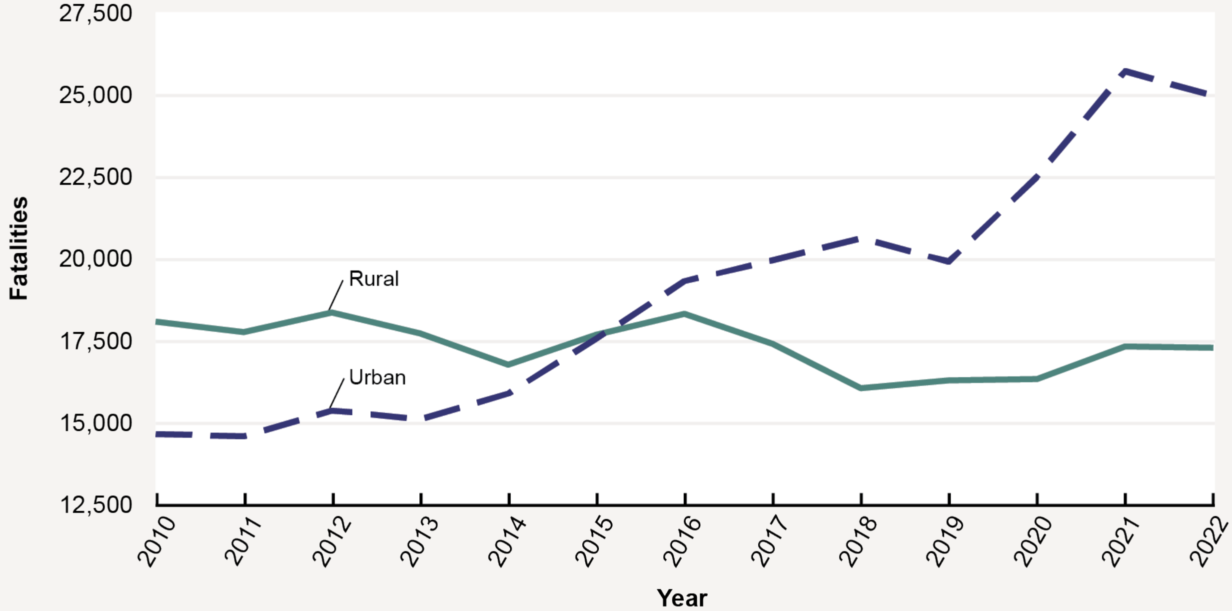
Males were the drivers in 72 percent of fatal crashes in 2022 and had a higher risk than females of being as the driver in fatal crashes as measured by 100 million miles of vehicle travel. The NHTS data shows that male/female split was 50/50 for walking, and 64 percent of e-scooter users, 60 percent of bicycle users, and 52 percent of bikeshare users were male [FHWA 2024]. They were also more likely than females to be speeding (20 versus 13 percent) and to be alcohol-impaired (33 versus 24 percent) when in fatal crashes [IIHS n.d.].

The rate of involvement of male drivers in passenger vehicle fatal crashes was two or three times that of females in every age group in 2021. Involvement rates decline for both sexes in all age groups until age 75 and above, when they again rise [NHTSA n.d.a]. Despite the continued high involvement rate for teenage drivers in fatal crashes, that rate is appreciably lower than in earlier decades. Factors contributing to this decline over time include, among others, greater adoption of graduated licensing systems, restrictions on nighttime driving, and prohibiting teenage drivers from having teenage passengers in their car [IIHS n.d.].

Most age groups showed a decline in highway fatalities in 2021 and 2022. The exception has been for older people. Fatal crashes involving drivers over 65 increased from 7,515 to 7,870, or 4.7 percent, between 2021 and 2022, and the number of deaths in these crashes (7,971) was the highest since NHTSA started collecting these data in 1975 [NHTSA 2024a].

Traffic fatalities in urban areas increased by 13 percent in 2020 (i.e., the first pandemic year), followed by an additional

Figure 5-4 Motor Vehicle Traffic Fatalities by Rural or Urban Location: 2010–2022



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration. Quick Facts 2022, "Urban Versus Rural Fatalities" April 2024. DOT HS 813 563. Available at www.nhtsa.gov/ as of July 2024.

Note: The change in 2010–2022 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 2024.

increase of 14 percent in 2021 before decreasing by just under 3 percent in 2022. In rural areas, by contrast, there were increases of less than 0.5 percent and 6 percent, respectively, in 2020 and 2021, followed by a very slight decline in 2022. Urban area fatalities involving an alcohol-impaired driver increased by 76 percent between 2013 and 2022, while those in rural areas declined by 2 percent. In 2022, 29 percent of the deaths in fatal crashes in urban areas involved speeding, which was 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.

Rural/Urban Highway Fatalities

Beginning in 2016, urban area highway fatalities have exceeded those in rural areas, so that by 2022 urban deaths exceeded rural deaths by 7,740 (Figure 5-4). Rural fatalities decreased by 3 percent between 2013 and 2022 while urban fatalities increased by 66 percent [NHTSA 2024a].

In 2022, rural areas had a much higher fatality rate (1.68 per 100 million VMT) than urban areas (1.15 per 100 million VMT) (Figure 5-5). However, the rural fatality rate has been trending downward over time, while the urban rate has trended upward, with the rate differential narrowing between 2013 and 2022. Although rural areas comprised only 32 percent of total VMT in 2022, they accounted for 41 percent of that year's traffic fatalities.

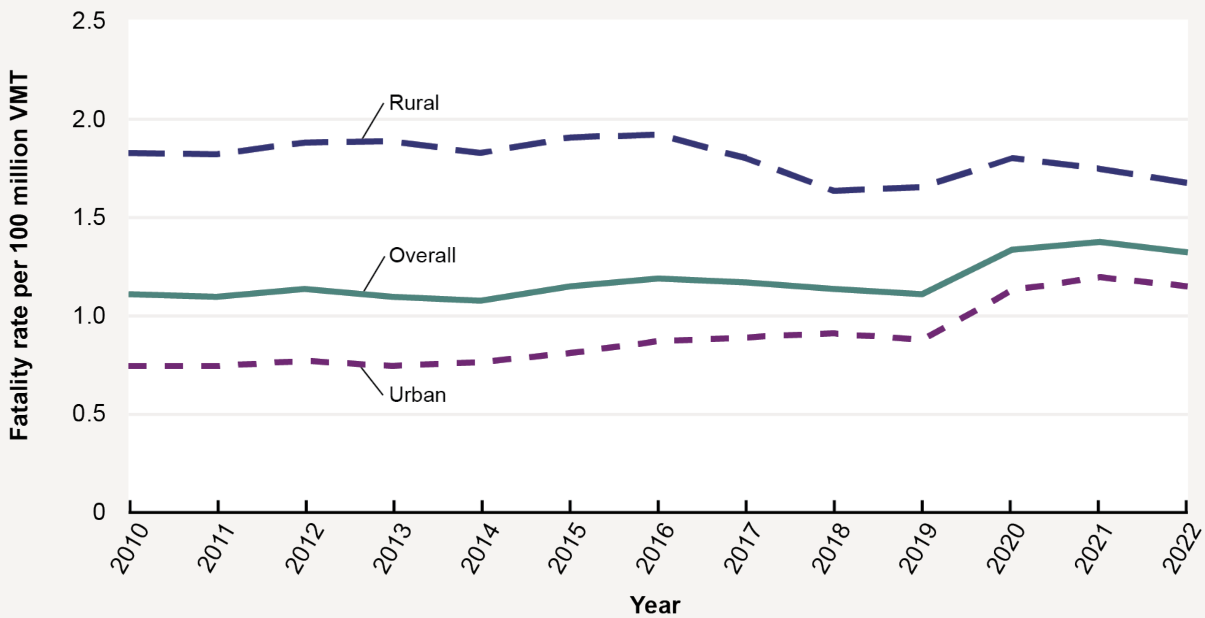
The overall number of rural traffic fatalities had been declining for many years before the slight rise in 2019. By contrast, urban traffic fatalities had been on the rise for several years before the pandemic and before the dramatic jump in 2020 [NHTSA 2024e]. Rural areas accounted for about 54 percent of fatal crashes involving large trucks in 2022, a decline from 63 percent in 2013 [NHTSA n.d.c.]. However, the total number of fatal crashes (both rural and urban) involving large trucks has increased appreciably over the period [NHTSA 2024e].

NHTSA's analysis of fatal crashes shows that emergency medical response time in rural areas is much longer than in urban areas. Although the arrival times to hospitals is largely unknown in fatal crashes, in 2022 of the crashes where both time of crash and hospital arrival time were known, about 38 percent of victims in rural fatal crashes did not arrive at a hospital for 1–2 hours from the time of the crash compared to 10 percent in urban fatal crashes [NHTSA n.d.a]. Differences in hospital arrival times could reflect factors such as emergency notification time, distances between crash scenes and medical facilities, and ambulance availability.

People Injured in Motor Vehicle Incidents

In 2019, an estimated 2.7 million people were injured in motor vehicle incidents. People injured in crashes dropped 17 percent to 2.3 million in 2020 (i.e., the first pandemic year), reflecting the far fewer injury-only crashes that year.

Figure 5-5 Fatality Rate per 100 Million VMT by Rural or Urban Location: 2010–2022



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration. Overview of Motor Vehicle Crashes in 2021, Traffic Fatalities, by Rural/Urban Classification, June 2024. DOT HS 813 560. Available at www.nhtsa.gov/ as of July 2024.

People injured then increased in 2021 to 2.5 million, before falling back in 2022 to 2.4 million [NHTSA 2024a].

Motor vehicle occupants were the third largest category of people treated in hospital emergency rooms for nonfatal injuries in 2022, with motorcyclists (not considered occupants) the sixth largest and pedestrians (by no means all injured by motor vehicles) the eighth largest according to the CDC [CDC n.d.b]. NHTSA estimates that about 8 percent, or 185,000, of people injured in motor vehicle crashes in 2020 were incapacitated [NHTSA 2024a].

Unlike fatalities, which are fully documented through a census of police and other accident reports, injury numbers are estimated from a sample. In 2016, NHTSA redesigned a nationally representative sample of police-reported traffic crashes to estimate the many millions 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. In 2020, NHTSA began reporting people injury 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 extensive, as most recently estimated by NHTSA for the year 2019. NHTSA 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 2023a].

Much speculation is now directed toward the safety ramifications of new technologies that can assume some or all functions of driving. While these technologies hold great promise to reduce highway deaths, injuries and their economic costs, and property damage, 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 NHTSA's effort to collect data on these driving systems.

Other Transportation Modes

Transit

Transit[5] deaths increased during the pandemic even though there was a steep decrease in transit use beginning in March

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

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 advanced driving systems to immediately report a crash if the advanced system was in use in the 30 seconds before the crash. NHTSA released initial data in June 2022 and regularly updates reported data on its website. One set of data is for Society of Automotive Engineers (SAE) level 2 advanced driver assistance programs, and the other set is for SAE levels 3–5 automated driving systems (i.e., vehicles currently being road tested that are capable of car control without a human driver).

Of the incidents involving level 2 automated driving systems in the data reported as of mid-July 2024, 40 fatalities and 20 serious injuries were cited in 311 crashes (1,360 of the reports apparently did not provide injury data). As for vehicles equipped with advanced driver assistance systems (ADS), which are mostly test vehicles, 551 involved collisions with another vehicle, and 28 involved a pedestrian or other vulnerable road user. Five serious and 13 moderate injuries were cited in the episodes in which injury data were reported for full ADS vehicles [NHTSA n.d.b].

These initial data are not sufficient for conclusions to be reached, and NHTSA is working with reporters to improve their submissions. In a May 2022 letter to NHTSA on a proposed revamp of the U.S. New Car Assessment Program (NCAP), the U.S. National Transportation Safety Board (NTSB) 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 n.d.a].

2020 due to the pandemic shutdown effects on local travel. Fatalities rose from 268 in 2019 to 340 in 2022—the highest number since 1990—before decreasing to 329 in 2023 [BTS n.d.]. The reason for the increase in transit fatalities despite lower transit use during the pandemic is unknown. The number of reported collisions of transit vehicles dropped from 23,000 in 2019 to about 17,000 in 2020, rebounding in subsequent years to over 22,000 in 2023.

Sixty-five percent of the 2023 fatalities involved transit rail, with the remainder involving bus (there were no deaths on ferry transit). Most of the fatalities in transit-related accidents were not passengers or transit employees/ contractors inside the transit vehicle. In 2023, onboard fatalities included 29 passengers (i.e., 15 on transit rail and 14 on buses) and 4 vehicle operators, together accounting for only 9 percent of all transit fatalities (Figure 5-6). More people are killed when struck by transit vehicles when waiting to be picked up or dropped off than died as passengers in transit vehicles. In 2023, 19 percent of the transit fatalities were suicides on transit property or involving transit assets.

Nonhighway modes, including 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 about 5 percent of total transportation fatalities and only a fraction of 1 percent of injuries in most years. In 2022, 2,049 people died in accidents/incidents involving these nonhighway modes (Figure 5-1).

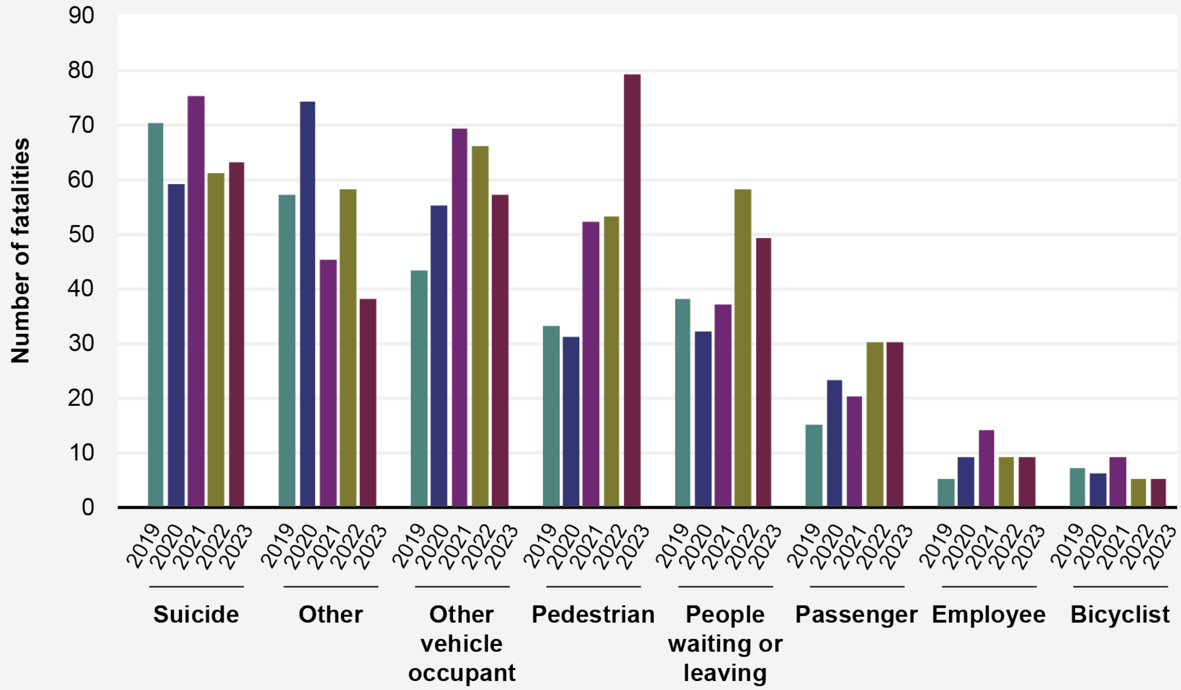
As for injured people, about 20,600 people were injured on nonhighway modes and transit bus in 2019 before falling appreciably in 2020. All but about 4,000 of these injuries were on transit bus (i.e., a highway mode). The number of injuries then began to increase, reaching just under 17,800 in 2022, but were still below the prepandemic level, with again all but about 4,000 of these on transit buses (Table 5-2). Transit bus is broken out separately here because bus injuries are reported by transit agencies, not estimated by the survey.[6,7]

As discussed throughout this section, the safety record of the nonhighway modes pre- and postpandemic has been mixed.

6 In contrast to highway injuries which are estimated through sampling, injuries for the nonhighway modes are compiled from incident reports filed by administrative agencies.

7 While bus transit is a highway mode, it is highlighted here because it is not separated out in Table 5-2.

Figure 5-6 Transit Fatalities by Category: 2019–2023



Source: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, available at https://www.transit.dot.gov/ntd as of July 2024.

Note: “Pedestrian” 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.

Water

Fatalities in water transportation, both commercial and recreational boating (also called boating below), totaled 715 in 2021 and 686 in 2022, down from a high of 853 in 2020 due to fewer boating fatalities. Boating accounts for the majority 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 declined from 2017–2019, but the U.S. Coast Guard (USCG) reported a 25 percent increase to 767 fatalities in 2020 (i.e., the first pandemic year). Boating fatalities then fell in each of the three subsequent years to 564 in 2023, the lowest level since 2013 [BTS n.d.]. Nearly all boating fatalities happen as people travel to and from recreational, fishing, or watersport activities [USCG 2024].

Aside from the boating fatalities, an additional 2,126 people were injured in 2023, and $63 million in property damage was reported. USCG notes that nonfatal accident statistics are severely underreported because people may be unaware that they are supposed to report these incidents or are unwilling to report them.

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 2023 due to boating accidents involved motorized craft; the remaining one-third involved boats without motors, with kayaks and canoes accounting for the most fatalities in this category (95 and 43, respectively) [USCG 2024].

Far fewer people die in boating mishaps today than in earlier decades. In 1980, there were 1,360 deaths, which was nearly 800 more deaths than in 2023 [BTS n.d.]. As measured by the amount of boating activity per fatality, however, it is less clear how much safer boating is today as there is a lack of adequate risk exposure measures. 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, which was a decrease from 94 in 2019. This number continued to decrease to 57 in 2021 and 50 in 2022.[8] Large vessels in collisions can inflict damage to other vessels and to on-land facilities, resulting in property damage and fatalities or injuries. Over the years, there have been many vessels colliding with bridges, most notably in the March 2024 collapse of the Francis Scott Key Bridge in Baltimore Harbor due to a container ship striking a bridge pier. Six maintenance workers on the bridge drowned as a result of the collision, and another worker was critically injured [NTSB 2024b].

Railroad

Railroad-related fatalities (including grade crossing and trespasser deaths) were just under 1,000 in 2023, the highest number since 1998. The increase reflects a 28 percent increase in trespasser deaths from 2022. As with transit, most fatalities associated with railroad operations occur outside the train and mostly include people struck by trains while on track rights-of-way (called “trespassers” in railroad reporting parlance) or people in motor vehicles struck at highway rail-grade crossings. Very few train passengers or crew members die in train accidents in most years. Trespasser and grade crossing fatalities are discussed further in the Ignoring Risks and Warnings section of this chapter.

Of the people who died in railroad-related accidents in 2023, FRA attributes about 26 percent of the fatalities to passenger train operations [FRA n.d.].

Aviation

Air transportation fatalities totaled 358 in 2022, with all but 19 of those fatalities involving general aviation, such as recreational flying. In most years, general aviation deaths greatly exceed those in commercial aviation (which includes large freight and passenger air carriers, commuter air services carrying 10 or fewer passengers, and air taxis).

There were 6 years between 2013 and 2022 with no passenger fatalities on U.S. passenger airlines, with a total of 12 fatalities reported over this entire 10-year period. U.S. air carriers that only carry freight had 3 fatalities in 2019. In recent years, there have been very few fatal crashes on large U.S. commercial passenger carriers (referred to as Part 121 carriers in regulatory parlance), However, there have been numerous close calls, such as runway incursions, hull breaches, equipment failures and near misses involving commercial carriers as well as other aircraft.

Smaller commercial air services are regulated under Part 135 of the Code of Federal Regulations (CFR). Among these services, commuter air passenger operations had 4 years with no fatalities from 2013–2022, with 32 total fatalities over the other 6 years. Air taxis, which is an on-demand service, registered fatalities in every year, with an average of 21 deaths per year. This average contrasts with an average of 44 air taxi fatalities per year between 2000 and 2009 and about 54 deaths annually between 1990 and 1999 [BTS n.d.].

8 This number 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.

According to a July 2024 NTSB report, there are insufficient data to allow a comprehensive assessment of the safety metrics for the different components of the Part 135 industry [NTSB 2024a]. Refer to the Data Gaps section in this chapter for more discussion.

General aviation deaths account for the great majority of aviation deaths in most years. General aviation deaths have declined appreciably—from over 1,000 annually in the 1970s and early 1980s to a yearly average of 376 over the last decade. Besides the number of deaths, two other measures of general aviation safety are helpful in showing trends. One measure—the number of fatal crashes—continued its steady decline from over 400 per year in the early 1990s to an average of 220 per year between 2013 and 2022. The number of fatal crashes differs from the number of fatalities depending on the number of plane occupants who died. The second measure—general aviation fatal accident rate per 100,000 flight hours—has decreased from 1.5 in 1995 to under 1 death in 100,000 flight hours in 4 of the 7 years between 2016 and 2022, when the rate was 0.945 [BTS n.d.; NTSB n.d.b].

Obtaining information about close calls and other safety threats to aviation has been an objective of the Aviation Safety Reporting System, a voluntary confidential reporting program launched by the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration's (NASA's) Aviation Safety Reporting System (ASRS) in 1976. Flight crew, maintenance staff, flight controllers, and others have made about 2 million reports on incident reports on a confidential basis, contributing to many changes in operating procedures over the years [NASA ASRS 2021]. However, as a recent ASRS report noted, the voluntary reporting has limitations related to quantitative statistical analysis, and the number of reports received might be underreported [NASA ASRS 2024].

Unmanned aircraft systems, or "drones," pose several challenges to aviation safety, but as of publication, no crashes in the United States have resulted. However, pilots took evasive actions to avoid contact regarding the 63 drone incidents from 2021–2022, with 4 involving commercial aircraft according to a recent report [USGAO 2024]. 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 telemetry data from 1.8 million piloted flights and 460,000 unmanned aircraft systems operations near the Dallas Fort Worth International Airport between August 2018 and July 2021 and found 24 near-misses. Researchers noted that extending drone exclusion zones near the ends of high risk runways would reduce risks [Embry-Riddle Aeronautical University 2023].

Oil/Hazardous Liquid and Gas Pipelines

In 2023, 15 people died and 36 were injured in 479 hazardous liquid and gas pipeline incidents. For the last 20 years (2004–2023), the average annual death toll was 13.4, with 54 injured people. Gas pipelines (especially gas distribution pipelines—such as to residences and commercial buildings) account for most of the fatalities in most years. Pipeline incident costs averaged $547 million per year over the 2004–2023, about 51 percent of which involved oil or other hazardous liquid spills [PHMSA n.d].

On-the-Job Transportation-Related Fatalities and Injuries

As is nearly always the case, transportation incidents were the most frequent cause of on-the-job fatalities in 2022 according to the latest census by the Bureau of Labor Statistics (BLS), accounting for 37.7 percent or 2,066 of the 5,486 total incidents. Transportation deaths were up by 4.2 percent from the prior year but still lower than in 2019 (i.e., 2,122) [BLS 2024].

In 2022, motor vehicle operators made up 56 percent (i.e., 1,198) of all transportation-related on-the-job fatalities. The majority of these were heavy or tractor-trailer truck drivers, with 874 deaths that year involved in highway incidents. This group had the had the sixth highest occupational fatality rate, with 28.8 deaths per 100,000 workers. Aircraft pilots and flight engineers experienced 48 fatalities, giving them the third highest occupational injury fatality rate, at 34.3 deaths per 100,000 full-time equivalent workers. For context, the fatal injury rate for all workers was 3.6 per 100,000 workers in 2021.

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 2022, 891 people died in highway work zones, down 70 from a 15 year high in 2021. Workers were 44 of the total,10 fewer than the average of 54 since 2011. Drivers and occupants of motor vehicles were 83 percent of the deaths. About 37,701 people were injured in crashes in work zones in 2022, about 4,500 fewer than in 2021 [NSC n.d.]. The data suggest that most of those injured or killed in work-zone crashes are people in vehicles, not workers in the work zone [NHTSA n.d.c]. A separate data source estimates that about 55 pedestrians (presumably highway construction workers) are killed in work zones each year [NCS n.d.].

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.

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 FAA does investigate incidents reported by crewmembers. In August 2024, FAA indicated that 310 incidents, including passenger efforts to breech the flight deck, sexual assaults on other passengers and physical assaults on crew members, had been referred to the Federal Bureau of Investigation for investigation [FAA 2024].

Crimes on Transit Vehicles or at Transit Facilities

Data indicate that murders decreased from 31 in 2020 to 25 in 2021, before jumping to 50 in 2022. Rapes declined from 13 in 2020 to 5 in 2021, and then increased to 17 in 2022. Robberies and assaults rose in 2021 and 2022 after the fall in 2020; the increase pushed the level in 2022 above that in 2019. The data are from jurisdictions serving at least 50,000 people and operating 30 vehicles or more [BTS n.d., table 2-38].[9] A recent Urban Institute analysis, using data from FTA's National Transit Database, found that assaults on transit workers in 2023 have tripled since 2008 [Urban Institute 2023].

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 versus 7 percent [Mineta 2020]. At the direction of the California State Legislature, the Mineta Transportation Institute has developed a survey instrument that transit agencies in California and elsewhere could use to evaluate harassment on their systems [Mineta 2023].

Contributing Factors to Transportation Crashes and Incidents

Analysts often examine how the following three factors, which often occur in combination, interact to contribute to transportation crashes and incidents:

- Human factors (e.g., operator or controller error)
- Vehicle or equipment-related factors (e.g., tire defect, or signal light failure)
- Environmental factors (e.g., adverse weather, smoke from forest fires).

Human factors play a key role in all modes and a dominant role in motor vehicle crashes. For 2021, police listed a driver-related factor for over half (54.2 percent) of the passenger vehicle drivers in fatal crashes that year, with speeding, impairment, failure to yield the right of way, and carelessness as the top factors. In contrast, just under one-third (31.9 percent) of large truck drivers in fatal crashes were cited for driver-related factors, with speeding, distraction, and carelessness being the top 3 reasons in 2021 [FMCSA 2023a].

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 wornout parts) [USGAO 2003]. In 2021, vehicle factors, most commonly tires, were recorded for 4.2 percent of large trucks and 2.0 percent of passenger vehicles involved in fatal crashes [FMCSA 2023a].

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).

Weather is a pervasive environmental factor in crashes and incidents in all modes. An analysis of 10 years of NHTSA crash data (from 2007 through 2016) found that 15 percent of fatal crashes, 19 percent of injury crashes, and 22 percent of property-damage only crashes took place during adverse weather or on slick pavements. An average of nearly 5,000 people died and 418,000 people were injured each year over the 10-year period in these adverse weather events [FHWA n.d.].

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

9 Security events must meet the National Transit Database reporting threshold (i.e., injury requiring immediate transport away from the scene, fatality, an evacuation for life-safety reasons, or estimated property damage equal to or exceeding $25,000).

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 NTSB investigations of transit and railroad mishaps.

As for highway motor vehicles, speeding tops the notation list in police reports of both passenger vehicles and large trucks in fatal crashes. While the 12,151 speeding-related deaths in 2022 was a decrease from 12,498 in 2021, this number was still higher than prepandemic numbers. In 2018 and 2019, there were less than 10,000 speeding-related deaths. About 35 percent of motorcyclists in fatal crashes in 2022 were speeding, the highest share among vehicle driver types, as were 22 percent of passenger car drivers, 15 percent of light-truck drivers, and 6 percent of large-truck drivers [NHTSA 2024f].

Males, especially young males, account for a high proportion of speeding drivers in fatal crashes. In 2022, 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 19 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, 38 percent of speeding drivers in fatal crashes in 2022 were found to have a BAC of 0.08 g/dL or above compared to 18 percent among nonspeeding drivers in fatal crashes.

More than half (52 percent) of the passenger vehicle drivers involved in fatal crashes who were speeding in 2022 were not wearing seat belts at the time of the crash, versus 22 percent of passenger vehicle drivers in fatal crashes who were not speeding, based on known restraint use [NHTSA 2024f].

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 0.00–0.02 g/dL [NIH NIAAA n.d.]. Drivers whose BACs are at or above these thresholds are considered alcohol impaired or inebriated. Using the 0.08 g/dL as a criterion, National Highway Safety Administration (NHTSA) estimates that, in 2022, an average of one alcohol-impaired-driving fatality occurred every 39 minutes [NHTSA 2024g].

As shown in Table 5-3, in 2022, 13,524 people died in motor vehicle crashes in which at least one driver had a BAC of 0.08 g/dL or higher—a slight decline from 2021; this was 32 percent of the U.S. traffic fatalities that year. Alcohol related deaths jumped in 2020, the first year of the pandemic, and reached their highest level since 2006 in 2021.[10]

Many inebriated drivers have BAC levels greatly exceeding the 0.08 g/dL level and/or are repeat offenders. In 2022, two-thirds of the fatalities in alcohol-impaired driving crashes involved a driver with a BAC of 0.15 g/dL or above—nearly twice NHTSA's inebriation threshold. Impaired drivers in fatal crashes were also 3 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 [NHTSA 2024g].

Over the decades, a nationwide campaign, with concerted efforts at the local, state and federal levels by many organizations, has lowered public tolerance for drunk driving. 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 noncomplying states. New measures continue to be put forward to further reduce fatalities arising from 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 n.d.].

Figure 5-7 displays categories of people who died in fatal crashes in 2022 when the driver had a BAC of 0.08 g/dL or higher. Drivers accounted for 8,012 (59 percent) of the fatalities; 3,877 (28 percent) were either passengers in a vehicle with an impaired driver or occupants of other vehicles, and 1,635 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.

Demographically, there were 4 alcohol-impaired male drivers for every female impaired driver in fatal crashes. People aged 21 to 34 comprised 39 percent of the impaired drivers.

10 According to the USDOT National Highway Traffic Safety Administration, an alcohol-impaired crash involves at least one driver or motorcycle rider with a Blood Alcohol Concentration (BAC) of at least 0.08 grams per deciliter (g/dL). Crashes where the BAC of the driver or rider measures over 0.01 are considered alcohol-related or alcohol-involved crashes.

Table 5-3 Fatalities by Highest BAC in Highway Crashes: 2010 and 2017–2022

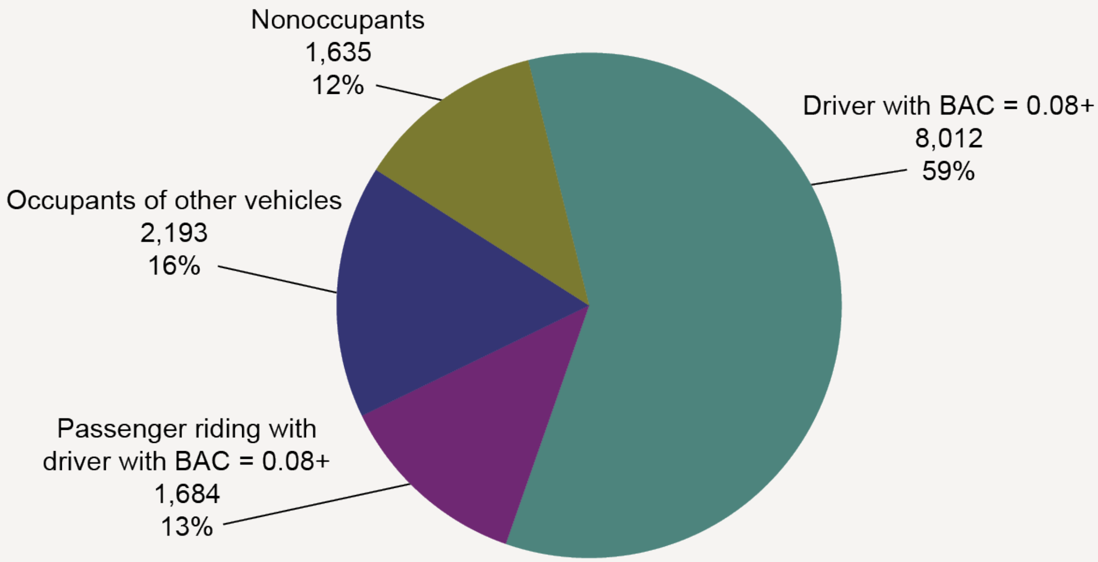
Mode	2010	2017	2018	2019	2020	2021	2022
TOTAL fatalities	**32,999**	**37,473**	**36,835**	**36,355**	**39,007**	**43,230**	**42,514**
BAC = 0.00, number	21,005	24,589	24,186	24,251	25,121	27,229	26,580
BAC = 0.00, percent	64	66	66	67	64	63	63
Fatalities in alcohol-related crashes (BAC = 0.01+), number	11,906	12,775	12,560	12,029	13,800	15,941	15,861
Fatalities in alcohol-related crashes (BAC = 0.01+), percent	36	34	34	33	35	37	37
BAC = 0.01 - 0.07, number	1,771	1,895	1,850	1,834	2,073	2,324	2,337
BAC = 0.01 - 0.07, percent	5	5	5	5	5	5	5
BAC = 0.08+, number	10,136	10,880	10,710	10,196	11,727	13,617	13,524
BAC = 0.08+, percent	31	29	29	28	30	31	32

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA), Traffic Safety Facts: Alcohol-Impaired Driving (Annual Issues) as of July 2024.

Note: Total fatalities include those in which there was no driver or motorcycle rider present. BAC values have been assigned by 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.

BAC = blood alcohol concentration.

Figure 5-7 Fatalities by Role in Crashes Involving at Least One Driver With a BAC of 0.08 or Higher: 2022



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts: Alcohol-Impaired Driving 2022*, June 2024.

Note: Nonoccupants includes pedestrians, pedalcyclists, and others not listed.

BAC = blood alcohol concentration.

USCG found operator alcohol use to be the primary contributing cause in 17 percent of boating accidents, or 211, in 2023, resulting in 79 fatalities [USCG 2024]. As of January 1, 2023, 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 [NIH NIAAA n.d.].

Drugs and Fatal Crashes

According to the USCG, drug use was the primary contributing factor in 14 boating accidents in 2023 (out of a total of 3,844), resulting in 11 fatalities [USCG 2024]. Many states test road vehicle drivers for presence of alcohol and drugs after fatal crashes.[11] A study by the Governors Highway Safety Association analyzed the results of these tests in 2016, finding that among drivers in fatal crashes that were tested for drugs and/or alcohol, about 44 percent tested positive for drugs and just under 38 percent tested positive for alcohol. More than half of those testing positive for drugs were positive for two or more drugs, and over 40 percent were also positive for alcohol. The tests were for any presence of alcohol or drugs in the driver's system. The study noted that presence of drugs does not imply impairment [GHSA 2018]. Since 1991,[12] Federal transportation agencies have required testing on the job for safety-sensitive transportation operators and workers in many industries.[13]

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 [Marcus, Rosekind 2017]. In the case of recreational boating, operator inattention was cited as the top contributing factor in all boating accidents (nonfatal as well as fatal) in 2023, according to the USCG—resulting in 33 deaths and 323 injuries from 586 accidents [USCG 2024].

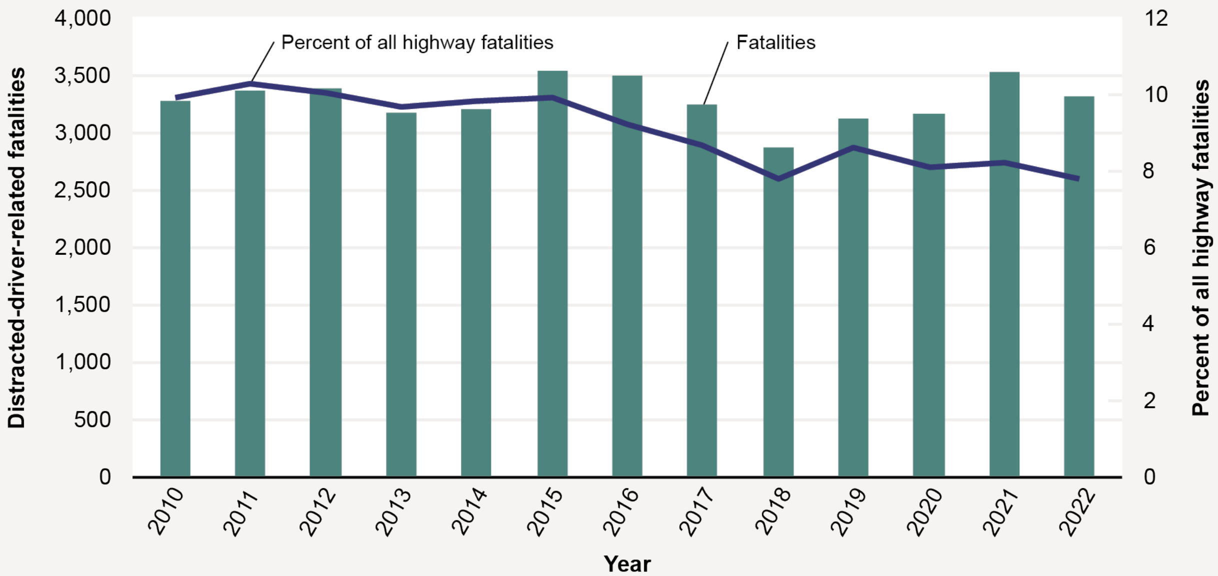
As for motor vehicles, the number of fatalities in distraction-affected highway crashes rose from 2,858 in 2018 to 3,521 or 8 percent of total motor vehicle related fatalities in 2021, before falling slightly to 3,308 in 2022 (Figure 5-8). Drivers aged 25 to 34 accounted for 23 percent of all distracted

11 Driving while under the influence may include by any legal or illegal substance such as alcohol, marijuana, opioids, methamphetamines, or any potentially impairing prescribed or over the counter drugs.

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

13 For citations to Federal regulations and minimum standards for required random testing rates under regulations issued by the USDOT operating administrations and the U.S. Coast Guard, refer to Bureau of Transportation Statistics' *Transportation Statistics Annual Report 2018*, box 6-C, p. 6-17.

Figure 5-8 Percentages of Motorcyclists Killed Not Wearing a Helmet: 2022



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, data provided September 2024.

drivers involved in fatal crashes in 2022 [NHTSA 2024h]. Vehicle occupants comprised 81 percent of fatalities in distraction-affected crashes that year, with pedestrians and other nonoccupants the remainder. It is not known how many nonoccupants were also distracted when struck (e.g., walkers engrossed in cell phone conversations while crossing a street).

Many activities (e.g., eating, sipping coffee, smoking, grooming, tending to a child) may be distracting to drivers and can also distract bicyclists, pedestrians, and bystanders with often catastrophic results. Among distracting activities, 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 2022 (3,047) were affected by driver distraction. In 368 of these, a cell phone was in use at the time of the crash [NHTSA 2024h]. Thirty-four 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.

Fatigue is a pervasive safety problem for all modes of transportation that manifests not only in crashes by vehicle operators but errors by supporting personnel such as flight controllers and maintenance staff. A review of 182 NTSB investigations found that 20 percent identified fatigue as a probable cause. The presence of fatigue as a cause ranged from 40 percent of the NTSB highway investigations to 4 percent of the marine investigations [Marcus, Rosekind 2017].

Drowsy driving was found to be a factor in 626 fatal crashes (about 1.6 percent), resulting in 693 fatalities in 2022 [NHTSA n.d.c.]. However, it is likely that the role of fatigue in crashes has been underestimated—perhaps vastly underestimated, with one study by the AAA Foundation for Traffic Safety finding the likely number of fatal crashes involving a drowsy driver to be 10 times the number recorded in FARS data, the primary NHTSA dataset on roadway deaths [AAA 2024].

Earlier research by the Foundation examined dash-cam footage of drivers in the moments before 589 crashes and found drowsiness in about 11 percent of crashes [AAA 2018].

Distracted or inattentive driving by commercial motor vehicle drivers was a contributing factor in approximately 5.2 percent of fatal crashes involving large trucks in 2020. In addition, truck driver impairment (e.g., fatigue, drugs/alcohol, illness) was a factor in 5.2 percent of these fatal crashes, the same percentage as distracted driving [FMCSA 2023a].

Ignoring Risks and Warnings

A common problem across transportation modes is that people sometimes ignore safety warnings (e.g., they speed through a changing traffic light or ignore a railroad crossing signal, or don't walk signal at an intersection, or avoid instructions to wear life jackets on boats) with disastrous results.

Highway intersections are a major location for motor vehicle crashes, resulting in many thousands of deaths, hundreds of thousands of injuries, and millions of fender benders each year. Failure to obey traffic signals and/or failure to yield the right of way are major causes of intersection crashes, with a great many fatal crashes attributable to behaviors such as ignoring a stop sign or running a red light [NHTSA 2007]. As is further discussed in the section on future development of innovations, intersection collision avoidance systems in vehicles and nearby infrastructure have the potential to reduce future fatal, injury, and property damage in intersections, but these innovations could require decades to fully deploy.

The large number of people struck by trains and dying on railroad property (much of which is marked with keep-out signs and high fences) equals or exceeds the total number of deaths in the transit or air modes in most years. These so called trespasser fatalities on railroad property were just under 400 in 2011 but have since risen dramatically—reaching 718 in 2023, an increase of nearly 80 percent, and the most since at least 1975. While trespassers accounted for about 61 percent of the total railroad fatalities between 2010 and 2019, the 2023 number comprised 72 percent of the railroad deaths that year.

While trespasser deaths have gone up in the last two decades, highway rail-grade crossing fatalities have declined, in part because of well advertised safety campaigns to "always expect a train." Crossing deaths averaged about 251 per year in the 10 years ending in 2023, or roughly one-third of all railroad-related fatalities. This compares to an average of 550 deaths per year in the 1990s. Grade crossing deaths dropped to 194 in 2020, the first pandemic year, but then rose. In 2023, there were 248 fatalities at grade crossings, preceded by 274 in 2022 [BTS n.d.].[14]

Many railroad-related deaths each year involve people committing suicide, averaging about 255 people a year in the 10 years between 2014 and 2023. 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. There were 63 suicides involving transit in 2023 (Figure 5-6).

14 Counts of highway grade-crossing fatalities are reported to both rail and highway agencies. In Table 5-1, to avoid double-counting, these fatalities are included in the overall count for highways but not for rail.

Suicides involving highway 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 sizable and continuing problem.

Countermeasures to Reduce Safety Risks

Safety devices, such as flotation devices for boaters, automobile and airplane seat belts, frontal air bags, child restraints, and motorcycle helmets, help save lives and reduce injuries in crashes and other transportation incidents, a conclusion supported by a great deal of research dating back decades. As an example, about 75 percent of people who died in boating accidents in 2023 drowned, and 87 percent of those who drowned were not wearing a life jacket [USCG 2024].

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 have been implemented to reduce in highway vehicle and other transportation fatalities and injuries [Kahane 2015; Masten et al. 2015]. 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 2023, up from 71 percent in 2000 and 85 percent in 2010 [NHTSA 2024j]. Rear seat occupants had a higher rate of seat belt use—about 80 percent in 2020 and 81.7 percent in 2022 [NHTSA 2024i]. Pickup truck occupants had the lowest usage at 87 percent in 2023 (Table 5-4).

Half of passenger vehicle occupants killed in 2022 were unrestrained (counting only those cases where restraint use was noted by officials at the crash scene). The percentage of unrestrained passenger vehicle occupants who died in crashes during the pandemic rose from 47 percent in 2019 to 51 percent in 2020, and remained above the 2019 level in 2021 and 2022 at 50 percent [NHTSA 2024i].

As for fatal crash survivors, 86 percent used restraints, while 14 percent did not in 2022 [NHTSA 2024i]. 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 [NHTSA 2019].

Table 5-4 Percentages of Safety Belt and Motorcycle Helmet Use: 2010 and 2017–2023

Category	Mode	2010	2017	2018	2019	2020	2021	2022	2023
Safety belt use[1]	**Overall**	**85**	**90**	**90**	**91**	**90**	**90**	**92**	**92**
	Drivers	86	90	90	91	91	91	92	92
	Right-front passengers	83	88	89	90	90	89	90	91
	Passenger cars	86	91	90	91	91	91	91	92
	Vans and sport utility vehicles	88	92	92	93	92	92	94	94
	Pickup trucks	75	83	84	86	86	85	87	87
Motorcycle helmet use[1,2]	**Overall**	**54**	**65**	**71**	**71**	**69**	**65**	**67**	**74**
	Operators	55	68	71	75	69	67	68	74
	Passengers	51	51	69	48	72	52	61	75

Source: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration, Traffic Safety Facts: Research Notes, Seat Belt Use (Annual issues); and Motorcycle Helmet Use—Overall Results (Annual issues). Available at http://www-nrd.nhtsa.dot.gov as of October 2024 as cited in USDOT, Bureau of Transportation Statistics, National Transportation Statistics, table 2-30, available at http://www.bts.gov as of October 2024.

Note: Occupants of commercial and emergency vehicles are excluded.

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

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

In 2023, observed seat belt use for front-seat passenger vehicle occupants was 91.9 percent, the highest usage on record, and up from 86.7 percent in 2014. The highest seat belt use was in the West (96.5 percent) with the lowest in the South (88.4 percent) [NHTSA 2024j].

Helmet Use

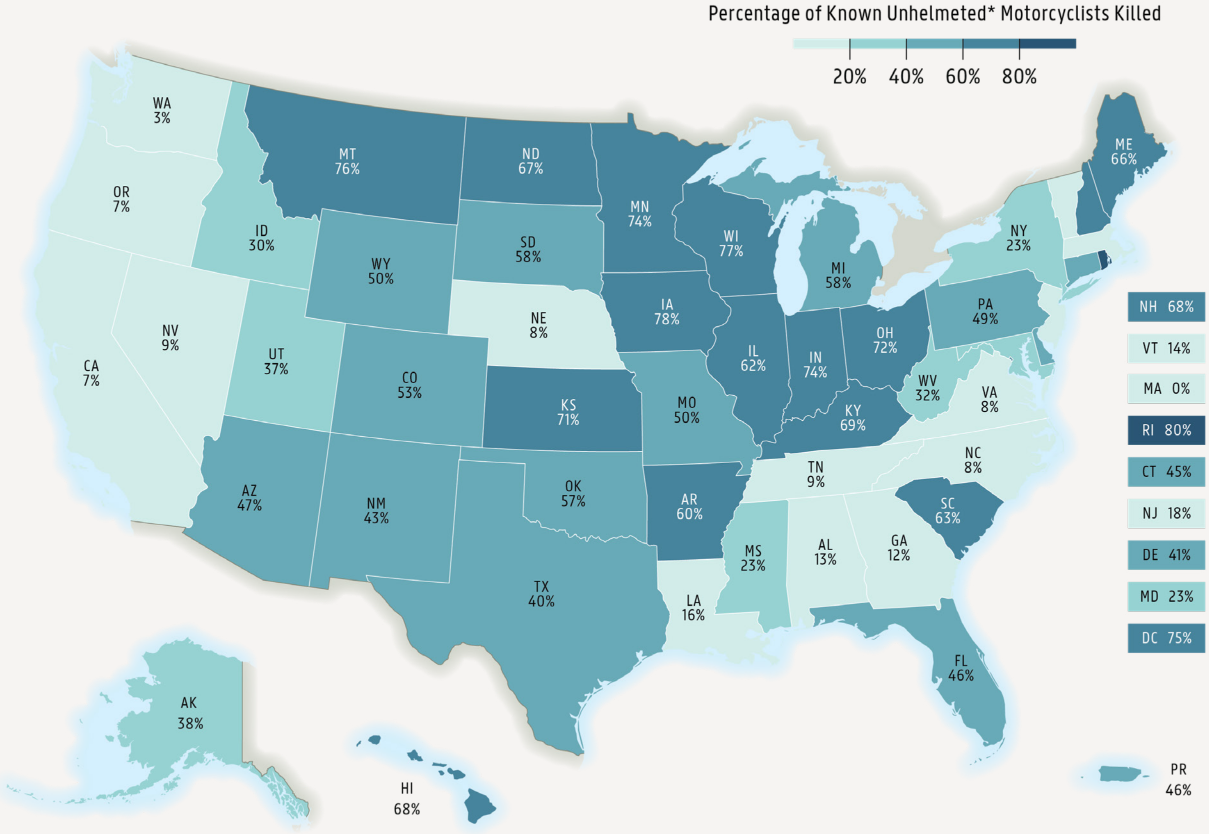
Good helmets can be effective in protecting people from head injuries when riding motorcycles, bicycles, and the increasing number of human-powered or motorized personal transportation devices, such as two-wheel scooters, skateboards, and e-scooters [Mineta 2019]. Helmets not only protect riders in collisions but from inadvertent falls, which are common.

NHTSA estimates that USDOT-compliant helmets[15] are 37 percent effective in preventing fatal injuries to motorcycle riders and 41 percent effective for motorcycle passengers [NHTSA 2023]. In 2017, according to NHTSA, helmets saved the lives of 1,872 motorcyclists [NHTSA 2019]. Overall usage of USDOT-compliant helmets has fluctuated in recent years (Table 5-4), reaching a high of 71 percent in prepandemic 2018 and 2019 before falling to 65 percent in 2021 (with a 4 percent drop between 2020 and 2021) and then rising to about 74 percent in 2023 [NHTSA 2023].

In 1975, 47 states and the District of Columbia adopted universal helmet use laws that required motorcycle helmets for all riders, but many states subsequently made their helmet laws less restrictive [Cosgrove 2007]. In 2022, only 18 states and the District of Columbia continued to have

15 USDOT-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 People Killed in Distracted-Driving Crashes: 2010–2022



Source: U.S. Department of Transportation, Federal Transit Administration, National Transit Database, available at https://www.transit.dot.gov/ntd as of July 2024.

Note: "Pedestrian" 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.

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 2022] (Figure 5-9).

Safety experts have long advocated that bicycle riders wear helmets. 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. In 2022, 1,105 bicyclists were killed and 46,195 were injured in traffic incidents involving motor vehicles [NHTSA 2024k].[16] This was a 13 percent increase in deaths and a 11 percent increase in 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. 2019].

Helmet use (or lack thereof) is also a prominent issue in many cities where battery powered e bikes, e-scooters, and a range of other so-called micromobility devices are in use. Many of these devices are for rent, and often used by novice riders in traffic or on sidewalks. Due to apps on smart phones, the rental location is often wherever the last rider left the micromobility device, and helmet use by new riders often is not monitored. Box 5-C describes the safety issues associated with the emergence of e-scooters and other powered individual mobility devices in U.S. cities.

Training and Refresher Training

Operator training can enhance safety in all transportation modes. With 235 million licensed drivers in the United States in 2022, motor vehicle driver training is a large endeavor. Driver education courses for teenagers are required for a driver's license in many states—23 in 2012, with requirements varying by states [NHTSA 2012]. Commercial driving licenses require training in the type of highway equipment the driver seeks to operate. An extensive pilot training system exists to meet the needs of pilots at all levels in the United States—over 800,000 pilots (including students) had active airman certificates in 2023 [FAA 2024]. FAA 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 [FAA n.d.].

Many general aviation crashes occur each year when pilots who are not instrument rated (licensed to fly using instruments in the plane when visibility is limited) or who are deficient in their instrument flying skills unexpectedly encounter adverse weather conditions that they are ill-prepared to handle [Skybrary n.d.].

Most states require recreational boaters to take some form of education and safety training. (The exceptions are 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 15 percent of deaths in fatal boating accidents in 2023 occurred in boats operated by a person known to have received a certificate for boating safety from a nationally approved provider [USCG 2024].

Monitoring and Enforcement of Safety Standards

Traffic safety enforcement is intended to encourage good driving habits (e.g., wearing a seat 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 [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 2022, according to the FBI, law enforcement agencies across the country made over 767,000 arrests for driving under the influence (DUI), an increase of more than 50 percent from 2019. Males accounted for almost three-quarters of the DUI arrests [FBI n.d.]. Studies have shown sobriety checkpoints are an effective countermeasure to reduce alcohol-impaired driving. Such checkpoints (temporarily at least) reduce alcohol-related crashes. Not all states authorize these checkpoints, however, and the need to devote law enforcement personnel and the high cost of publicizing these programs are thought to have limited their use [CDC n.d.c].

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 2022, there were roughly 764,000 interstate freight carriers (including a large number of self-employed truckers), 40,000 intrastate hazardous material (HazMat) carriers (in addition to the 6,500 HazMat carriers counted in the interstate freight carrier category), and roughly 10,000 interstate passenger carriers (e.g., bus companies). In 2022, there were just under 3.0 million roadside inspections of trucks and buses conducted by state and federal inspectors, up by 103,000 from 2021, but still 487,000 fewer inspections than in 2019 before the pandemic,

16 Prior to 2022, NHTSA counted bicycles with a motor as a motorcycle, a category of motor vehicle. Beginning in 2022, motorized bicycles are not counted as motor vehicles. From 2022 forward, deaths and injuries involving only crashes of motorized bicycles are no longer be included in the FARS database (a crash involving a bicycle—whether motorized or not—and a motor vehicle that is not a bicycle would continue to be counted in FARS, but a crash involving just two bicycles one of which was motorized would not). Of the 43 fatalities on motorized bicycles in 2021, 7 involved only motorized bicycles.

BOX 5-C

MICROMOBILITY SAFETY AND SHARED TRAVELWAYS

Before the pandemic, nearly 300 local bikeshare and e-scooter systems were available to the public, serving more than 200 cities, but many suspended operations at least temporarily in 2020. E-scooters and bicycles are seen by some transportation planners as a solution to the "last mile problem," making it easier for people to get to and from their homes to transit stations and to their ultimate destinations. Speed is an issue as riders on some of these mobility devices can cruise at 15 miles per hour or even faster—a speed too fast for most pedal bicyclists to maintain, too slow for highways, and too fast for sidewalks.

Rider safety, and to some extent pedestrian safety, are a concern as rental opportunities for these devices have proliferated. Some users don't wear helmets and training even for first time users is often limited to tutorials presented on the app 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 (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 [CPSC 2023].

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 [CPSC 2022]. Defective brakes are another danger.

and the number of safety inspectors fell by about 1,000, from 13,597 prepandemic to 12,591 in 2022 [FMCSA 2023b].

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 has fluctuated since 2018, from about 30,150 to a low of 22,230 in 2020, then rebounding to 32,463 in 2022 [FMCSA 2023a]. 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 noncompliance 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 217 lives and prevented 6,819 crashes and 3,461 injuries in fiscal year 2020 [FMCSA 2024].

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 FRA.

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 2023, 24,265 hazardous materials incidents (excluding pipeline incidents) associated with these shipments were reported to PHMSA—down about 900 from 2022 [PHMSA n.d.].

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 2023, about 4,100 occurred during loading,11,000 during unloading, and nearly 800 during storage.[17] Spillage during transport accounted for additional incidents. Vehicle crashes or train derailments account for a relatively small share of the incidents—PHMSA's hazmat incident database shows 12 derailments, 60 highway vehicular crashes and 32 rollovers in 2023—although some of these may have major community impacts.

The above incidents do not include pipelines, which are reported separately to PHMSA. In 2023, the United States had about 229,000 miles of oil pipeline and 2,8 million miles of gas pipeline, according to PHMSA. Table 5-6 shows the severity of pipeline incidents from 2010 through 2023 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 [BTS n.d.].

Rail Tank Car Safety

The February 2023 derailment of a mixed freight train that included several tank cars carrying hazardous materials in East Palestine, OH, has drawn much continuing national attention. The train included two kinds of tank cars: several so called DOT-111 tank cars containing hazardous materials (one of which apparently was punctured in the derailment with its contents catching on fire) and 5 DOT-105 specification tank cars containing vinyl chloride, which were

17 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 2017–2023

Category	Mode	2010	2017	2018	2019	2020	2021	2022	2023
Reported incidents	**TOTAL**	**14,805**	**17,485**	**18,652**	**22,776**	**21,892**	**25,157**	**25,161**	**24,265**
	TOTAL number of vehicular accident/ derailment-related	**358**	**290**	**303**	**261**	**169**	**127**	**98**	**126**
	Percentage of vehicular accident/derailment-related incidents out of TOTAL reported incidents	**2.4**	**1.7**	**1.6**	**1.1**	**0.8**	**0.5**	**0.4**	**0.5**
Air	Overall	1,295	1,159	1,414	1,673	1,639	1,633	1,381	1,111
	Vehicular accident-related	2	15	5	10	4	2	2	1
Highway	Overall	12,658	15,744	16,754	20,684	19,879	23,122	23,407	22,815
	Vehicular accident-related	320	251	273	228	139	97	79	110
Rail	Overall	747	573	479	413	372	397	368	332
	Vehicular accident/ derailment-related	35	24	25	23	26	28	17	15
Water[1]	Overall	105	9	5	6	2	5	5	7
	Vehicular accident-related	1	0	0	0	0	0	0	0

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 July 2024.

Note: Incidents are defined in 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). 2021 and 2022 Highway and Rail data are revised.

[1] Water includes only packages (nonbulk) marine. Nonpackaged (bulk) marine hazardous material incidents are reported to the USCG and are not included.

not punctured and did not catch fire in the derailment, but did vent material through pressure relief equipment during the day following the derailment. 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. The National Transportation Board, in its final report on the incident, questioned the need for the controlled release and burning of the vinyl chloride, noting that the vinyl chloride venting from the pressure relief equipment in the DOT-105 tank cars had ceased in the day after the derailment [NTSB 2024c].

The rapid growth in crude oil shipments by freight rail was a surprising transportation trend in the second decade of this century. Rail shipments grew from 23.7 million barrels in 2010 to a peak of 382.0 million in 2014, before declining to a 2021 level (117.6 million barrels) that was still roughly 5 times that of 2010 [USDOE EIA n.d.]. 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 2016]. 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,[18] the Bureau of Transportation Statistics (BTS) assembles and collects data on rail tank cars

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

Table 5-6 All Reported Hazardous Liquid and Gas Pipeline Incidents: 2010–2023

Year	Number of incidents	Fatalities	Injuries	Property damage as reported (million dollars)	Barrels spilled (hazardous liquid)	Net barrels lost (hazardous liquid)
2010	577	22	108	1,690,381,009	100,558	49,452
2011	578	13	55	424,543,339	89,110	57,375
2012	559	12	57	226,900,033	45,885	29,248
2013	611	9	44	367,476,436	117,464	85,595
2014	694	19	94	269,474,404	48,383	22,155
2015	705	11	48	348,267,614	102,226	81,100
2016	629	16	88	375,919,587	86,135	46,221
2017	625	7	32	333,928,480	89,698	45,006
2018	625	7	78	2,174,416,388	108,300	70,600
2019	644	11	34	345,040,897	58,869	26,287
2020	559	15	37	278,804,437	156,110	105,558
2021	533	11	33	204,367,073	63,785	41,319
2022	466	3	20	875,114,190	81,483	30,457
2023	452	15	36	303,352,193	44,794	19,838

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 July 2024.

Note: 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 a Liquefied Natural Gas facility, and that results in one or more of the following consequences: ([illegible]) A death, or personal injury necessitating in-patient hospitalization; ([illegible]) 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 July 2024. Note that 2020, 2021, and 2022 data are revised.

transporting Class 3 flammable liquids[19] 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.[20]

In 2023, new and retrofitted DOT-117 rail tank cars grew to 67 percent (70,013 tank cars) of the entire fleet used to carry Class 3 flammable liquids, compared to 8 percent in 2016. Of these, 36,707 tank cars are new, and 31,306 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 [BTS 2024].

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 are sometimes hesitant to share potentially sensitive precursor safety information due to business and legal concerns. As a principal federal statistical agency, BTS has the authority to mitigate these concerns by administering data collection programs under the Confidential Information Protection and Statistical Efficiency Act (CIPSEA).[21] Under CIPSEA, BTS pledges data will be used only 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' 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 eleventh year in 2024.

- 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 and 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.

- SafeMTS (Safe Maritime Transportation System), administered by BTS and sponsored by the Maritime Administration (MARAD), provides a trusted, proactive means for the maritime industry to report information about near-miss events, enabling early identification of potential safety issues. In 2024, BTS and the Maritime Administration (MARAD) continued to build the program following completion of a pilot effort in 2023, including implementing processes related to data collection, processing, storage, and analysis. BTS and MARAD also worked to apply learnings from the pilot into the ASTM near-miss reporting standard for the maritime industry [BTS 2024].

Emerging Issues: A New Normal in Transportation

Highway Fatalities

Given recent increases in highway motor vehicle 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 rose steeply largely due to risky behaviors—speeding, distracted driving, drinking alcohol and drug use, and not wearing seatbelts—in the pandemic to over 40,000 each year in 2021, 2022 and 2023. While NHTSA projects a dip under 40,000 in 2024, it is not clear that the risky driving behaviors that propelled the increase during the pandemic has fully abated. If those risky behaviors continue further into the decade of the 2020s and beyond, new abatement strategies will be needed. Good data and research will be needed to track the future direction.

Good data will also be needed to evaluate specific safety strategies focused on reducing fatalities and injuries. For example, current research and development priorities to find ways to reduce deaths and injuries at highway intersections—

19 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.

20 DOT-117 (TC-117 in Canada): A nonpressurized 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.

21 Title □ of the Foundations for Evidence-Based Policymaking Act of 2018, Pub. L. 115-435 (reauthorizing 2002 E-Gov Act).

the location of 10,000 or more deaths per year—will require evaluation data as implementation projects are rolled out.

With U.S. highway fatalities rising, what explains the continued downward fatality trend in the EU, which in some metrics is broadly comparable to the United States? EU traffic fatalities rose slightly (3 percent) in 2023 but were still 10 percent below the prepandemic number in 2019, while U.S. deaths were an estimated 17 percent more. Comparative data will be critical to this evaluation, including whether different rates of adoption of advanced safety technology are part of the explanation.

Railroad Derailments

While the yearly average number of derailments has declined appreciably in recent decades, over 1,000 still occur each year—averaging two or three a day in the United States (including derailments in rail yards). As previously mentioned, several oil train derailments in the 2010–2015 period resulted in major disasters. The most destructive was the derailment of an oil train originating in the United States that derailed in a Canadian town that resulted in 47 deaths. More recently, the 2023 derailment of a freight train with a consist of both oil tanker cars and vinyl chloride cars in East Palestine, OH, required evacuations in nearby communities and focused greater public attention on hazardous materials transportation. Clean up costs and other costs could amount to more than 1 billion dollars [USEPA 2024]. In two separate incidents in 2022, Amtrak passenger trains derailed after colliding with highway vehicles resulting in several deaths. Commuter rail and transit rail derailments have also occurred. 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 2024c].

Data Gaps

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

- Fatal and serious-injury crashes involving pedestrians, pedal and battery powered cyclists, and other vulnerable road users are increasing. More data on these crashes are needed 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. Data on what happens at intersections—the location of 10,000 or more traffic fatalities per year—could help in focusing countermeasures.

- More granular data and comparative 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 and after 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. Another aspect to evaluate is the contrast in the weight of the respective passenger vehicle fleets among respective countries: U.S. passenger vehicles as a whole are much heavier and larger than passenger vehicles in Europe (and other advanced economy countries such as Japan).

- The data needed to evaluate the safety of advanced driving systems is only now being collected. There will be a continuing need for safety data from crashes (and crash precursors or close calls) involving advanced driver assistance technologies and automated driving systems as they are installed in new vehicles and to analyze resulting safety implications. Data collected from new initiatives, such as the vehicle-to-everything deployment plan referenced above, will need to be analyzed and disseminated to encourage others to deploy such innovations.

- 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 vehicle 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 vehicle 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 to develop this database.

- The 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.

- While large commercial air carriers have very few fatal accidents, the safety record for commuter airlines, air taxis, air tour operators, and other for-hire services regulated under Part 135 of Chapter 14 of the Federal code is much poorer. Examining over 550 fatal and nonfatal accidents involving these planes, the NTSB noted in July 2024 that currently available data are inadequate for safety trend analysis of the Part 135 operators, and recommended that DOT, through FAA or others, fill this gap either through mandating reporting or development of survey instruments to obtain the requisite data from Part 135 operators [NTSB 2024a].

References

American Automobile Association Foundation for Traffic Safety (AAA)

——2024. Traffic Safety Impact of the COVID-19 Pandemic: Fatal Crashes in 2020-2022. July 2024. Research Brief. Available at www.aaafoundation.org/ as of August 2024.

——2018. Prevalence of Drowsy Driving Crashes: Estimates from a Large-Scale Naturalistic Study (February 2018). Research Brief. Available at www.aaafoundation.org/.

AP NEWS. 2016. "A timeline of recent oil train in the US and Canada," AP NEWS. June 4, 2016. Available at https://apnews.com.

Bureau of Justice Statistics (BJS). 2022. Contacts Between Police and the Public, 2020. November 2022. Special Report NCJ 304527. Available at http://www.bjs.gov/.

Bureau of Labor Statistics (BLS). 2024. Census of 2022 Fatal Occupational Injuries (CFOI)—Current and Revised Data. Available at https://www.bls.gov/.

Bureau of Transportation Statistics (BTS)

——no date. National Transportation Statistics (NTS). Available at http://www.bts.gov/.

——2023. Safe Maritime Transportation System (SafeMTS): Report on the Pilot. 2023. Available at http://www.bts.gov/.

——2024. Progress Towards Safer Rail Tank Cars transporting Flammable Liquids: 2024 Report. Available at www.bts.gov.

Centers for Disease Control and Prevention (CDC)

——no date a. "End of the Federal COVID-19 Public Health Emergency (PHE) Declaration." Available at https://www.cdc.gov/coronavirus/2019-ncov/your-health/end-of-phe.html.

——no date b. WISQAR (Web-based Injury Statistics Query and Reporting System).

——no date c. SC: Sobriety Checkpoints (Motor Vehicle Prioritizing Interventions and Cost Calculator for States). Available at https://www.cdc.gov/.

Cosgrove, L. 2007. Historical Perspective of Motorcycle Helmet Laws. May 2007. National Highway Traffic Safety Administration. Available at http://www.nhtsa.gov/.

Embry-Riddle Aeronautical University. 2023. *Study Offers Objective Insights to Near Miss Collisions between Drones, Airplanes*. Available at https://news.erau.edu/.

European Union (EU). 2024. "2023 Figures Show Stalling Progress in Reducing Road Fatalities in Too Many Countries." Directorate-General for Mobility and Transport. Available at https://transport.ec.europa.eu/.

Federal Aviation Administration (FAA)

——no date. Fly Safe: Prevent Loss of Control Accidents. Available at www.faa.gov.

——2024. FAA refers more unruly passenger cases to the FBI. August 21, 2024. Press release. Available at www.faa.gov.

Federal Bureau of Investigation (FBI). no date. Crime in the United States Annual Reports (online). Available at http://www.fbi.gov/.

Federal Highway Administration (FHWA)

——no date. Weather: How do Weather Events Impact Roads? FHWA Road Weather Management, Available at www.fhwa.dot.gov/.

——2024. The 2022 National Household Travel Survey: Summary of Travel Trends. Available at https://nhts.ornl.gov.

Federal Motor Carrier Safety Administration (FMCSA)

——2024. FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model (CIEM), Version 1.3 Report for FY 2020 Interventions. February 2024. Available at https://ai.fmcsa.dot.gov/.

——2023a. Large Truck and Bus Crash Facts 2021 (November 2023). Printable version. Available at www.fmcsa.dot.gov/.

——2023b. 2023 Pocket Guide to Large Truck and Bus Statistics (December 2023). Available at www.fmcsa.dot.gov/.

Federal Railroad Administration (FRA). no date. Office of Safety Analysis Web Site and AIP Statistics. Available at https://safetydata.fra.dot.gov.

Governors Highway Safety Association (GHSA)

——no date. Alcohol-impaired driving. Available at GHSA.org.

——2018. Drug-Impaired Driving: Marijuana and Opioids Raise Critical Issues for States (May 2018). Available at www.ghsa.org.

Insurance Institute for Highway Safety (IIHS). no date. Fatality Statistics (Online). Available at http://www.iihs.org.

Kahane, C. J. 2015. Lives saved by vehicle safety technologies and associated Federal Motor Vehicle Safety Standards, 1960 to 2012 (January 2015). Report No. DOT HS 812 069. Washington, DC: National Highway Traffic Safety Administration. Available at http://www.nhtsa.gov/.

Marcus, J. H., and M. S. Rosekind. 2017. "Fatigue in transportation: NTSB investigations and safety recommendations," *Injury Prevention 23*(4). Available at https://pubmed.ncbi.nlm.nih.gov/26929259/.

Masten, S. V., F. D. Thomas, K. T. Korbelak, R. C. Peck, and R. D. Blomberg. 2015. *Meta-analysis of graduated driver licensing laws*, Report No. DOT HS 812 211. Available at https://rosap.ntl.bts.gov/.

Mineta Transportation Institute (Mineta)

——2023. Learning About Street Harassment on Transit: A Survey Instrument for Transit Agencies. December 2023. Report 2301. Mineta Transportation Institute: College of Business at San Jose State University. Available at https://transweb.sjsu.edu/.

——2020.Crime and Harassment on Public Transportation: A Survey of SJSU Students Set In International Context. Available at https://transweb.sjsu.edu/.

——2019. How and Where Should I Ride This Thing? "Rules of The Road" for Personal Transportation Devices. May 2019. Available at https://transweb.sjsu.edu/.

National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS)

——2024. ASRS Database Report Set NMAC Incidents. May 2024. Available at https://asrs.arc.nasa.gov/docs/rpsts/nmac.pdf.

——2021. Presentation of Becky Hooey, October 20, 2021. Available at https://ntrs.nasa.gov/citations/20210014592.

National Safety Council (NSC). no date. Injury Facts. Motor Vehicle Safety Issues: Work Zones. Available at www.sc.org.

National Highway Traffic Safety Administration (NHTSA)

——no date a. Traffic Safety Facts: Annual Report Tables. Available at www.nhtsa.gov/.

——no date b. Standing General Order on Crash Reporting for Incidents involving ADS and Level 2 ADS. Available at www.nhtsa.gov/.

——no date c. Fatality and Injury Reporting System Tool (FIRST). Available at www.nhtsa.gov/.

——2024a. Overview of Motor Vehicle Crashes in 2022. DOT HS 813 560. June 2024 (Revised). Available at www.nhtsa.gov/.

——2024b. Early Estimate of Motor Vehicle Traffic Fatalities for the First Half (January-June) of 2024. DOT HS 813 633. September 2024. Available at www.nhtsa.gov/.

——2024c. Motorcycles: 2022 Data. July 2024. DOT HS 813 589. Available at www.nhtsa.gov/.

——2024d. Non-Traffic Surveillance: Fatality and Injury Statistics in Non-Traffic Crashes in 2021. DOT HS 813 539. April 2024. Available at www.nhtsa.gov/.

——2024e. Rural/Urban Traffic Fatalities. DOT HS 813 599. July 2024. Available at www.nhtsa.gov/.

——2024f. Speeding: 2022 Data. July 2024. DOT HS 813 582. Available at www.nhtsa.gov/.

——2024g. Alcohol-Impaired Driving: 2022 Data. August 2024 (Revised). DOT HS 813 578. Available at www.nhtsa.gov/.

——2024h. Distracted driving in 2022. April 2024. DOT HS 813 559. Available at www.nhtsa.gov/.

——2024i. Occupant Protection in Passenger Vehicles. DOT HS 813 573. May 2024. Available at www.nhtsa.gov/.

——2024j. Occupant Restraint Use in 2022— November 2023. DOT HS 813 523. Available at www.nhtsa.dot.gov/.

——2024k. Bicyclists and Other Cyclists: 2022 Data. July 2024. HS 813 591. Available at www.nhtsa.gov/.

——2023. Motorcycle Helmet Use in 2022—Overall Results. DOT HS 813 466. August 2023. Available at www.nhtsa.gov/.

——2022. Summary Report: Standing General Order on Crash Reporting for Automated Driving Systems. DOT HS 813 325. June 2022. Available at www.nhtsa.gov/.

——2019. Lives Saved in 2017 by Restraint Use and Minimum Drinking-Age Laws. DOT HS 812 683. March 2019. Available at www.nhtsa.gov/.

——2012. A Fresh Look at Driver Education in the United States. April 2012. DOT HS 811 543. Available at www.nhtsa.dot.gov/.

——2007. Analysis of Fatal Motor Vehicle Traffic Crashes and Fatalities at Intersections, 1997 to 2004. DOT HS 810 682. February 2007. Available at www.nhtsa.gov/.

National Institutes of Health (NIH), National Institute on Alcohol Abuse and Alcoholism (NIAAA). no date. Alcohol Policy Information System 9. Available at https://alcoholpolicy.niaaa.nih.gov/.

National Transportation Safety Board (NTSB)

——no date a. Letter from the Chair to U.S. DOT Docket Management Facility, Docket Number NHTSA 2021-0002. May 24, 2022. Available at https://NTSB.gov.

——no date b. Accidents, Fatalities, and Rates, 2020 Statistics. Spreadsheet. Available at https://NTSB.gov.

——2024a. Safety and Industry Data Improvement for Part 135 Operations. July 24, 2024. Aviation Investigation Report AIR-24-03. Available at https://NTSB.gov.

——2024b. Contact of the Containership Dali with the Francis Scott Key Bridge and Subsequent Bridge Collapse. May 14, 2024. Marine Investigation Preliminary Report. Available at https://NTSB.gov.

——2024c. Norfolk Southern Railway Train Derailment with Subsequent Hazardous Materials Release: East Palestine, Ohio, February 3, 2023. June 25, 2024. Railroad Investigative Report RIR-24-05. Available at https://NTSB.gov.

Pipeline and Hazardous Materials Administration (PHMSA). no date. Pipeline Data Portal All Significant Incidents. Available at www.phmsa.dot.gov/.

Scott, L. R., S. Bazargan-Hejazi, A. Shirazi, D. Pan, S. Lee, S. A. Teruya, and M. Shaheen. 2019. "Helmet use and bicycle-related trauma injury outcomes," *Brain Injury 33*(13-14). Available at https://doi.org/10.1080/02699052.2019.1650201.

Skybrary. no date. Inadvertent VFR flight into IMC. Available at http://skybrary.org/.

U.S. Coast Guard (USCG). 2024. Recreational Boating Statistics 2023. May 2024. Available at www.uscgboating.org/.

U.S. Consumer Products Safety Commission (CPSC)

——2023. Micromobility Products-Related Deaths, Injuries, and Hazard Patterns: 2017–2022. Available at cpsc.gov.

——2022. CPSC Calls on Manufacturers to Comply with Safety Standards for Battery Powered Products to Reduce the Risk of Injury and Death. Press Release December 22, 2022. Available at cpsc.gov.

U.S. Department of Energy (USDOE), Energy Information Administration (EIA). no date. Crude Oil Movements by Rail. Available at https://www.eia.gov/.

U.S. Department of Transportation (USDOT). no date. Cruise Line Incident Reports. Available at https://www.transportation.gov/.

U.S. Environmental Protection Agency (USEPA). 2024. United States Reaches Over $310 Million Settlement with Norfolk Southern to Address Harms Caused by East Palestine Train Derailment. May 23, 2024. News Release. Available at www.epa.gov.

U.S. General Accountability Office (USGAO)

——2024. Aviation Safety Federal Efforts to Address Unauthorized Drone Flights Near Airports. March 2024. GAO-24-107195. Available at www.gao.gov/.

——2003. Highway Safety Factors Contributing to Traffic Crashes and NHTSA's Efforts to Address Them. Testimony Before the Subcommittee on Competition, Foreign Commerce, and Infrastructure, Committee on Commerce, Science, and Transportation, U.S. Senate. May 22, 2003. Available at www.gao.gov/.

Urban Institute. 2023. Assaults on Transit Workers Have Tripled in the Last 15 Years. Income Inequality and Social Tensions Have Contributed. Urban Wire. November 2023. Available at www.urban.org.

CHAPTER 6

ENERGY AND SUSTAINABILITY

The U.S. transportation system is the world's largest, producing 5.8 trillion passenger miles of travel and carrying 5.4 trillion ton-miles of freight in 2022 [BTS 2024d, 2024e]. Such massive movements of people and goods required an enormous amount of energy, 27.9 quadrillion (10^{15}) Btu in 2023 [BTS 2024f]. Worldwide, transportation has begun a transition from fossil energy to more sustainable sources of energy.

Although there are many perspectives on sustainability, the U.S. Government has defined it as follows:

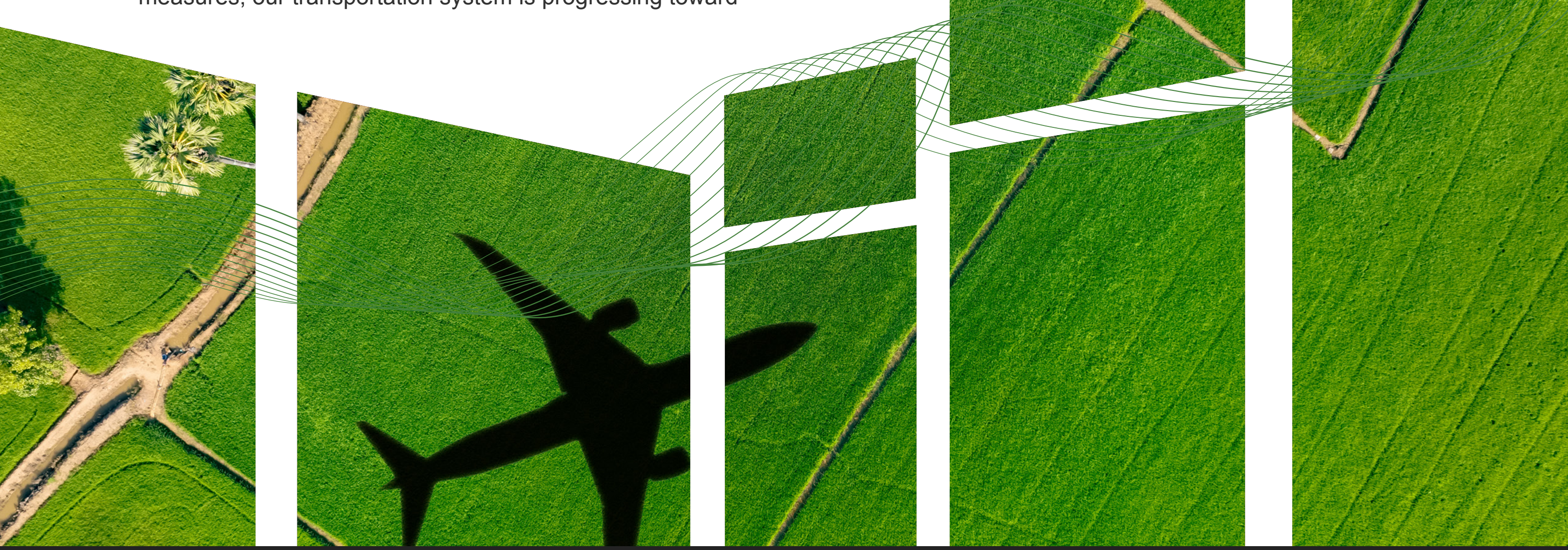
> To pursue sustainability is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations [USEPA 2024a].

Measuring progress toward sustainable transportation is challenging, yet it clearly implies maintaining or improving environmental quality while expanding, recycling, or at least not depleting the natural resources and the social and economic systems that support and are served by our transportation system. Human behavior, economics, public policy and technological change all play crucial roles in the pursuit of sustainability. Transitioning to a sustainable transportation system is a complex and novel challenge, and decision making must be informed by accurate measures of its progress and effects.

This chapter presents data on the patterns and trends in transportation's energy use and their implications for the sustainability of our transportation system. By many measures, our transportation system is progressing toward sustainability: maintaining energy security while decreasing energy use per passenger and ton-mile, reducing pollution harmful to human health, increasing material recycling, reducing pollution of waterways and groundwater, and embarking on a large-scale transition from fossil fuels to electricity and renewable energy. However, our transportation system today is still predominantly reliant on petroleum for energy and continues to be the largest source of carbon dioxide (CO_2) emissions in our economy.

Energy Use Patterns and Trends

The 27.9 quadrillion Btu (quads) of energy use by transportation in 2023 places it second to only electric power generation (32.1 quads) in total energy use among sectors of the U.S. economy (Figure 6-1). Only three nations' entire economies used more energy than our transportation system did in 2023: China, India, and the



HIGHLIGHTS

Transportation has continued to make progress toward sustainable energy, as sales of battery electric, plug-in hybrid, and hybrid electric vehicles increased to 16.9 percent of passenger car and light truck sales in 2023 and to 18 percent in the first 6 months of 2024 and transit ridership and electric bus fleets grew.

New fuel economy and greenhouse gas (GHG) emission standards were finalized and will require continued improvement in energy efficiency and reduce the GHG emissions of new highway vehicles by 50 percent by 2032.

Public charging infrastructure to support a transition to electric vehicles increased to more than 69,000 stations across the United States by mid-2024, of which more than 10,000 were fast chargers.

As a result of increased domestic petroleum production, improved energy efficiency, and greater use of alternative energy, the United States continues to be a net exporter of petroleum and is no longer dependent on petroleum imports.

Although transportation remains dependent on petroleum for 88.8 percent of its energy, transportation's petroleum dependence in 2023 was the lowest in more than 70 years.

The U.S. transportation system continues to reduce its negative environmental impacts by reducing emissions of air pollutants, limiting spills and leakage of petroleum into fresh water and groundwater, and increasing recycling of vehicles and infrastructure.

Transportation vehicles and infrastructure are actively recycled. An estimated 95 percent of motor vehicles and 85 percent of their content are recycled. Of the 441.9 million tons of asphalt pavement laid in 2022, 104.8 million tons were recycled asphalt.

Fuel economy improvements have saved consumers $6.5 trillion dollars since 1975.

Because of fuel economy improvements, U.S. oil consumption was 5 million barrels per day lower in 2022.

Seventy percent of U.S. petroleum consumption has been by transportation since 2000. However, in 2023 the United States was the world's largest petroleum producer at 20.6 million barrels per day.

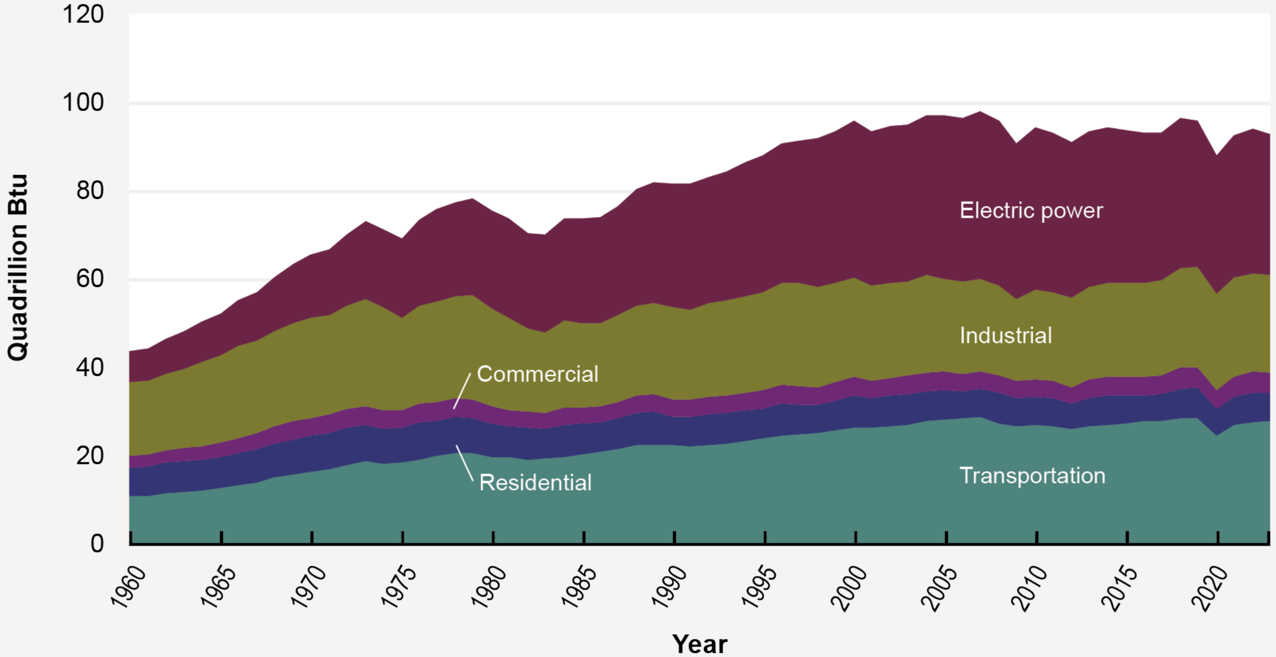
Transportation continues to be the largest emitter of GHG emissions in the United States and accounted for 30 percent of total U.S. carbon dioxide emissions in 2023.

Russian Federation [EI 2024]. While energy use by the rest of the U.S. economy decreased by 3.3 percent from 2000 to 2023, transportation's energy use increased by 5.6 percent. The increase since 2000 masks significant improvements in energy efficiency. For example, total highway vehicle travel increased by 18.8 percent over the same period [FHWA 2023]. Transportation's energy use fell by 14.7 percent in 2020 from 2000 due to the COVID-19 pandemic and has yet to return to the 2019 level of 28.6 quads (Figure 6-1).

Highway vehicles accounted for the great majority of transportation's energy use in 2022: 83.8 percent (Figure 6-2). The distribution of energy use by mode has changed only a little since 2019. The shock of the COVID-19 pandemic caused aircraft energy use to drop precipitously. Consequently, its share fell from 7.3 percent in 2019 to 5.3 percent in 2020 and 6.6 percent in 2021 but recovered to 7.4 percent in 2022. Conversely, the share of energy used by freight hauling truck tractor-trailers increased from 13.5 percent in 2019 to 15.7 percent in 2020 and returned to 13.7 percent in 2022. While the pandemic reduced energy use by other modes, energy use by truck tractors increased in 2020 and 2021 but decreased in 2022.

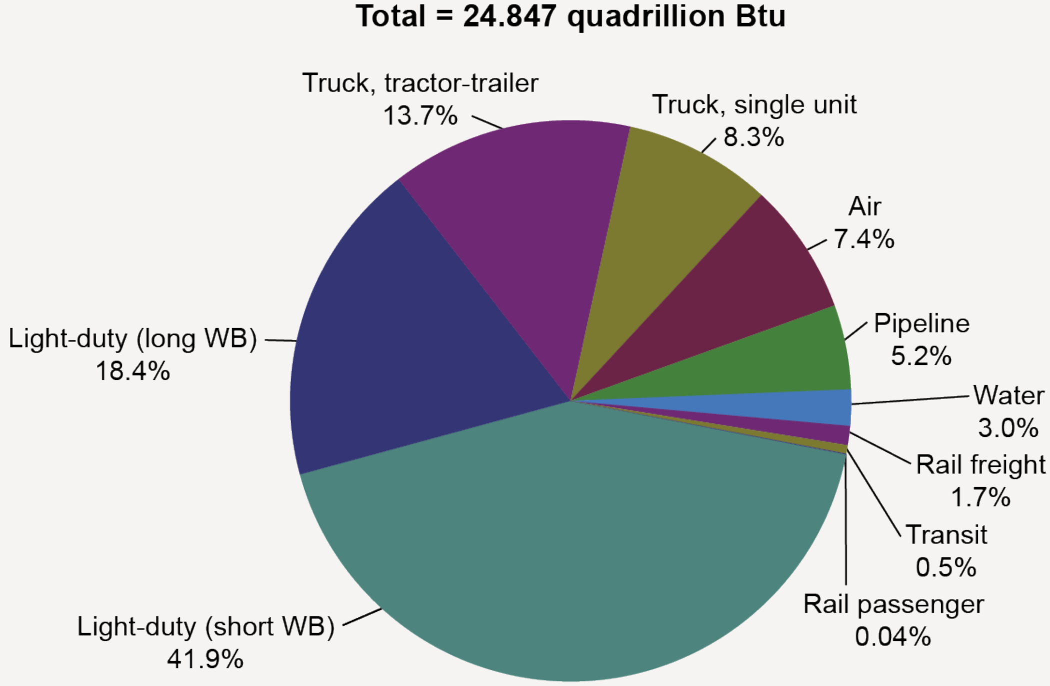
Since the first half of the 20th century when U.S. transportation transitioned from animal power and external combustion steam engines fueled by coal to internal combustion vehicles powered by petroleum, our transportation system has relied on petroleum fuels for energy (Figure 6-3). Coal-powered steam engines died out by 1960, initiating a period of petroleum dependence that has lasted for over half a century. Since 1950, relatively small amounts of electricity have powered transit and intercity passenger rail and somewhat larger amounts of natural gas have powered the pumps of natural gas pipelines, augmented in recent decades by modest amounts of natural gas use by trucks and buses. Blending of biomass fuels with gasoline and diesel increased from 1.2 percent in 2005 to supply 6.4 percent of transportation's energy in 2023. While not shown in Figure 6-3, electricity use by motor vehicles is growing rapidly, albeit from a very small base (refer to Figure 6-13). Estimates by the U.S. Energy Information Administration indicate that electricity use by plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) exceeded energy use by rail transit vehicles for the first time in 2023 [EIA 2024b]. Adding electric vehicle (EV) energy use to Figure 6-3 would more than double electricity use.

Figure 6-1 U.S. Consumption of Energy From Primary Sources by Sector: 1960–2023



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 August 2024.

Figure 6-2 Transportation Energy Use by Mode: 2022



Source: U.S. Department of Transportation, Federal Aviation Administration, Federal Highway Administration, and Federal Transit Administration; U.S. Department of Energy, Nationnal 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 August 2024.

Note: The following conversion rates were used: jet fuel = 135,000 Btu/gallon; aviation gasoline = 120,200 Btu/gallon; automotive gasoline = 125,000 Btu/gallon; diesel motor fuel = 138,700 Btu/gallon; compressed natural gas = 138,700 Btu/gallon; distillate fuel = 138,700 Btu/gallon; residual fuel = 149,700 Btu/gallon; natural gas = 1,031 Btu/ft^3; electricity 1kWh = 3,412 Btu, negating electrical system losses. To include approximate electrical system losses, multiply this conversion factor by 3.

WB = wheelbase.

Energy Security

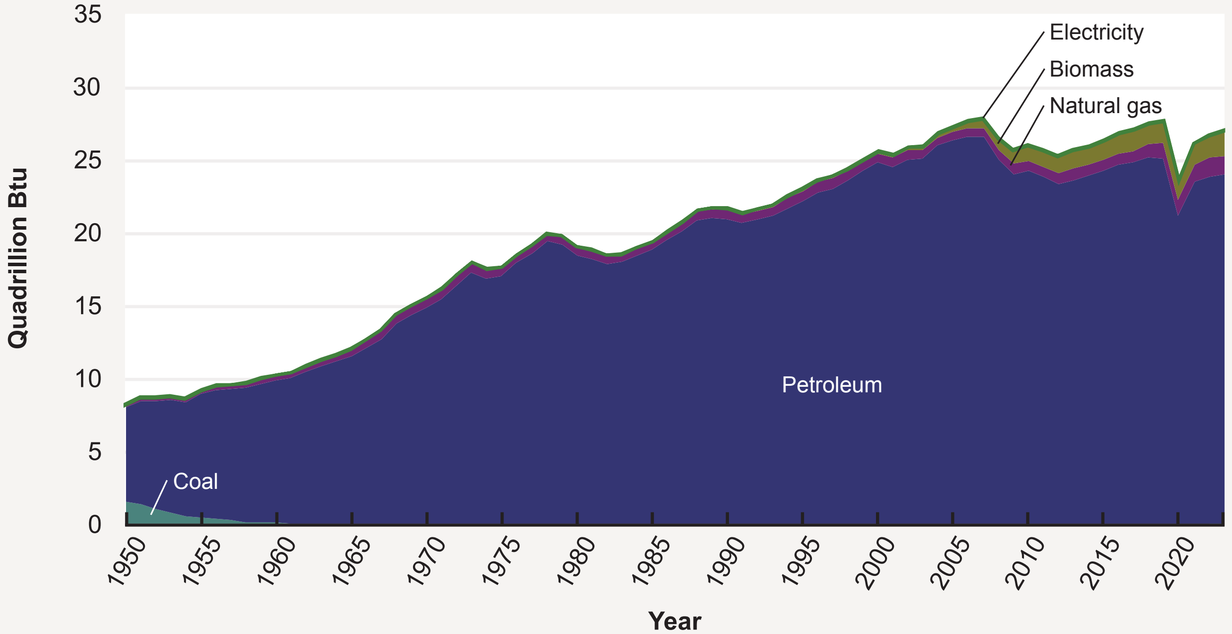
Reliance on Petroleum and Energy Security

Transportation remains the dominant user of petroleum in the U.S. economy, accounting for 70.1 percent of U.S. petroleum use in 2023 (Figure 6-4). Transportation's share of U.S. petroleum demand increased sharply as electric power generation shifted from petroleum toward coal and natural gas following the oil price shocks of the 1970s and early 1980s. From the mid-1980s to 2000, transportation's share trended gradually upward as residential and commercial buildings moved from oil to natural gas and electrical heating. Since 2000, transportation has accounted for approximately 70 percent of U.S. petroleum consumption.

Transportation continues to be predominantly dependent on petroleum, the source of 88.7 percent of the energy it used in 2023 (Figure 6-4). As high as that percentage is, it is nonetheless the lowest level of petroleum dependence in more than 70 years and continues a declining trend that began after 2005 [EIA 2024a]. Over the last two decades, increased blending of biofuel with gasoline and diesel has displaced the most petroleum, with electricity and sustainable aviation fuel (SAF) beginning to have an impact in recent years.

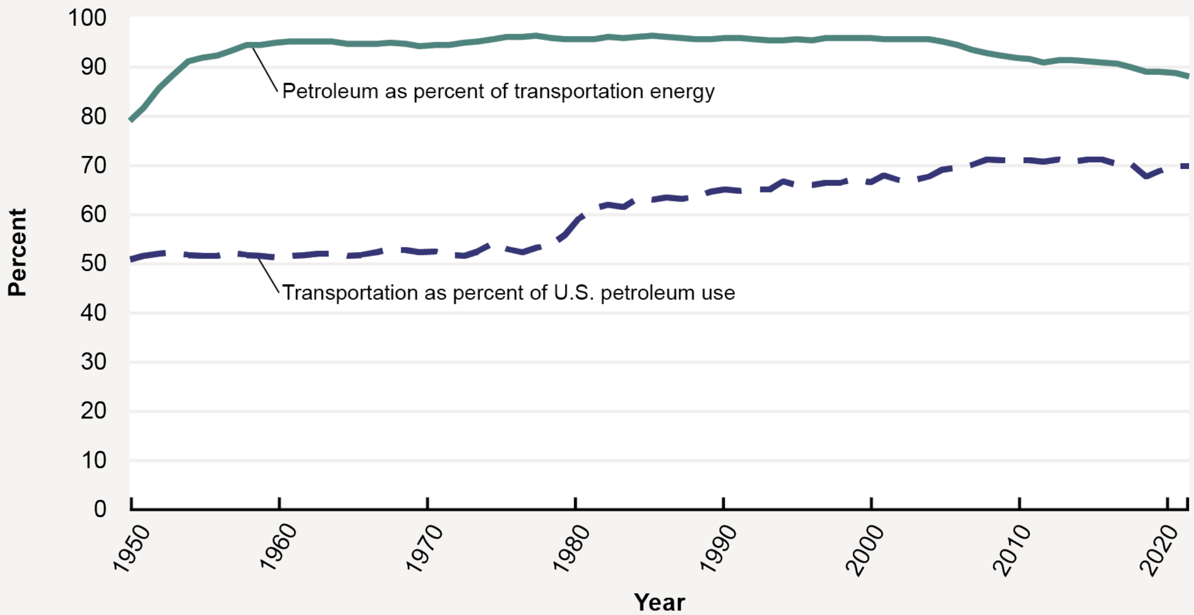
Transportation's dependence on petroleum makes the economy vulnerable to oil price shocks that can be caused by unforeseen events or the use of market power by major oil producers. However, the United States is no longer dependent on petroleum imports. Since 2020, domestic petroleum supply has exceeded U.S. demand, with net exports reaching 1.7 million barrels per day (mmbd) in 2023 (Figure 6-5). Increased domestic supply has been the biggest factor in achieving independence from petroleum imports. U.S. petroleum supply (including liquids co-produced with natural gas) increased from 8.8 mmbd in 2010 to 20.6 mmbd in 2023, making the United States the world's largest oil producer [EIA 2024a]. Increased crude oil production from tight oil formations (fracking) accounted for 8.3 mmbd of U.S. oil supply in 2023 [EIA 2024g]. Increased production of natural gas plant liquids, which are counted

Figure 6-3 Transportation Energy Use by Fuel Type: 1950–2023



Source: U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, table 2.5, available at www.eia.gov/ as of August 2024.

Figure 6-4 Transportation and U.S. Petroleum Dependence: 1950–2023



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 August 2024.

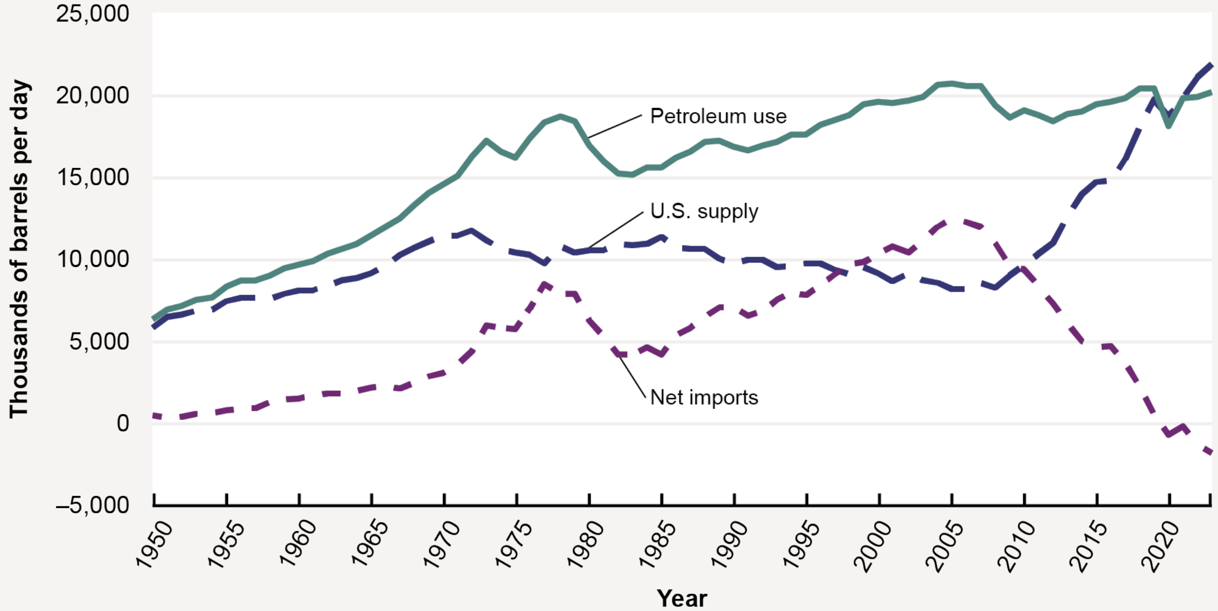
as petroleum supply, from fracking tight gas formations increased by 4.4 mmbd from 2010 to 2023 [EIA 2024h]. U.S. petroleum use decreased suddenly with the onset of the Great Recession of 2007–2009. However, as the economy recovered, petroleum use did not return to pre-recession levels due to increased energy efficiency and substitution of other energy sources. Improved fuel economy of cars, light and heavy trucks, and aircraft played a major role in restraining the growth of petroleum demand. Had the fuel economy of U.S. passenger cars and light trucks remained constant at 1975 levels, U.S. petroleum use would be approximately 5 mmbd higher than it is today [USDOT 2022; Greene, Sims, Muratori 2020]. Increased use of biofuels was also a factor, as explained in the subsequent section on alternative fuels. The combination of increased domestic petroleum supply and restrained growth of petroleum demand caused net imports to decline sharply and made the United States a net exporter of petroleum in 2020 for the first time in over 70 years.

Critical Minerals: Emerging Energy Security Concern

Since the oil embargo by Arab members of the Organization of Petroleum Exporting Countries (OPEC) cartel in 1973–1974 and the subsequent oil price shock, U.S. energy security has been chiefly concerned with dependence on petroleum and petroleum imports. Although the transportation system remains dependent on petroleum fuels, the United States is now the world's largest petroleum producer and a net exporter of petroleum. In the future, the transition to electric transportation and renewable electricity generation appears likely to redefine energy security in terms of the supply of critical minerals essential for batteries, electric motors, and electricity generation and transmission. Large-scale and rapid transition to EVs and low-carbon electricity will require many times the world's current production of critical minerals and rare earth elements [IEA 2021]. According to the U.S. Department of Energy (DOE), achieving current goals for EVs and battery production may require a ten-fold increase in domestic supply of graphite, cobalt, nickel, and lithium to ensure a secure transition [USDOE 2024a].

The concentration of oil supply in a small number of OPEC nations gave that cartel the power to influence world oil supply and oil prices. Today, there is concern about the concentration of 80 percent of the world's capacity to mine and process critical minerals like lithium, graphite, and rare earth elements in China [Johnson, Jacobs 2024]. The circumstances differ for each critical mineral, but in general, the problems are not lack of global resources but the concentration of current resource production and processing in a few countries. China currently has dominant positions in the supply of processed graphite (92 percent), rare earth elements (87 percent), cobalt (72 percent), lithium (58 percent) and gallium (98 percent). Mining of rare earths (70 percent), gallium and graphite is also concentrated in China, while the Democratic Republic of the Congo mining leads in cobalt mining. World resources of critical minerals and rare earths are more widely distributed, so the problem

Figure 6-5 U.S. Petroleum Use, Domestic Supply, and Net Imports: 1950–2023



Source: U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, table 3.1, available at www.eia.gov/ as of August 2024.

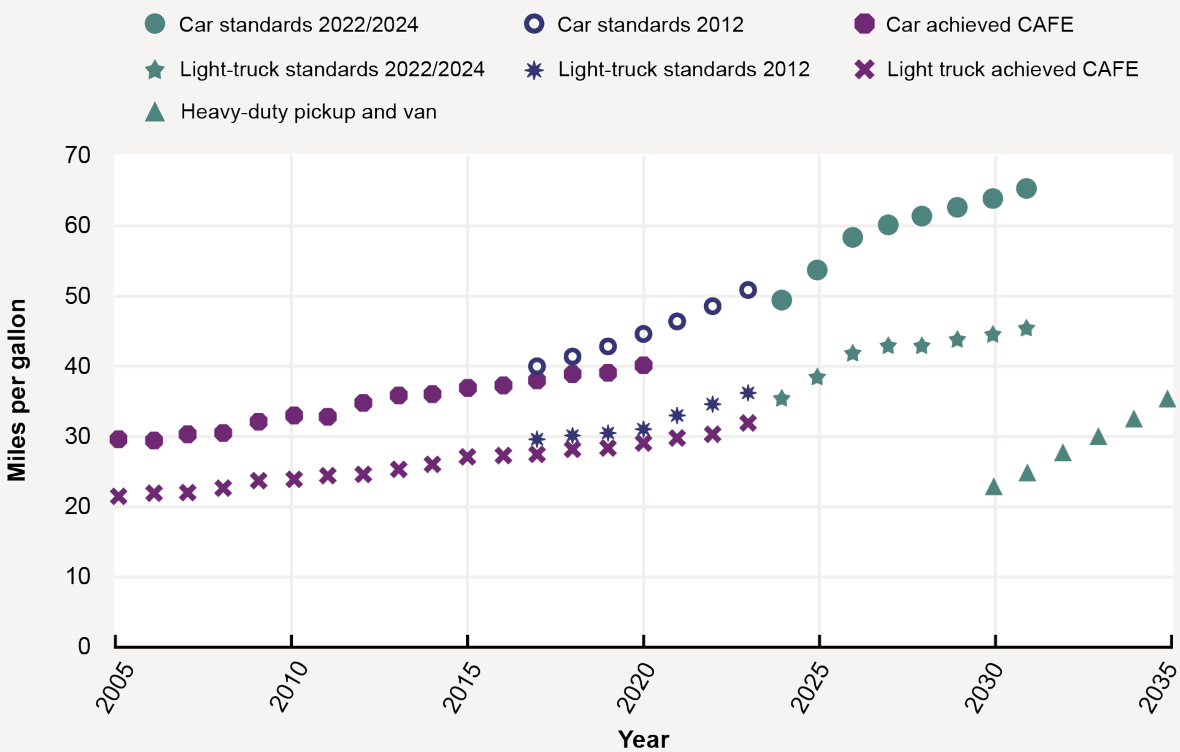
is chiefly one of rapidly expanding supply while at the same time diversifying sources and increasing domestic production. To accomplish this, the U.S. Government has begun investing $55 billion via loans to expand domestic mining and processing of graphite, lithium carbonate, and other materials for EV batteries and motors [USDOE 2024a]. At the same time, battery and motor research and development is exploring alternatives to the critical minerals described previously. For example, lithium iron phosphate (LFP) EV batteries do not require nickel, manganese, or cobalt (NMC) and are cheaper than NMC lithium batteries. However, LFP batteries have somewhat lower energy density. In the first 6 months of 2023, 66 percent of China's EV battery production consisted of LFP batteries and only 34 percent was NMC [Pan, Li, Ju 2024]. While tracking the evolution of critical mineral and rare earth markets and their effects on U.S. energy security will be a complex challenge, this work is essential to ensuring a secure and efficient transition to electrified transportation.

Energy Efficiency

Light-Duty Vehicles and CAFE Rule

In 2024, the National Highway Traffic Safety Administration finalized new fuel economy standards for passenger cars, light trucks, and heavy-duty pickups and vans for model years 2027 and later [NHTSA 2024]. The new regulations build on a history of passenger car and light-truck standards dating back to the passage of the Corporate Average Fuel Economy (CAFE) law in 1975 and first standards set in 1978 when new passenger cars averaged 19.9 miles per gallon (MPG) on federal tests and 16.9 in actual use, and new light trucks averaged 15.3 and 12.9 MPG, respectively [USEPA 2024b]. In 2023, new cars averaged 46.1 MPG on the federal test and 34.9 MPG on the road, while light trucks achieved 31.4 MPG on the test and 24.0 MPG in use. Together with CAFE standards finalized in 2022, the new standards call for a 29 percent increase in passenger MPG and a 26 percent increase in light truck MPG by 2031 [NHTSA 2012, 2022,

Figure 6-6 CAFE and Achieved MPG for Passenger Cars, Light Trucks, and Heavy-Duty Pickups and Vans



Source: Environmental Protection Agency, 2024, *2023 Automotive Trends Report*, available at https://www.epa.gov/automotive-trends/explore-automotive-trends-data as of November 2024. National Highway Traffic Safety Administration (NHTSA), 2024, "Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027 and Beyond and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030 and Beyond," *Federal Register, 89*(121), 52540–52954. NHTSA, 2022, "Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks," *Federal Register, 87*(84), 25731–26092. NHTSA, 2012, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," *Federal Register, 77*(199), 62624–63200.

2024]. The MPG levels required in 2031 by the new standards are more than twice the achieved in 2005 (Figure 6-6). (The achieved levels shown in Figure 6-6 are from U.S. Environmental Protection Agency [EPA] estimates based on detailed test cycle MPG estimates and numbers of vehicles produced and do not include various credits earned by manufacturers or other compliance flexibility provisions of the CAFE law, such as credit trading.)

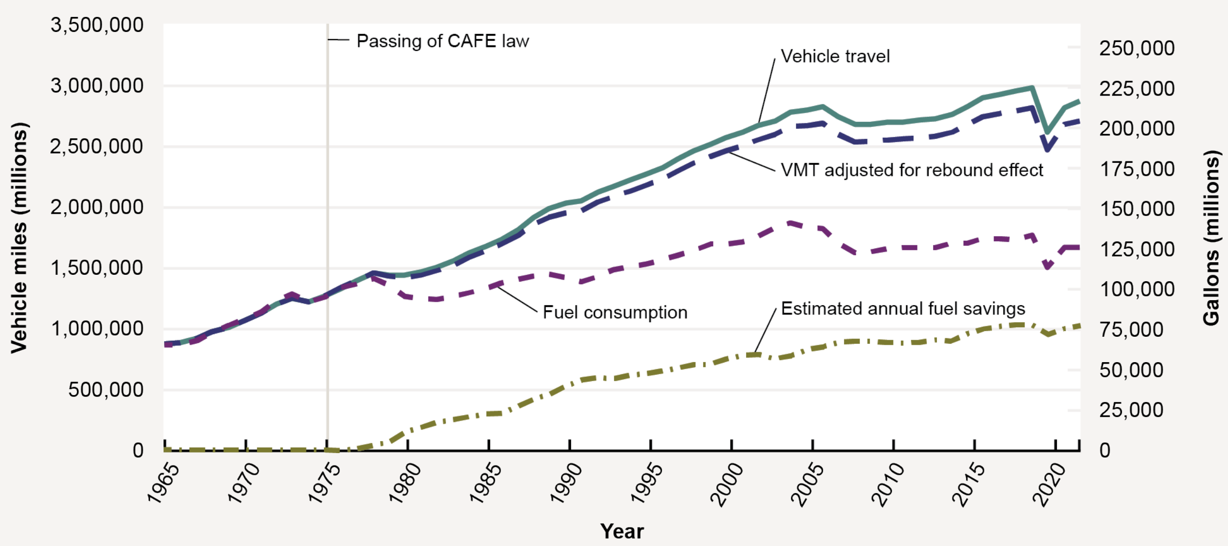
Fuel economy improvements to light-duty vehicles since the CAFE law was passed in 1975 are estimated to reduce fuel use, exceeding 2.2 trillion gallons of gasoline as of the end of 2022 (Figure 6-7), which is enough gasoline to fuel all the passenger cars and light trucks in the United States for the past 17 years. The estimated total savings to motorists since 1975 amount to over $6.5 trillion (2022 dollars). The petroleum savings in calendar year 2022 alone amounted to 5 mmbd. The reduction in car and light truck gasoline use, together with the 10 mmbd of increased domestic petroleum production, has freed the U.S. economy from dependence on imported petroleum. The estimates account for the tendency of vehicle use to increase when fuel economy is increased (the "VMT Adjusted for Rebound Effect" line shows how much lower VMT would have been without fuel economy improvements), the increase in real income due to cost-effective fuel economy improvements, and the effect of reduced U.S. petroleum demand on world oil prices [Greene, Sims, Muratori 2020].

Comparing the Energy Efficiencies of EV and Gasoline Vehicles

In March 2024, the DOE finalized a rule specifying how electricity used by EVs should be converted to equivalent petroleum fuel consumption [USDOE 2024b]. The Petroleum Equivalency Factor (PEF) established by the DOE is required for the enforcement of fuel economy standards, but it is also a rigorous method for comparing the energy efficiencies of EVs and internal combustion engine vehicles that could be used to estimate how much motor fuel tax should be paid by EVs. While EPA greenhouse gas (GHG) standards consider BEVs to have zero emissions and therefore omit any GHG emissions from the production of electricity, the PEF incorporates upstream energy used to produce electricity.

The CAFE law prohibits DOT from considering the fuel economy of BEVs (or the fuel economy of PHEVs when running in all-electric mode) when setting fuel economy standards. However, BEV fuel economy does count when determining whether manufacturers are complying with CAFE standards. This requires assigning MPG estimates to the electricity use of BEVs and PHEVs. By law, the DOE must specify a PEF, several Watt-hour/gallon, to be divided by an EV's EPA test-cycle electricity use in Watt-hour/mile to estimate the MPG of EVs. In establishing the PEF, DOE must consider (1) the electrical energy efficiency of the vehicle, its mission, and weight, (2) national average electrical generation and transmission efficiencies, (3) the need of the

Figure 6-7 Miles of Travel and Fuel Use by Light-Duty Vehicles: 1965–2022



Source: Greene et al., 2020, Updated spreadsheet provided by authors, 10/25/2024. VMT and fuel consumption data from U.S. Department of Transportaton, Federal Highway Administration, *Highway Statistics*, annual issues, Table VM-1.

Note: VMT Adjusted for Rebound Effect shows how much lower VMT would have been without fuel economy improvments. Corporate Average Fuel Economy (CAFE) law was passed by Congress in 1975 as part of the Energy Policy and Conservation Act.

VMT = vehicle-miles traveled.

Nation to conserve energy and the scarcity of fuels used to generate electricity and, (4) the patterns of EV use relative to petroleum-fueled vehicles.

The intent of the PEF method is to include the energy used to generate and transmit electricity in calculating EV fuel economy, in proportion to the amount of upstream energy used to produce, refine and deliver petroleum fuels. Because the gasoline delivered to the tank of a conventional vehicle constitutes 83 percent of the energy content of the gasoline plus upstream energy use to transport and refine it, the PEF counts 83 percent of the energy content of the electricity delivered to the EV plus the energy used to generate and transmit electricity. Designing the PEF raised questions about how to measure renewable energy used to produce electricity, the rapidly changing mix of energy sources used to generate electricity and whether to continue counting only 15 percent of the energy used by dedicated alternative fuel vehicles in estimating their fuel economy. The DOE determined that renewable energy sources were not scarce in the same way as fossil fuels, and that their production and generation efficiency should be set at 100 percent (i.e., primary energy use equals electricity produced). For nuclear energy, the energy used to produce fissile fuel was included, but generation efficiency was assumed to be 100 percent. Future PEF factors were estimated based on a projection of the future fuels mix for electricity generation [NREL 2022], and the PEF for a vehicle sold in a particular model year was based on a survival- and mileage-weighted average of the annual PEF values over its expected lifetime. The DOE decided to phase out the 15 percent alternative fuel factor so that 100 percent of the energy would be counted by the 2030 model year.

If EVs are to become truly zero-emission by 2050, electricity generation must also become net zero emission. As the transitions of vehicles and electricity generation proceed, measuring the sustainability of transportation will increasingly require measuring the sustainability of electricity generation. Since 2010, the mix of fuels used to generate electricity has been changing rapidly. Electricity production has moved away from coal (from 44.8 percent of energy use in 2010 to 16.2 percent in 2023) toward natural gas (23.9 to 43.1 percent) and renewable solar and wind power (2.3 to 14.1 combined percent) (Table 6-1). Consequently, CO_2 emissions from electricity generation in 2023 fell by 37.5 percent relative to 2010, reaching levels not seen since the late 1970s [EIA 2024a]. The PEF rule anticipates continued rapid change in the mix of energy sources used to generate electricity through 2032, as shown in the column labeled PEF 2032 in Table 6-1. Coal and natural gas shares are projected to shrink to 3 percent and 19 percent, respectively, with renewable solar and wind increasing to 53 combined percent. Because of the new PEF rule, a midsize EV sport utility vehicle (SUV) rated at 30 kWh per 100 miles sold in 2024, would be given a petroleum equivalent MPG rating of (82,049 Watt-hour/gallon) ÷ (300 Watt-hour/mile) = 292.3 MPG. In 2030, an EV rated at 30 kWh per 100 miles would be assigned a fuel economy of (28,996 Watt-hour/gallon) ÷ (300 Watt-hour/mile) = 96.6 MPG, a very respectable level of fuel economy but only one-third of the 2024 MPG. The most important reason for the decrease in MPG from 2024 to 2032 is counting 100 percent of the electricity use rather than only 15 percent, followed by the change in the energy sources used to generate electricity shown in column PEF 2032.

Table 6-1 Electricity Generation by Energy Source: 2010 vs. 2023

	Billion kWh		Percentage		
Energy source	**2010**	**2023**	**2010**	**2023**	**PEF 2032**
TOTAL	**4,125**	**4,178**	**100**	**100**	**100**
Coal	1,847	675	44.8	16.2	3.0
Petroleum	37	16	0.9	0.4	0.0
Natural gas	988	1,802	23.9	43.1	19.0
Nuclear	807	775	19.6	18.6	16.0
Hydropower	260	240	6.3	5.7	7.0
Solar	1	165	0.0	3.9	25.0
Wind	95	425	2.3	10.2	28.0
Other	90	79	2.2	1.9	2.0

Source: U.S. Department of Energy, Energy Information Administration, Monthly Energy Review September 2024, table 7.2a, available at https://www.eia.gov/totalenergy/data/monthly/ as of October 2024. National Renewable Energy Laboratory, 2022. *2022 Standard Scenarios Report: A U.S. Electricity Sector Outlook*, available at https://www.nrel.gov/docs/fy23osti/84327.pdf.

kWh = kilowatt hour; PEF = petroleum equivalency factor.

Medium and Heavy-Duty Vehicle Efficiency

Recently published estimates from the 2021 Vehicle Inventory and Use Survey (VIUS) of U.S. trucks provide new information on truck energy efficiency and trends (Table 6-2) [BTS 2024g]. Light trucks for personal use (pickups, SUVs, and light vans) show a trend of gradually increasing fuel economy from 2005 to 2022, similar to the estimates for new light trucks in Figure 6-6. This is expected because the definitions of light truck in Figure 6-6 and pickups, SUVs, and vans in Table 6-2 are similar, though not identical. Similar trucks in commercial use have somewhat lower fuel economy but also show increasing fuel economy over the past two decades. Medium and heavy truck fuel economy estimates show no trend of increasing fuel economy. Many factors affect the average estimates, including the weight of vehicles and their payloads, body types, duty cycles and trends in horsepower. More detailed analysis of the VIUS data is necessary to understand the factors driving these trends.

Table 6-2 Estimated Fuel Economy of Trucks by Type and Use: 1999–2022

Model year	Pickups, SUVs, and Vans: personal use	Pickups, SUVs, and vans: commercial use	Medium and heavy trucks: commercial use
Prior model years	16.5	15.1	8.0
1999	16.0	14.4	8.5
2000	16.7	15.8	8.3
2001	17.1	14.6	8.6
2002	16.6	14.2	8.8
2003	17.1	15.9	9.1
2004	16.7	15.5	8.5
2005	17.8	16.5	8.5
2006	17.9	15.5	8.7
2007	18.8	16.2	8.0
2008	18.2	16.9	8.5
2009	18.4	17.5	7.9
2010	18.8	16.9	8.4
2011	19.5	17.0	8.9
2012	19.4	16.0	8.7
2013	19.9	19.2	7.6
2014	20.5	18.7	8.3
2015	21.1	17.6	8.5
2016	21.4	19.2	8.4
2017	21.9	18.3	8.4
2018	21.5	18.3	9.1
2019	22.2	21.7	8.7
2020	23.6	21.1	8.6
2021–2022	24.9	20.8	7.7

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 2021 VIUS, available at https://www.bts.gov/vius.

Note: Numbers are based on simple averages of MPG estimates, are not weighted by vehicle miles traveled, and do not accurately measure average MPG for all vehicles.

MPG = miles per gallon.

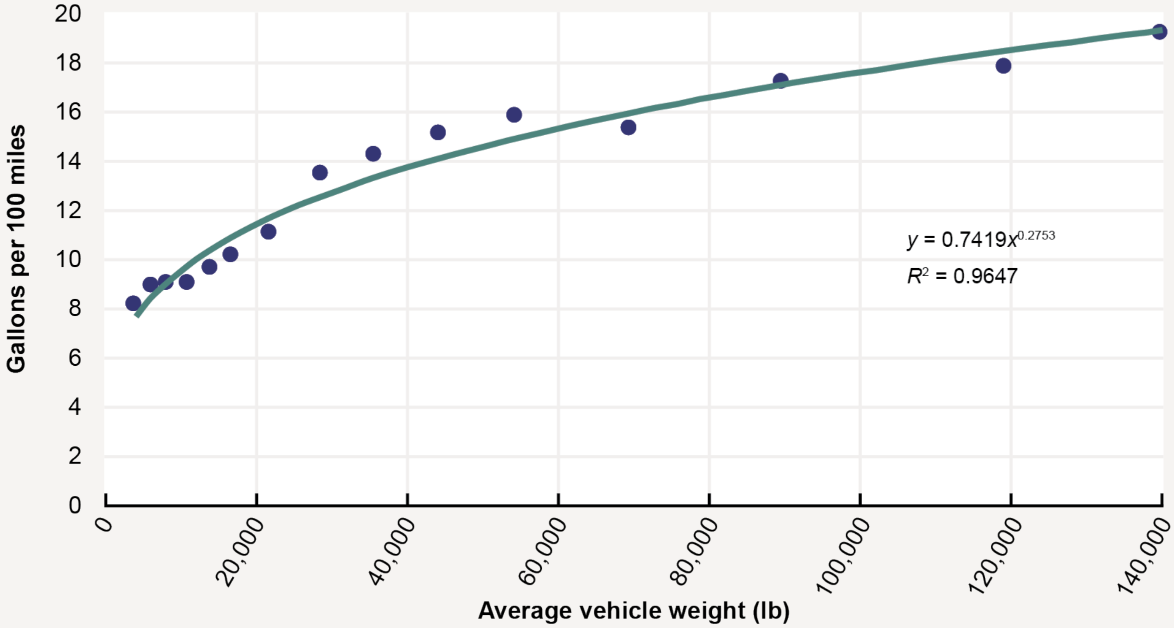
Medium and heavy truck fuel consumption is strongly correlated with vehicle weight due to the physics of accelerating mass and the effects of vehicle size and weight on aerodynamic drag and tire friction. The VIUS MPG estimates indicate that fuel consumption per mile increases at a decreasing rate with increasing average vehicle operating weight (vehicle weight plus payload). The VIUS data displayed in Figure 6-8 imply that every 10 percent increase in average weight increases fuel consumption per mile by about 2.75 percent, indicating increasing energy efficiency per ton-mile with increasing truck weight. That is, larger trucks with greater payload capacity use less energy per ton-mile than smaller trucks with smaller capacities. More detailed analysis of the VIUS data is necessary to understand how range of operation, truck configuration, and duty cycles affect this relationship.

Air and Rail Efficiency

The energy intensity of air passenger travel returned to pre-COVID-19 levels in 2023 after spiking during the pandemic (Figure 6-9). Combined international and domestic passenger miles traveled by air fell by 64 percent in 2020 versus 2019, while combined aircraft miles decreased by only 40 percent, and average seat occupancy rates dropped by 31 percent. Domestic and international air travel in 2021 stood at 35 percent below the 2019 level but was only 10 percent lower in 2022 and recovered to 1.6 percent higher in 2023. The return-to-normal operations also brought energy intensities almost entirely back in line with the long-term trend. Technological improvements to airframes, jet engines and aircraft control systems are expected to reduce the energy intensity of passenger air travel by more than 10 percent by 2050 [FAA 2023a]. Improvements to the air transportation system operations through communications, navigation, surveillance, automation, and information management saved an estimated $1.6 billion in fuel costs between 2010 and 2022, with additional savings achievable through future system improvements [FAA 2023b].

The energy intensity of rail freight increased by 0.8 percent in 2022 but remained 4.4 percent below the pre-COVID-19-pandemic level in 2019 [BTS 2024b, table 4-25]. Ton-miles carried were nearly identical to 2021 levels, but tons per car-mile increased by 2.6 percent while energy use per car-mile increased by only 1.0 percent. Further improvements in rail freight energy efficiency can be achieved in the near term by increased use of stop-start systems to reduce

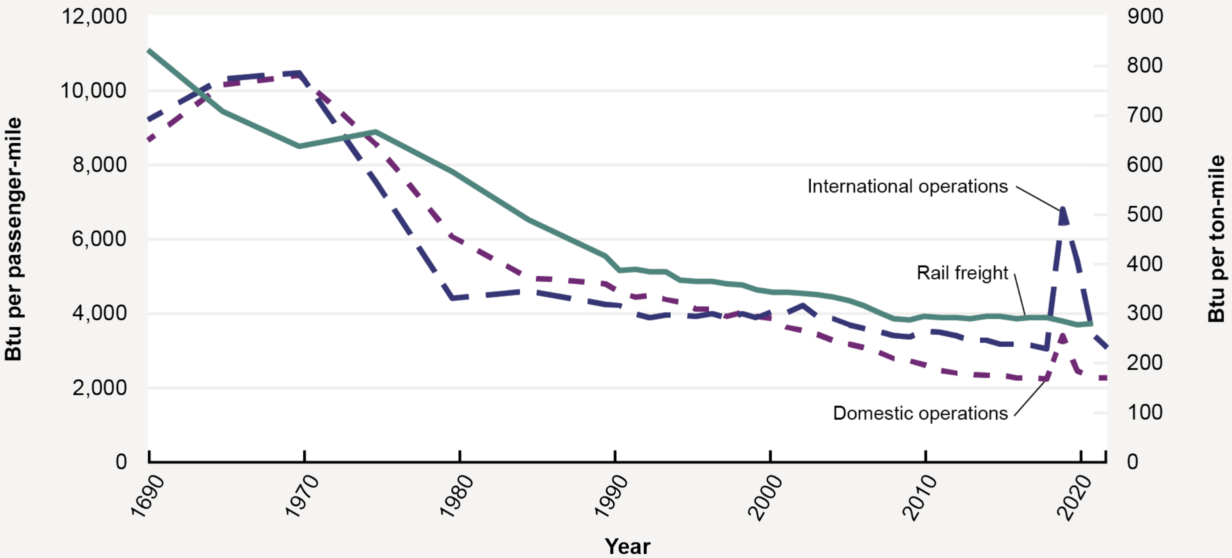
Figure 6-8 Commercial Truck Fuel Consumption by Average Weight



Source: U.S. Bureau of Transportation Statistics, 2021 Vehicle Inventory and Use Survey, VIUS PUF Tabulation Tool, available at https://data.bts.gov/stories/s/VIUS-PUF-Draft/mc6b-y96m/.

Note: Data excludes pickups, SUVs, and light vans. "Average vehicle weight" is the average operating weight, which is vehicle weight plus payload.

Figure 6-9 Energy Intensity of Certificated Air Carriers and Rail Freight Services: 1960–2023



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 2024. *National Transportation Statistics*, tables 4-21 and 4-25.

Note: Air carreirs include all services, Class I rail freight.

idling, advanced fuel management, and distributing power by strategically positioning locomotives throughout the train and GHG emissions can be lowered by increased use of biodiesel and renewable diesel [Association of American Railroads 2024]. Hybrid diesel-electric locomotives that could reduce energy intensity by 10 percent or more are being tested. In the future, all-electric or hydrogen fuel cell powered locomotives would further reduce energy intensity and could eliminate locomotive GHG emissions when paired with renewable electricity [Aredah et al. 2024].

Transition to Clean Fuels and Vehicles

Electric Vehicle Sales and Market Trends

A global transition to EVs is in progress. The number of new electric automobiles sold worldwide in 2023 rose to 13.8 million, a 35 percent increase over the 10.2 million sold in 2022, amounting to 18 percent of total world auto sales [IEA 2024]. In China, one-third of all new automobiles sold were EVs in 2023. In the United States—the third largest EV market—the 1.44 million BEVs and PHEVs sold were 9.3 percent of the 15.5 million new vehicles sold in 2023 [Manzi 2023]. In California, one in four (24.9 percent) new cars and light trucks sold in the first 6 months of 2024 was a BEV or PHEV [CEC 2024], the highest market share in the United States. BEVs predominated, however, with an 85.1 percent share of the California EV market.

Sales of HEVs, PHEVs, and BEVs reached a combined 16.9 percent share of the U.S. light-duty vehicle market in 2023 and 18 percent in the first 6 months in 2024 (Figure 6-10). Although HEVs obtain all their energy from gasoline, they make substantial use of electric motors to synergistically improve fuel economy by about 50 percent [NHTSA 2024] and can be a bridging technology for introducing consumers to electric drive. Globally, BEVs constituted 68.8 percent of EV sales; PHEVs constituted the remaining 31.2 percent. The BEV share has been increasing relative to PHEVs in all three major markets: China, the European Union, and the United States. In China and the European Union, the first and second largest markets, BEVs made up two-thirds of EV sales. In the United States, BEVs were 78.6 percent of EV sales in 2023 [IEA 2024].

Although EV sales have grown rapidly, the U.S. vehicle stock evolves slowly, and EVs still make up a very small portion of it. At the end of 2023, there were approximately 3.3 million EVs on U.S. roads, a 65 percent increase over 2 million in 2022, which was 54 percent higher than the 1.3 million in 2021 [Edmunds 2024a]. Yet, EVs are only approximately 1.2 percent of the estimated 283 million highway vehicles in operation on U.S. roads [BTS 2022].

Charging Infrastructure to Support the EV Transition

A market share of 9.3 percent of new vehicle sales places EVs in the middle of the “Early Adopter” phase of the classic model of innovation diffusion [Rogers 1962]. At 16.9 percent, the combined market share of HEVs, PHEVs and BEVs has crossed into the “Early Majority” market segment. Members of the Early Majority differ from Early Adopters in that while they are willing to change, they want concrete evidence that the innovation works and will succeed. A key component of that evidence is a recharging infrastructure that is available and dependable.

BOX 6-A

BEVS, PHEVS, EVS, PEVS, AND HEVS

BEV: Battery Electric **V**ehicles, also called all-electric vehicles, obtain all their energy from a battery that is charged by plugging the vehicle into an electrical outlet or charging equipment. These vehicles always operate in all-electric mode.

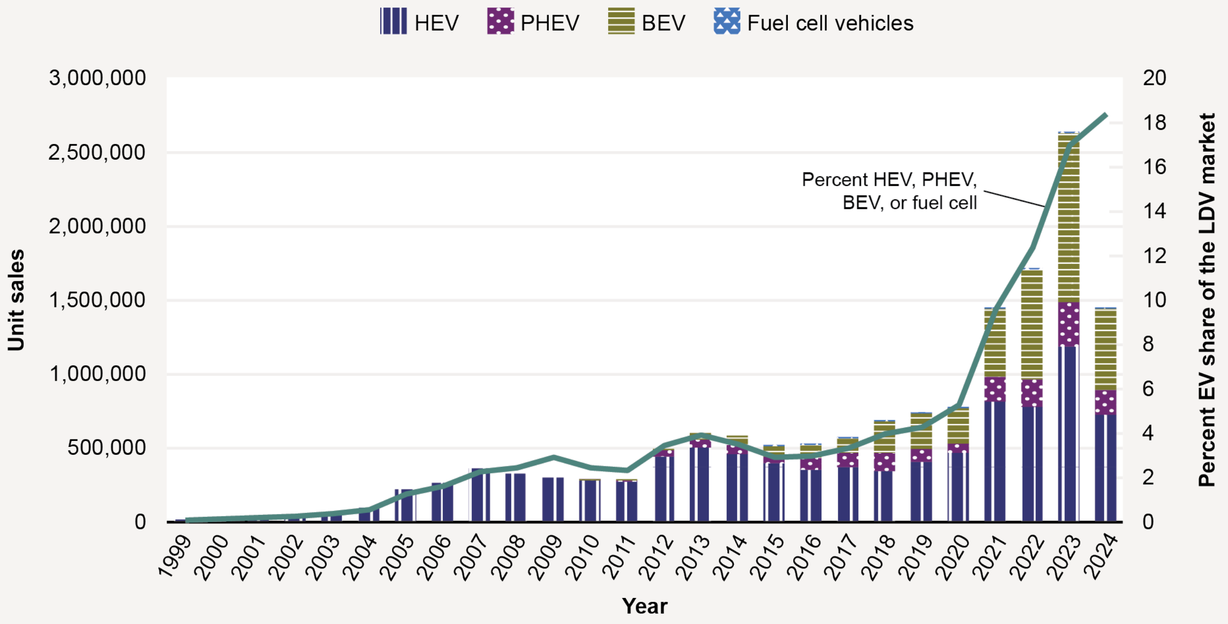
PHEV: Plug-in **H**ybrid **E**lectric **V**ehicles are powered by an internal combustion engine and an electric motor that uses energy stored in a battery. PHEVs can operate in all-electric (or charge-depleting) mode or in internal combustion engine (charge-sustaining) mode. To enable operation in all-electric mode, PHEVs require a larger battery than an HEV, which can be plugged in to an electric power source to charge.

EV: Electric **V**ehicles, typically refers to BEVs and PHEVs.

PEV: Plug-in **E**lectric **V**ehicle, also refers to BEVs and PHEVs, because both can obtain electricity by plugging in.

HEV: Hybrid **E**lectric **V**ehicles are powered by an internal combustion engine and one or more electric motors that uses energy stored in a battery. All the energy to propel the HEV ultimately comes from the gasoline used to operate the internal combustion engine, and the battery is charged through regenerative braking, not by plugging in.

Figure 6-10 Sales of Hybrid, Plug-In Hybrid, and Battery EVs: 1999–June 2024



Source: Argonne National Laboratory, Electric Drive Vehicle Sales, available at www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates as of June 30, 2024.

Figure 6-11 Intercity Fast Charging Corridors: Completed and Pending Mid-Year 2023

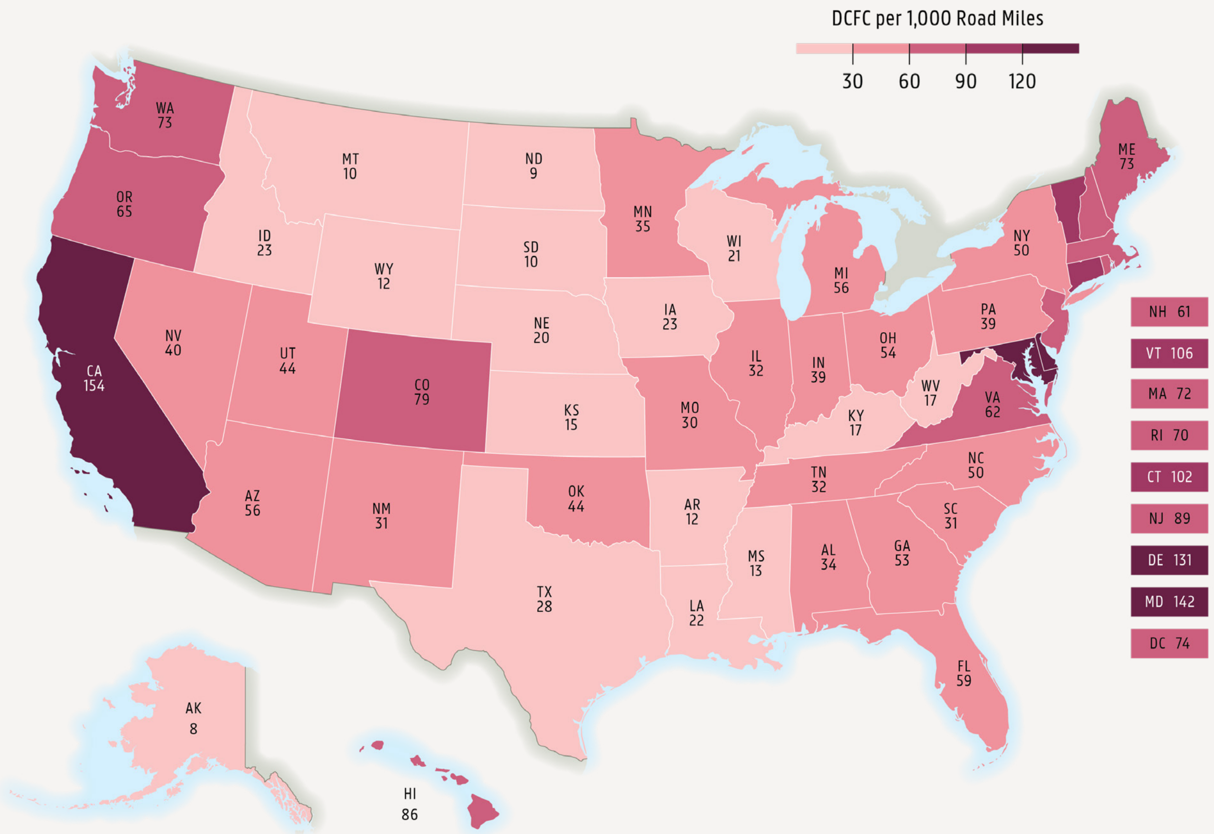
Source: Alternative Fuels Data Center, "Alternative Fueling Station Locator," as of November 2024. Map data © MapTiler, © OpenStreetMap contributors. Available at https://afdc.energy.gov/stations#/corridors?show_corridor_stations=false.

Note: A "Pending Corridor" is a proposed intercity fast charing corridor as of mid-year 2023.

EV charging infrastructure is growing rapidly. The experience of charging an EV differs from gasoline refueling in important ways, especially in the time required and the option to charge at home rather than at a public station. Because transitioning road transportation to electrification presents novel challenges for public policy, the Departments of Transportation and Energy created the Joint Office of Energy and Transportation to coordinate and provide technical and financial support to state and local governmental and private sector agencies deploying charging infrastructure [JOET 2023]. Created pursuant to the Bipartisan Infrastructure Law of 2021, the Joint Office supports the National Electric Vehicle Infrastructure program that provides $5 billion to assist states in creating a nationwide EV fast charging network of stations no more than 50 miles apart. Many major intercity routes already meet the 50-mile requirement, and plans are in place for a nearly complete nationwide network (Figure 6-11). Additionally, the Joint Office provides guidance and technical assistance to $2.5 billion in grants to communities deploying EV charging stations and other clean fuel infrastructure, $5 billion in support for low and no-emission transit buses, and $5 billion in support for electric school bus deployments.

In addition to supporting intercity travel, fast chargers are especially useful for households that lack home-based charging or whenever EV drivers need a quick recharge. Slower level 2 public chargers enable EV owners to “top-up” when they park for an extended period of time, such as at work, or while shopping or dining out. The availability of all types of EV chargers has been increasing rapidly. In mid-2023, there were 55,829 public charging stations with 2–3 ports (plugs) per station in the United States, of which 7,908 were Direct Current fast charging stations with a total of 33,375 ports. As of mid-August 2024, there were 69,436 public charging stations with 195,522 ports, of which 10,842 were fast chargers with 44,714 charging ports, a 37.1 percent increase in the number of fast-charging stations and a 34.0 percent increase in the number of ports [USDOE 2024c]. Of the fast-charging stations, 6,623 are “ultra-fast” charging stations with power levels between 50 and 150 kW, capable of charging a 300 mile range EV to 80 percent of capacity in about 30 minutes. Another 4,328 are hyper-fast chargers with over 150 kW of power, of which 1,741 are rated at over 350 kW. At present, the availability of public chargers varies widely across states. Figure 6-12 shows the number of Direct Current Fast Chargers per 1,000 roadway miles by state.

Figure 6-12 Fast Chargers per 1,000 Roadway Miles by State: Mid-Year 2024



Source: U.S. Department of Energy, Alternative Fuels Data Center, Electric Vehicle Charging Station Locations. U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, table HM-30, available at http://www.fhwa.dot.gov/policyinformation/statistics.cfm as of October 2024.

Fast chargers charge at their maximum rate up to about 80 percent of battery capacity. At that point they slow down to avoid reducing battery life. A 150 kW fast charger can charge an EV with a 65 kWh battery (maximum of 250–300 miles of range for a mid-size EV) from 20 percent to 80 percent of the battery's capacity in 15 to 20 minutes. A 350 kW fast charger can to the same in about 10 minutes. However, not all EVs can accept the highest charging rates. A test of model year 2022–2024 EVs found that the average charging power that could be utilized by 50 EV models ranged from 96 kW to 223 kW, and the average time to add 100 miles of range (a function of vehicle size and charging power) ranged from 7 minutes for a mid-size sedan to almost 19 minutes for a full-size pickup truck [Edmunds 2024b].

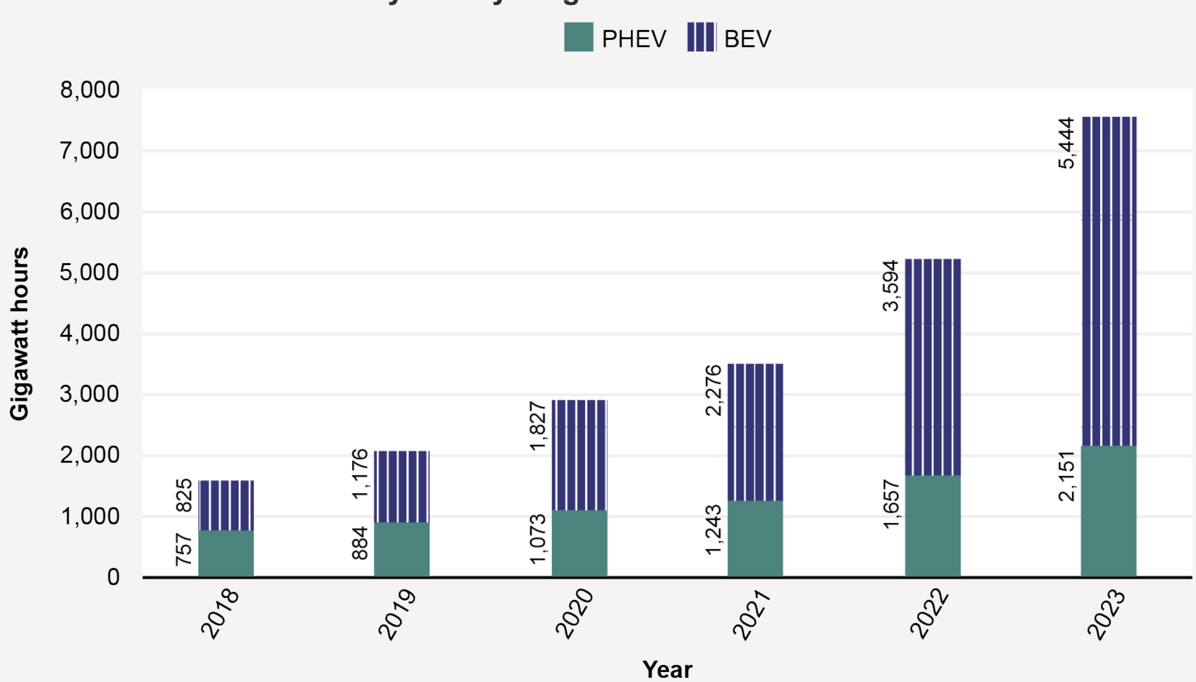
Another important difference between refueling conventional vehicles and charging EVs is that most EV owners do the majority of their charging at home. A survey of 7,979 EV and PHEV owners in California found that only 14 percent relied entirely on public or workplace charging; only 3 percent exclusively relied on public charging, while 53 percent charged only at home [Lee et al. 2020]. A recent survey of North American EV owners found that 86.0 percent had access to home charging and 96.3 percent used home charging at least a few times a week [Chargelab 2024]. Most (59.6 percent) also used public charging at least once a week. The convenience and typically lower cost of home charging makes having an EV an attractive option [Borlaug et al. 2020]. How much charging EV owners do at home will affect the number, types, and locations the public charging network requires as well as their business models.

Electricity use by EVs is increasing rapidly yet it is still a very small fraction of transportation's total energy use. The EIA's estimates through May, 2024 show a 48.4 percent increase over the same period in 2023 [EIA 2024c, Table D.1]. The estimated 7.6 gigawatt-hours of use by BEVs and PHEVs shown in Figure 6-13 equals 0.026 quads of direct electricity use and 0.063 quads of primary energy use including upstream generation and transmission losses. While this exceeds the 0.056 quads of electricity use by transit shown in Figure 6-2, it is less than one-half of 1 percent of total transportation energy use.

Alternative Gaseous and Liquid Fuels

Ethanol blended with gasoline at 10 percent by volume (E10) continues to be the largest source of renewable energy for U.S. transportation (Figure 6-14). The 1,127 trillion Btu of fuel ethanol consumed in 2023 constituted 63.0 percent of transportation's biofuel use. Because nearly every gallon of gasoline sold in the United States contains 10 percent ethanol, ethanol consumption increased by 1.4 percent from 2022 to 2023, in step with the 1.5 percent increase in gasoline consumption [EIA 2024e]. Use of biodiesel and renewable diesel, chiefly by medium and heavy-duty highway

Figure 6-13 Estimated Electricity Use by Plug-In Vehicles: 2018–2023



Source: Energy Information Administration, *Electric Power Monthly*, *May*, 2024c, Table D.1.
Note: The estimates are direct electricity consumption by EVs and do not include generation or transmission losses.

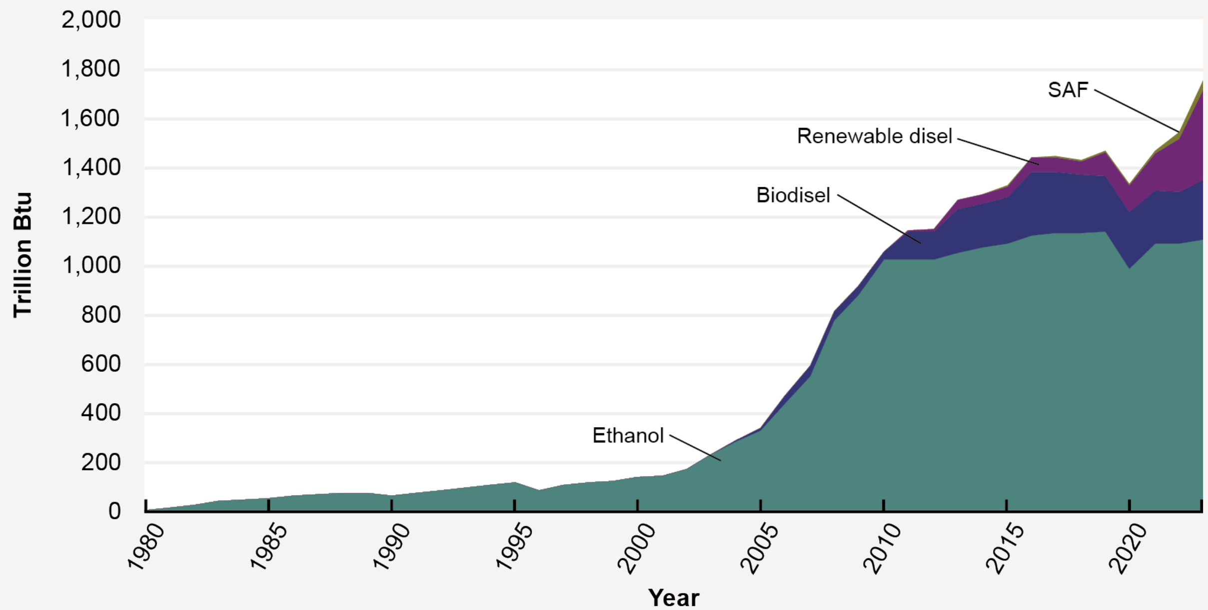
vehicles, increased by 42.7 percent in 2023, and made up 34.8 percent of transportation biofuel use in 2023. Biodiesel is primarily fatty acid methyl esters, derived from vegetable oils and animal fats and blended with petroleum diesel in concentrations of 2 to 20 percent by volume. Renewable diesel can be produced from a variety of biomass feedstocks, is processed to be chemically similar to petroleum diesel and can therefore be blended in a wider range of concentrations. The great majority of renewable diesel is used in California to achieve compliance with the state's Low Carbon Fuels Standards [USDOE 2024d].

The fastest growing renewable transportation fuel, albeit from a much smaller quantity in 2022, is SAF. SAF use increased by 47.0 percent in 2023, after almost tripling from 2021–2022. SAF is produced from agricultural and waste feedstocks as a replacement for petroleum jet fuel. Announced expansions of SAF production are expected to increase U.S. production from 19,000 barrels per day in 2023 to over 50,000 barrels per day in 2025 [EIA 2024f]. U.S. jet fuel consumption in 2023 was 1.6 mmbd, indicating there is a long way to go to meet a White House target of 100 percent SAF use in aviation by 2050 [White House 2021].

Use of propane and natural gas by transportation in 2023 changed little from 2022. By far the greatest use of natural gas is as fuel for the pumps that power natural gas pipelines: 1.266 quads in 2023, an increase of 0.7 percent over 2022 [BTS 2024c]. Increased U.S. natural gas exports induced an increase in use of liquefied natural gas in shipping, from 27 trillion Btu in 2022 to 32 in 2023 [EIA 2024d]. Rail use of natural gas in liquefied form increased from 0.5 trillion Btu in 2022 to 1.0 in 2023. Heavy trucks consumed 51.8 trillion Btu of natural gas in 2023, just slightly more than the 51.3 trillion consumed in 2022. Natural gas use by transit buses increased slightly from 26 to 27 trillion Btu, and propane use remained at 1.5 trillion Btu. Use of propane by school buses remained at about 8 trillion Btu in 2023, while natural gas school buses used only 1 trillion Btu. Propane use by heavy trucks remained low at 1.4 trillion Btu in 2023. Use of both propane and natural gas by passenger cars and light trucks is estimated to have decreased slightly from 2022 to 2023 to about 0.7 trillion Btu for each fuel [EIA 2024d]. Overall, the Energy Information Administration estimates that natural gas use by motor vehicles decreased from 562 million gallons of gasoline equivalent in 2022 to 459 million gallons in 2023 (Figure 6-15), reflecting the shift toward electrification.

Alternative fuels for maritime shipping are in the process of development and demonstration. Efforts are focused on fuels that can economically supply the volumes of energy required, while having the potential to achieve zero emission goals. Among 340 international projects monitored by the Global Maritime Forum, pilot projects and demonstrations featuring ammonia and hydrogen were the first and second most numerous, respectively [Rosenberg, Leitão 2024]. Projects testing methanol and batteries decreased from 2021 to 2024 as the technology approached commercialization. Batteries remain the leading technology for smaller ships (less than 5,000 dead weight tons [dwt]), while projects using ammonia

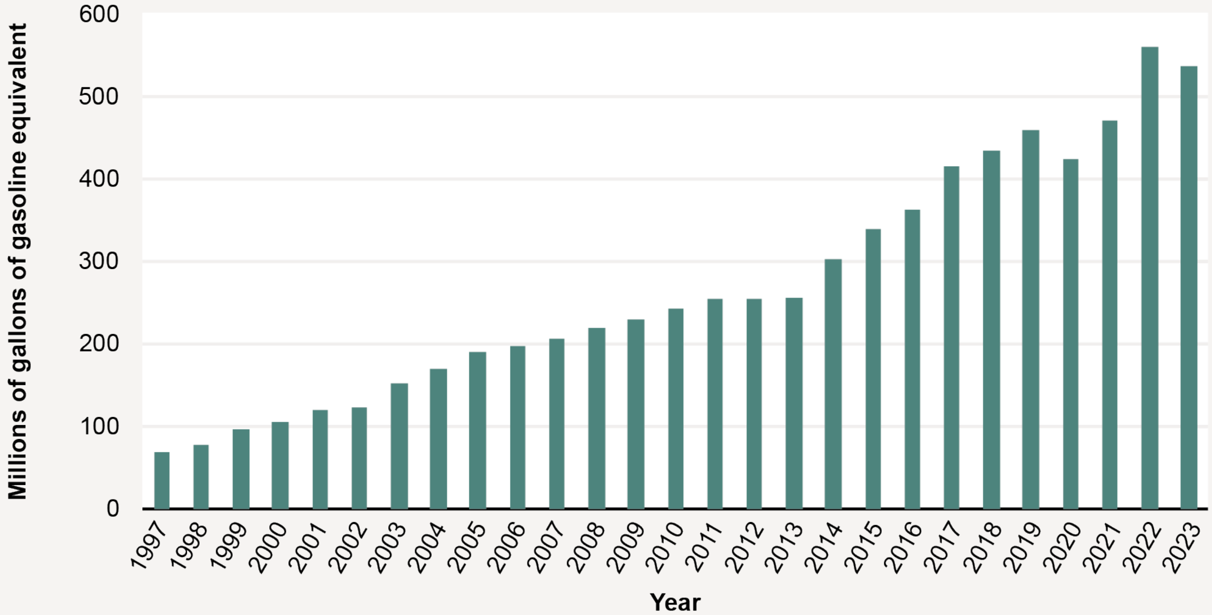
Figure 6-14 Transportation Use of Biofuels: 1980–2023



Source: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, Table 10.2c, available at www.eia.gov/ as of August 2024.

SAF = sustainable aviation fuel.

Figure 6-15 Natural Gas Use by U.S. Vehicles: 1997–2023



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 2024.

for fuel overwhelmingly involved ships over 5,000 dwt. Research and development of solid-state lithium batteries for small ships and aircraft continues to make progress toward near-term commercialization [Hertz 2024]. Hydrogen and ammonia were used for either fuel cell electric propulsion or as fuel for internal combustion engines. Methanol was predominantly used as a fuel for internal combustion engines. Almost four out of five fuel production projects used electrolysis powered by renewable energy to produce either green hydrogen or green methanol.

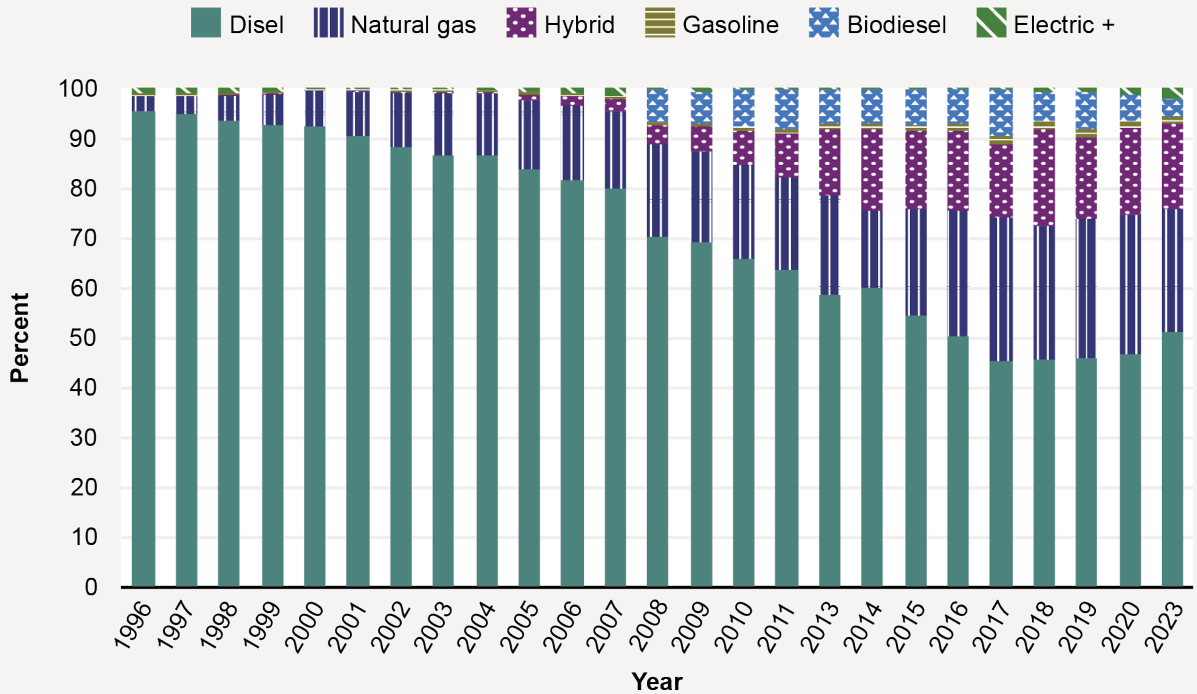
Transition to Clean Modes

Zero-emission vehicles (ZEVs) yield their greatest environmental and health benefits in congested urban areas where people are exposed to the poorest air quality, noise, and the negative impacts of climate change [USDOT 2024a]. Substituting trips by walking, biking, e-biking, e-scooters and electrified transit for trips by fossil fuel-powered internal combustion engine vehicles can reduce particulate and ozone pollution and promote healthy exercise. Both public transit and micromobility modes were hit hard by the COVID-19 pandemic. Transit modes lost half of their 2019 ridership and trips by shared micromobility modes in North America also fell from 147 million in 2019 to 73.5 million in 2020 [NACTO 2023]. In 2023, transit and micromobility ridership continued to rebound. Transit ridership grew by 28.7 percent in 2022, 16.1 percent in 2023, and 8.0 percent in the first quarter of 2024 [APTA 2024]. Bus transit ridership increased by 34.6 percent from 2021 to 2023 and is up 10.2 percent in the first quarter of 2024.

In 2023, transit vehicles continued to transition to cleaner alternatives. Rail transit modes are electrified with the exception of some commuter trains that are pulled by diesel locomotives. The majority of transit buses, however, are still powered by internal combustion engines. Over the past two decades, approximately half of the diesel-powered transit buses in the United States have been replaced by alternatives powered by natural gas, biodiesel, or hybrid-electric powertrains [APTA 2023]. Until 2008, the small fraction of vehicles labeled "Electric +" in Figure 6-16 were powered by propane; in recent years these are predominantly battery electric buses. Supported by the Bipartisan Infrastructure Law and programs such as the Federal Transit Administration's Low and No Emission Program and the Grants for Bus and Bus Facilities Program, the U.S. electric bus fleet grew from 5,480 vehicles in 2022 to 6,147 as of September 2023 (Table 6-3) [Hynes et al. 2024].

Micromobility modes, e-bikes and e-scooters can substitute for short vehicle trips and connect to longer distance trips by transit. Accurate data on total sales and stocks of electric bikes (e-bikes) are not available. Imports of electric bikes are reported to have increased from 880,000 in 2021 to 1.1 million in 2022, but decreased to 990,000 in 2023 [Vosper 2024]. However, a substantial number of e-bikes are manufactured in the United States, so the number of imported e-bikes underestimates total sales. A different industry source has only 491,000 e-bikes sold in the United States in 2023, down from 527,000 in 2022, but reports a rebound of over 13 percent in the first 4 months of 2024

Figure 6-16 Percent of Transit Buses by Fuel Type



Source: APTA, 2023 Transit Fact Book: Appendix A. Includes “Bus Vehicle” and “Commuter Bus Vehicle.”

Table 6-3 U.S. Zero-Emission Bus Fleets: 2021–2023

Bus type	2021	2022	2023	Increase, 2022 to 2023	Percent increase, 2022 to 2023
Battery electric	3,168	5,269	5,775	506	9.6
Fuel cell electric	129	211	372	116	76.3
Full size TOTAL	3,297	5,480	6,147	667	12.2
Small TOTAL	615	876	1,010	134	15.3

Source: CALSTART, Reports and Analyses, Buses: Zeroing in on ZEBs, tables 1 and 4, available at https://calstart.org/resources/#busesresources as of August 2024.

Table 6-4 Estimates of Energy Use by e-Bikes and e-Scooters in the United States: 2023

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	44	35.4	805	2.0	1,609	8	13	566
E-scooters	145	63.9	441	1.2	529	15	8	1,150
TOTAL	—	—	—	—	—	—	—	**1.7**

Source: Bureau of Transportation Statistics’ calculations (NACTO 2023, NABSA 2024).

Note: Uses data on vehicles and trips for the United States (p.10) but trip lengths (p. 8) are for North America since U.S.-only estimates are not available.

— Not applicable.

Wh = watt hour; kWh = kilowatt hour.

[Nerd Collective 2024]. Table 6-4 includes only e-bikes owned by shared mobility companies and excludes the much larger numbers privately owned. The estimated 44,000 shared e-bikes in U.S. cities produce about 35 million trips per year, with an average trip length of 2 miles. Traveling approximately 1,600 miles per year, and using a roughly estimated 8 Watt-hour/mile, implies a total annual energy use of 566 mega-watt hours and 13 kWh per vehicle. Rideshare companies operate approximately 145,000 e-scooters, that average 1.2 miles per trip and only a little over 500 miles per vehicle per year. E-scooters use about twice as much electricity per mile as e-bikes because e-bike riders provide most of the energy themselves by pedaling.

Active Transportation Modes

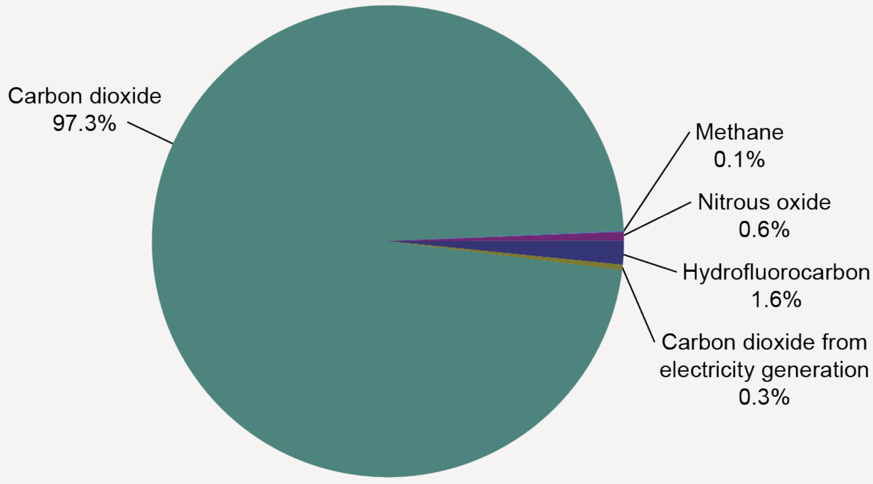
Nonmotorized or "active transportation" includes walking, biking, scooters, wheelchairs, and other options for which humans provide all the energy. The potential for active transportation is great because approximately half of all trips in the United States are under three miles in length [USDOT 2024b]. In the United States, walking and cycling accounted for only 2.9 percent of all trips to work in 2022. National Household Travel Survey data indicate that the percent of trips by bicycle has remained relatively steady at about 1 percent from 2001 to 2022, while walking trips rose from 8.7 percent in 2001 to 11.9 percent in 2017, but declined to 6.8 percent in 2022 [Bikeleague 2024]. Active transportation can incorporate physical activity in daily activities, improving physical and mental health. Because active transportation produces no net GHG emissions, it can contribute to mitigating climate change when substituted for fossil fueled modes.

Greenhouse Gas Emissions and Air Quality

Transportation continues to be the largest source of GHG emissions among U.S. economic sectors, accounting for 28.5 percent of U.S. GHG emissions in 2022 [USEPA 2024c, table 2-12]. Emissions from electricity generation were the second largest source, accounting for 24.9 percent of total U.S. emissions (Figure 6-18). In 2022, only 0.1 percent of the total GHG emissions attributed to transportation were due to emissions from electricity generated for transportation use, the rest were direct emissions from transportation vehicles and operations. Weighting GHGs by their impact on global warming, CO_2 constitutes 97.3 percent of transportation's direct GHG emissions (Figure 6-17). The importance of hydroflouorocarbons (HFCs), the second most important GHG emitted by transportation, continued to decrease in 2022. HFCs, which are potent GHGs, were a common refrigerant in the air conditioners of vehicles manufactured prior to 2021. EPA regulations require that refrigerants with higher global warming potential be replaced with more environmentally benign refrigerants in new vehicles. As the stock of vehicles in use gradually turns over, leakage of HFCs from automobile air conditioners should continue to abate, further increasing CO_2 share of transportation's GHG emissions.

CO_2 emissions from energy consumption have decreased across all sectors of the U.S. economy since 2007 (Figure 6-18). However, transportation's CO_2 emissions have decreased the least. From 2007 to 2023, total U.S. CO_2 emissions from energy consumption decreased by 27.3 percent and emissions from residential and commercial

Figure 6-17 Transportation's GHG Emissions by Gas: 2022



Source: U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2022, table 2-12, available at www.epa.gov/ghgemissions/ as of August 2024.

Note: The data for the transportation sector includes only fossil and renewable fuels consumed directly. The data for nontransportation includes the residential, commercial, and industrial sectors, which include only fossil fuels consumed directly, and electric utilities, which includes all fuels (fossil, nuclear, geothermal, hydro, and other renewables) used by electric utilities. Most renewable fuels are not included. Totals may not add to 100 percent due to rounding.

buildings decreased by 30.9 percent. Emissions from industrial activities decreased by only 19.9 percent, but industrial emissions peaked 10 years earlier in 1997 and have since fallen by 26.7 percent. CO_2 emissions from transportation energy use are only 8.6 percent lower than their peak in 2007 and increased slightly in 2023 while emissions from every other sector declined (Figure 6-18).

Ninety-seven percent of transportation's GHG emissions come from direct fossil fuel consumption in transportation vehicles. Because gasoline, diesel and jet fuel have similar but not identical carbon contents, the distribution of GHG emissions by transportation mode is almost identical to that of transportation energy use (Figure 6-2). Highway vehicles were responsible for 81.7 percent of transportation's GHG emissions in 2022 [USEPA 2024c, table 2 13].

Regulating Transportation's GHG Emissions

Light- and Medium-Duty Vehicles

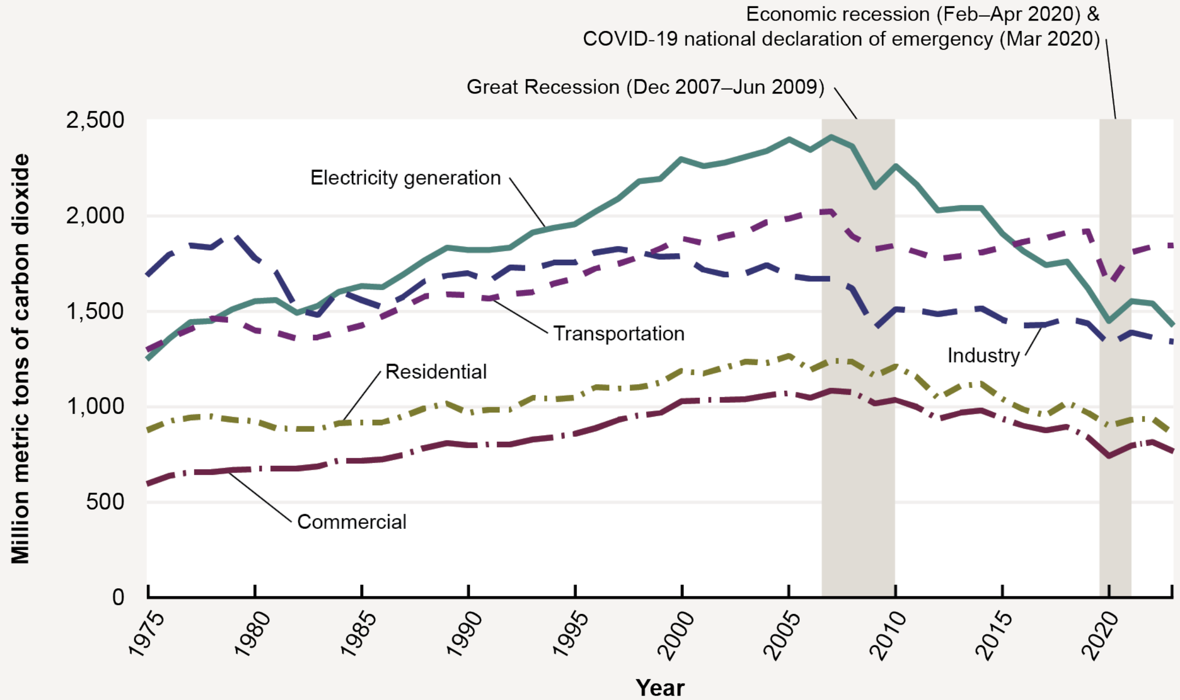
In April, 2024, the EPA finalized new emissions regulations covering GHG, hydrocarbon, particulate and nitrogen oxide emissions by new light-duty and medium-duty vehicles in April, 2024 [USEPA 2024e]. The light duty standards apply to passenger cars and light trucks with gross vehicle weights below 8,501 lb and the medium duty standards apply to vehicles with GVWs from 8,501 to 14,000 lb. The standards call for a 50 percent reduction in GHG emissions by 2032 for light-duty vehicles and a 44 percent reduction for medium-duty vehicles compared with previous standards (Table 6-5). These are estimates of the standards' impacts. Because the standards depend on the sizes and types of vehicles sold and used, the reductions actually achieved may differ somewhat.

Like the CAFE standards, the GHG standards are technology-neutral performance standards, and include mechanisms for acquiring and trading credits within and among firms (e.g., Yeh et al. [2021]). The final rule offers three pathways by which the standards could be met with a combination of internal combustion engine (ICE), HEV, PHEV and BEV vehicles (Figure 6-19). The example shares of BEVs in 2032 range from 35 percent in the High HEV_PHEV pathway to 56 percent in the High BEV pathway.

Heavy-Duty Vehicles

In April of 2024, the EPA also issued a final rule requiring substantial reductions in GHG emissions from heavy-duty vocational trucks (e.g., delivery trucks, refuse haulers, utility trucks transit, shuttle and school buses) and tractor trailers including day cabs and sleeper cabs [USEPA 2024d]. The standards take effect in 2027 and require reductions in CO_2 emissions ranging from 25 percent for long-haul tractors to

Figure 6-18 U.S. CO_2 Emissions From Energy Consumption: 1975–2023



Source: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, Table 11.2-11.6, available at www.eia.gov/ as of August 2024.

60 percent for light-heavy vocational vehicles (e.g., bucket trucks used by electric utilities) (Table 6-6). The standards are performance-based and technologically neutral.

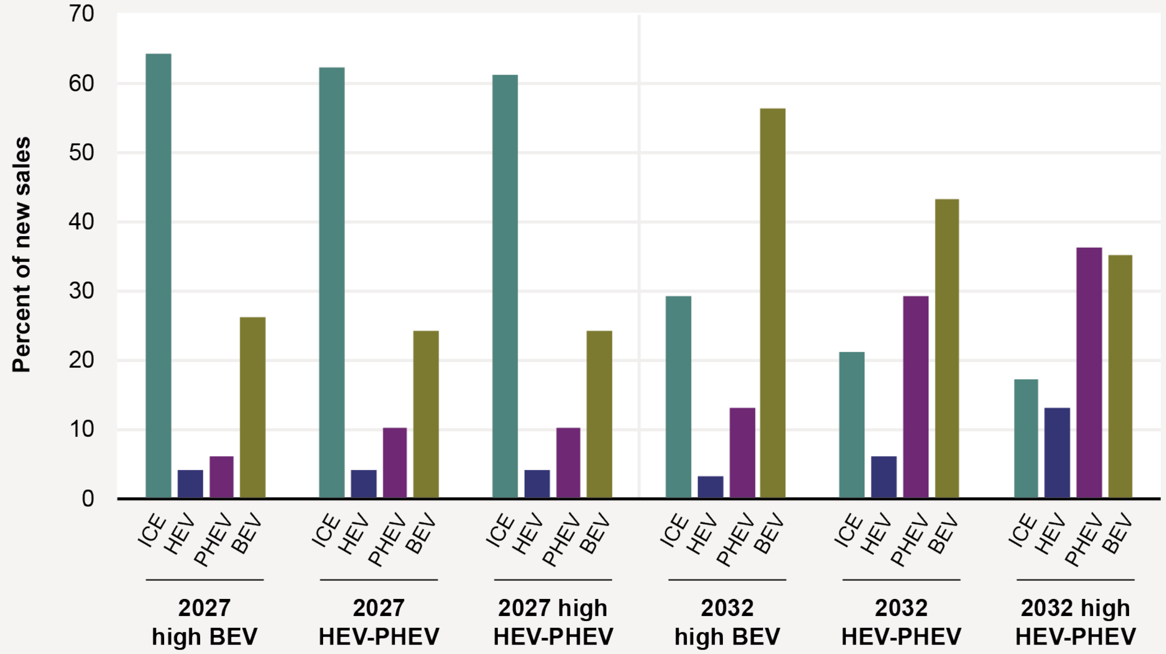
The EPA rule provided two examples of how the standards for 2032 could be met, one emphasizing ZEV technologies (BEVs and hydrogen fuel cells) and another emphasizing advanced conventional technologies, HEVs, and hydrogen-powered internal combustion engines (Table 6-7). In the lower ZEV example, the market shares of BEVs and fuel cell electric vehicles (FCEVs) are half those of the high-ZEV case for vocational vehicles, and one-fourth to one sixth as large for heavy-duty tractor trailers. The examples illustrate the uncertainty about the rate at which the heavy-duty market will adopt ZEV technology, as well as the potential for heavy-duty vehicle manufacturers to meet the standards with different combinations of technologies.

Table 6-5 Light- and Medium-Duty Vehicle GHG Standards: Projected Targets by Regulatory Class (CO_2 Gram/Mile)

Duty	Class	2027	2028	2029	2030	2031	2032
Light-duty vehicle	Cars	139	125	112	99	86	73
	Trucks	184	165	146	128	109	90
	TOTAL light-duty fleet	**170**	**153**	**136**	**119**	**102**	**85**
Medium-duty vehicle	Vans	392	391	355	317	281	245
	Pickups	497	486	437	371	331	290
	TOTAL medium-duty fleet	**461**	**453**	**408**	**353**	**314**	**274**

Source: U.S. Environmental Protection Agency, 2024. Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, *Federal Register Vol. 89*, No. 76, table 1 and table 2.

Figure 6-19 Three Alternative Pathways to Meet 2032 Light-Duty Vehicle GHG Standards



Source: U.S. Environmental Protection Agency, 2024. Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, Federal Register Vol. 89, No. 76, table 3.

GHG = greenhouse gas; ICE = internal combustion engine; HEV = hybrid electric vehicle; PHEV = plug-in hybrid electric vehicle; BEV = battery electric vehicle.

Maritime shipping includes the transport of goods on coastal, oceanic and inland waterways. The International Maritime Organization, the United Nations agency responsible for regulating international shipping, has established goals of reducing the total GHG emissions from international shipping by 20 percent by 2030, with a stretch goal of 30 percent, and by at least 70 percent by 2040, with an ambition of an 80 percent reduction, relative to 2008 emissions, and net zero emissions at approximately 2050 [IMO 2023]. Ocean-going ships carry 80 percent of the world's trade by volume and are chiefly powered by heavy fuel oil whose combustion emits large quantities of CO_2 [USDOT 2024c].

Air Quality Trends

Nationwide, concentrations of six of nine air pollutant metrics increased slightly in 2023 while three continued to decline, following long-term decreasing trends (Figure 6-20). Figure 6-20 shows national average concentrations. As noted in the following paragraph, unhealthy air quality is still experienced on some days in major cities. Ozone (O_3) is not directly emitted but is formed in the atmosphere by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds. Ozone is harmful to respiratory health. Carbon monoxide (CO) is produced by combustion, and transportation vehicles remain the largest source. Inhaling CO reduces the ability of blood to transport oxygen. Very small particles of solids or liquids in the air can be inhaled deeply into the lungs and cause a variety of respiratory problems. Separate standards regulate particulate matter (PM) smaller than 2.5 microns (PM2.5) and from 2.5 to 10 microns (PM10). For reference, the thickness of human hair is 50–70 microns. Lead (Pb) is harmful to the nervous system, kidneys, the immune system, and cardiovascular system. Transportation vehicles were once a major source of lead pollution but with the elimination of leaded gasoline ambient lead levels have been dramatically reduced. Piston engine aircraft using leaded aviation fuel are the only remaining transportation source. Oxides of sulfur (SO_2) are harmful to the respiratory system and are emitted primarily via the combustion of fossil fuels in electricity generation and industrial processes. Regulation of the sulfur content in gasoline and diesel has nearly eliminated SO_2 emissions from highway vehicles. Nitrous oxide (NO_2) aggravates respiratory

Table 6-6 Percent Reduction From the Phase 2 CO_2 Emissions Standards

Truck type	2027	2028	2029	2030	2031	2032
Light-heavy vocational	17	22	27	32	46	60
Medium-heavy vocational	13	16	19	22	31	40
Heavy-heavy vocational	—	—	13	15	23	30
Day cab tractor	—	8	12	16	28	40
Sleeper cab tractor	—	—	—	6	12	25

Source: U.S. Environmental Protection Agency, 2024, "Final Standards to Reduce Greenhouse Gas Emissions from Heavy-Duty Vehicles for Model Year 2027 and Beyond." Available at https://www.epa.gov/system/files/documents/2024-04/420f24018.pdf.

— Not applicable.

Table 6-7 Examples of Percent Sales Shares of Engine Technologies That Could Meet Phase 3 Heavy-Duty Emissions Standards in 2032

	High ZEV	Lower ZEV example					
Vehicle type	ZEV	ZEV	ICEV	HEV	PHEV	Natural gas	Hydrogen ICEV
Light heavy-duty vocational (GVW 8,500 to 19,500 lb)	60	30	1	40	0	5	24
Medium heavy-duty vocational (GVW 19,501 to 33,000 lb)	40	20	18	44	0	5	13
Heavy heavy-duty vocational (GVW over 33,000 lb)	30	14	42	27	0	5	12
Short-haul tractors	40	10	39	20	0	5	26
Long-haul tractors	25	4	64	10	0	5	17

Source: U.S. Environmental Protection Agency, 2024. "Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles—Phase 3, tables ES-3 and ES-4. *Federal Register Vol. 89*, no. 78.

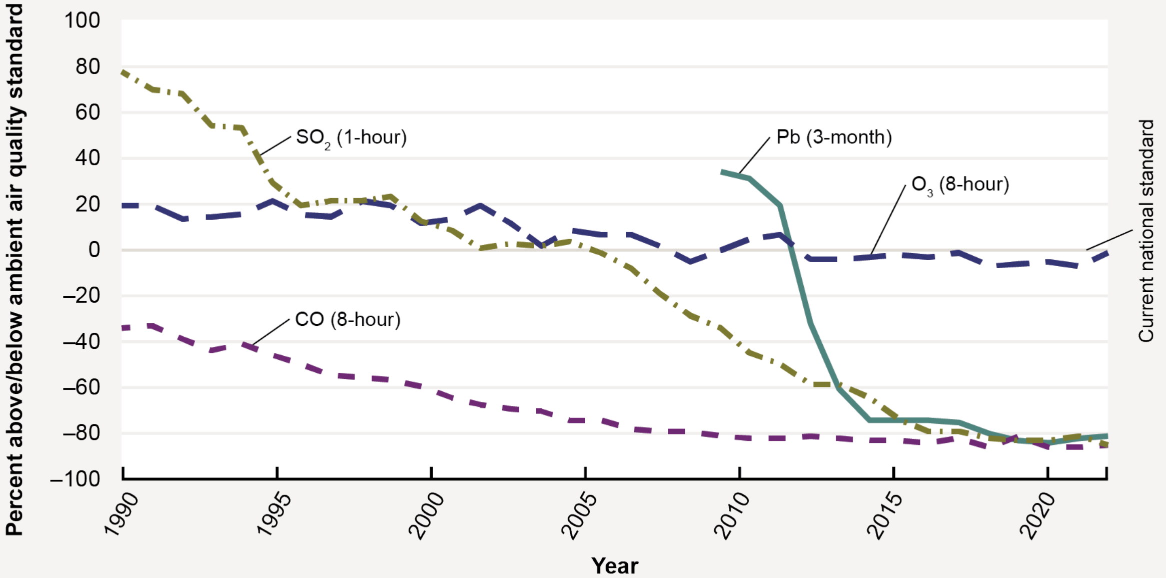
ZEV = zero-emission vehicle; ICEV = internal combustion engine vehicle; HEV = hybrid electric vehicle; PHEV = plug-in hybrid electric vehicle; GVW = gross vehicle weight.

diseases and contributes to forming ozone. NO_2 is chiefly produced by the combustion of fossil fuels. In addition to the pollutants shown in Figure 6-20, numerous toxic pollutants not shown have also declined as a result of environmental regulations [USEPA 2024f].

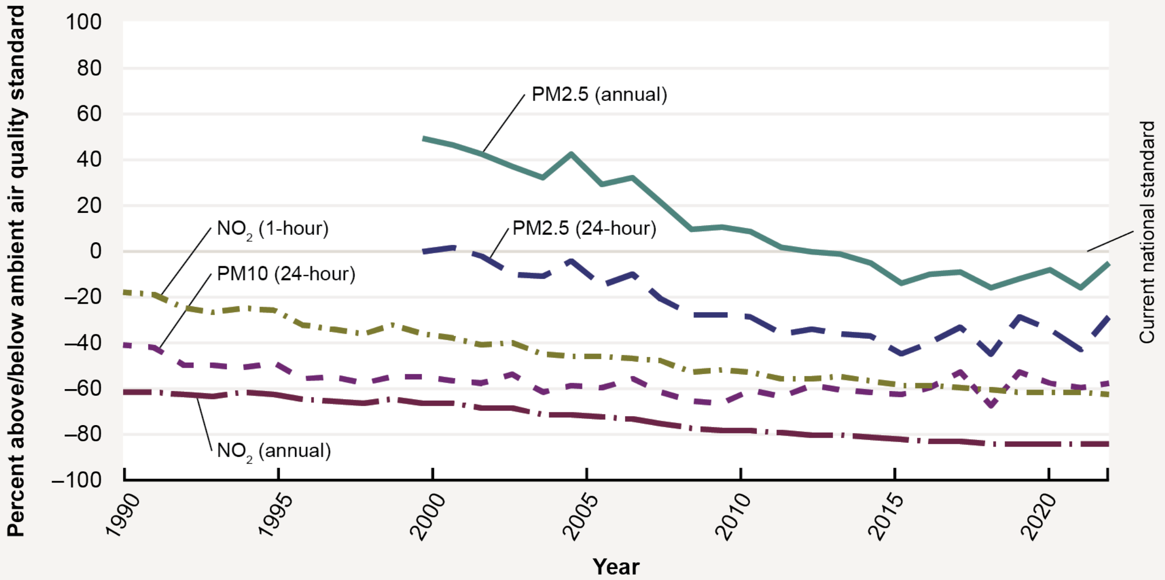
Pollutant emissions from transportation have decreased even more rapidly than total U.S. emissions. Transportation's share of major air pollutants has decreased for all major pollutants (Figure 6-21). In 2023, transportation's share of pollutant emissions exceeded 50 percent of total U.S.

Figure 6-20 National Average Air Pollutant Concentrations: 1990–2023

A. Lead, Ground-Level Ozone, Sulfur Dioxide, and Carbon Monoxide



B. Particulate Matter and Nitrogen Dioxide



Source: U.S. Environmental Protection Agency, 2023. Our Nation's Air: Trends Through 2022, available at https://gispub.epa.gov/air/trendsreport/2023/#introduction as of August 2024.

Pb = lead; O_3 = ground-level ozone; CO = carbon monoxide; PM = particulate matter; NO_2 = nitrogen dioxide; SO_2 = sulfer dioxide.

emissions for only CO: 50.4 percent, down from 76.4 percent in 2003. Nonetheless, air quality remains a concern. In 2023, the 35 major U.S. cities whose air quality has been continuously monitored by the EPA experienced a combined total of 822 days of air quality judged “unhealthy for sensitive groups,” the greatest number of unhealthy days since 1,297 in 2012 [USEPA 2024f]. Air quality is affected by weather conditions, including temperature. Ozone formation is increased on hot and sunny days, and wildfires and droughts can greatly increase particulate pollution.

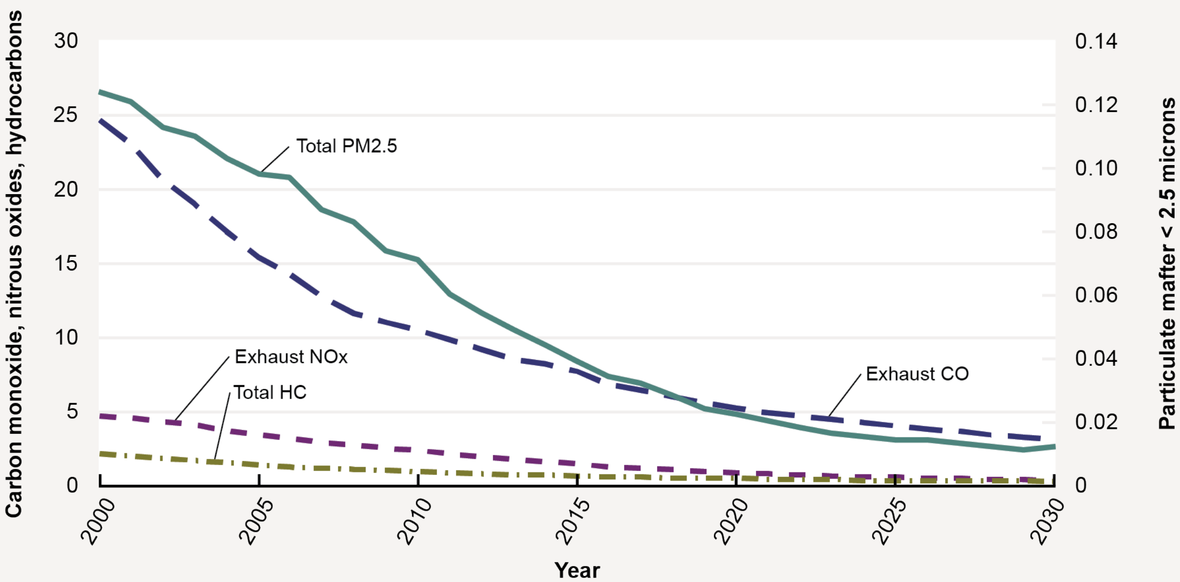
Additional Effects on the Environment and Sustainability

Water Quality

Thousands of small oil spills occur in U.S. waters each year. Spills impact wildlife, property, and habitat, and affect marine transportation. Most releases are less than one barrel (42 gallons of oil). Large spills greater than 10,000 barrels are much less frequent. The total quantity of oil released into U.S. waters is dominated by a few very large spills, such as the Deepwater Horizon 3.19 million-barrel spill in April 2010 and the Ixtoc spill of 3.00 million barrels in June 1979, both in the Gulf of Mexico [NOAA 2024]. In addition to the size of a spill, its location, time of year, ecosystem sensitivity and type of oil affect its impact. Oil spills have done damage along the eastern and western seacoasts, Alaska, Hawaii, inland waterways and in the Caribbean. At the time of writing, data on all oil spills into U.S. waters was not available for 2023. However, the International Tanker Owners Pollution Federation provides worldwide data for 2024 oil tanker spills greater than 7 tonnes [ITOPF 2024]. Only one such large oil spill occurred in U.S. waters. Both the number and volume of global oil spills have been declining since the early 1970s. In 2023 there was one tanker oil spill of over 700 tonnes in Asia and nine smaller spills, one of which occurred in U.S. waters. The total volume of oil spilled in 2023 was 2,000 tonnes, about one-sixth of the volume spilled in 2022.

Runoff from roads and other infrastructure contains oils, heavy metals and other toxic substances that can pollute lakes, rivers, bays and groundwater. Salt is used to deice

Figure 6-21 Estimated National Average Emissions per Vehicle Using Gasoline and Diesel by Pollutant: 2000–2030 (Gram/Mile)



Source: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, personal communication, June 21, 2024.

Note: Estimates are by calendar year. Vehicle types are defined as follows: light-duty vehicles (passenger cars); light-duty trucks (two axle, four tire); buses (school, transit and other); heavy-duty vehicles (trucks with more than two axles or four tires); motorcycle (highway only). Emissions factors are averages based on the national average age distributions, vehicle activity (speeds, operating modes, vehicle-miles traveled fractions, starts and idling), temperatures, humidity, inspection/maintenance and antitampering programs, and average gasoline fuel properties in that calendar year. Gasoline-electric hybrids are accounted for in the values for gasoline vehicles. This table was generated using MOVES4, the U.S. Environmental Protection Agency’s mobile source emissions factor model. More information on MOVES is available at www.epa.gov/moves. Data for this update are based on new estimation models and are not comparable to previous releases. MOVES4 includes updates to historical data and methods as well as updates to future year projections and thus provides the current best estimates of emissions for all calendar years. Inputs for 2022 and later are projections.

CO = carbon monoxide; PM = particulate matter; NOx = nitrogen oxides; HC = hydrocarbons.

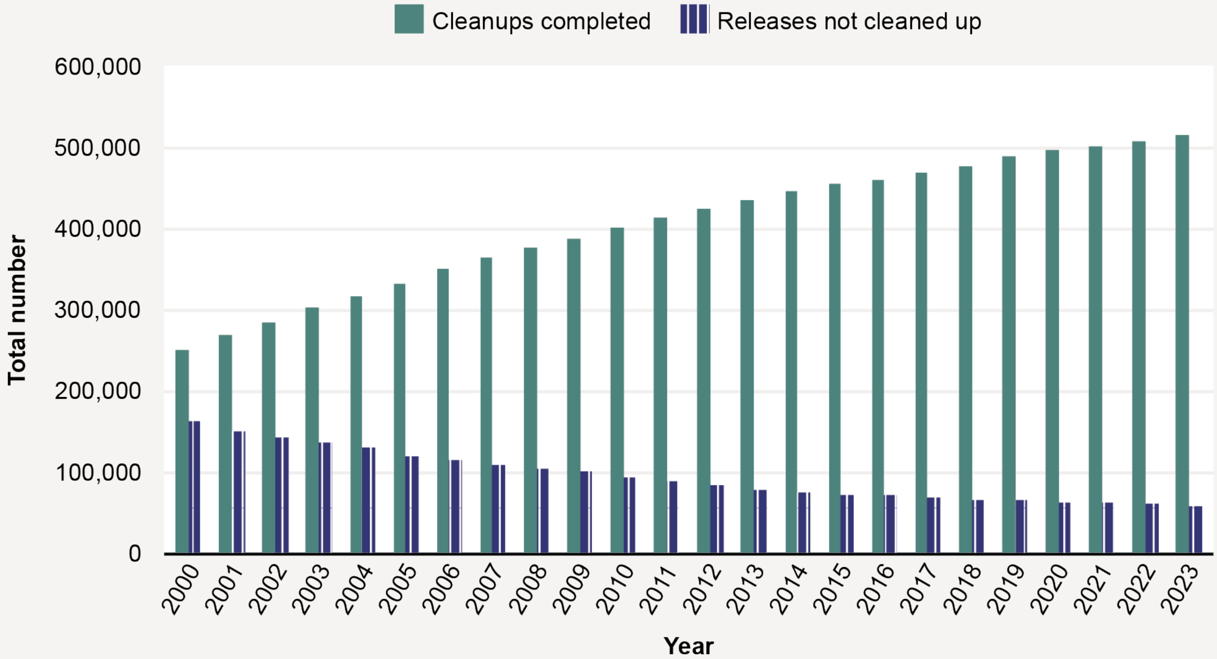
U.S. roads because it reduces vehicle accident rates during snowy or icy conditions by an estimated 78–87 percent [Usman et al. 2010]. About 95 percent of the salt applied is common salt (sodium chloride) because there are no ecologically superior, cost-effective substitutes. The US Geological Survey estimates that salt use for roadway deicing accounted for 41 percent (16.8 million tons) of total U.S. salt use in 2023, similar to levels used in 2022. Road deicing and other sources of salt such as water softening, irrigation, mining, and wastewater are increasing freshwater and groundwater salinization across North America with harmful effects on freshwater ecology [Kaushal et al. 2018].

In the United States, more than half a million underground storage tanks contain petroleum, petroleum fuels and other hazardous substances [USEPA 2024h]. The vast majority contain petroleum fuels for transportation use. Prior to federal regulation, most tanks were made of steel and were susceptible to rusting and leaking their contents into surrounding soil, potentially contaminating groundwater. In the 1980s, when the EPA began regulating underground storage tanks and detecting leaks, there were approximately 2.1 million tanks in the United States. Many were leaking or failed to meet regulatory standards, creating a backlog of sites to be cleaned up. Since then, standards and inspection requirements have been increasingly tightened and funds provided for cleaning up leaks and spills. Cleanups have consistently exceeded new incidents and the backlog of sites awaiting remediation has steadily declined (Figure 6-22). As of December 2003, more than 500,000 leaks had been cleaned up and most states had reduced the backlog of sites needing remediation by about 80 percent (Figure 6-22). As of last year, all but eight states had cleaned up 80–89 percent of their underground tanks and 34 had cleaned up 90–100 percent.

Solid Waste and Recycling

The transportation system produces millions of tons of solid waste each year in the form of 12–15 million scrapped vehicles, worn out pavement, and dismantled infrastructure. An estimated 95 percent of motor vehicles are processed for recycling each year, and approximately 85 percent of their material content is recycled [AAI 2024]. The remainder consists primarily of shredded plastic, fiber and cloth and goes to landfill. In 2021, an estimated 274 million tires weighing over 5 million tons were scrapped [USTA 2022]. Of the total tonnage, 71 percent went to a variety of uses including being burned for fuel (27.7 percent) and reused as ground rubber (28.0 percent). An estimated 14.6 percent went to landfills while 14.3 percent was unaccounted for. Lead-acid automotive batteries are the most fully recycled product in the United States, with an estimated recycling rate of 99 percent [USEPA 2020]. A study of the rate of lead recycling from lead-acid batteries found an effective lead recycling rate of 100 percent [Vault Consulting 2023]. When a vehicle is scrapped, standard practice is to remove all fluids including fuel, engine oil, coolant and other oils, about 19 liters per vehicle, and store them for recycling and disposal [USEPA 2017].

Figure 6-22 Releases and Cleanups From Leaking Underground Storage Tanks: 2000–2023



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 4-55, available at https://www.bts.gov/content/leaking-underground-storage-tank-releases-and-cleanups as of August 2024.

Transportation infrastructure is also actively recycled. Of the 441.9 million tons of asphalt pavement laid in 2022, 104.8 million tons was reclaimed asphalt pavement, a 5.8 percent increase over 2021 [NAPA 2024]. Less than 0.2 percent of reclaimed asphalt pavement went to landfill. Other recycled materials used in asphalt pavement in 2022 included recycled asphalt shingles (673,000 tons), recycled tire rubber (52,146 tons), steel and blast furnace slag (776,344 tons), recycled fibers (2,947 tons) and coal combustion products (2,303 tons). Concrete from pavements and structures can also be recycled. An early estimate put the quantity of recycled concrete from all sources at 100 million tons per year, roughly equivalent to the tonnage of reclaimed asphalt [USGS 2000]. In a 2012 survey of U.S. construction firms 40 percent mentioned transportation infrastructure as a source of recycled concrete [Jin, Chen 2015]. The majority of respondents (71 percent) indicated that they typically recycled more than 75 percent of their concrete waste. Most (77 percent) indicated that recycled concrete is used as “backfill or roadbase” with only 23 percent indicating use as aggregate for producing new concrete. In general, recycled concrete aggregate underperforms in comparison to natural aggregate and is typically blended with new aggregate. How best to make use of recycled concrete remains an active area of research (e.g., Fanijo et al. [2023]).

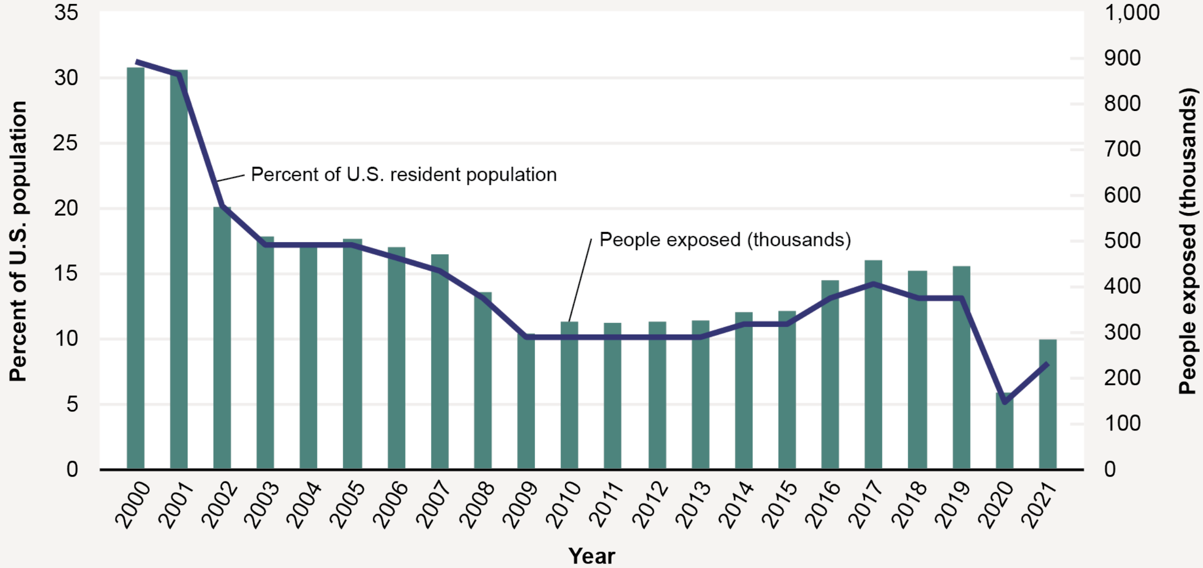
Collisions With Wildlife

A 2008 study by the Federal Highway Administration estimated that there were between 1 and 2 million collisions between motor vehicles and large wildlife per year, and that 4–10 percent of reported collisions resulted in injuries to vehicle occupants [FHWA 2008]. Vehicle occupant deaths in collisions with animals increased from about 100 per year between 1975 and 1985 to 222 in 2006, and stood at 184 in 2022 [IIHS HLDI 2024]. An estimated 1.8 million insurance claims involving collisions with animals were filed between mid-2022 and mid-2023 [State Farm 2023]. Collisions with deer were the most common, followed by rodents, dogs, raccoons and coyotes. The annual costs of collisions with large wildlife was estimated to be $8.4 billion (2008 dollars). The study also identified 21 endangered species for which road mortality was among the major threats to survival of the species. In the National Parks, collisions with wildlife account for approximately ten percent of all vehicle collisions [Cherry et al. 2019]. Despite implementation of mitigation practices, wildlife–vehicle collisions continue to be a safety and ecological concern that remains inadequately documented and poorly understood (e.g., Villamagna, Laflamme, Kim [2024]).

Noise

Unwanted or disturbing sound is known to have a variety of effects on human well being including increased stress, interference with communication, reduced productivity, hearing loss, and sleep disruption, with consequent effects on health. Epidemiological studies indicate that transportation noise increases the risk of cardiovascular morbidity and mortality, including heart failure and stroke [Münzel et al. 2024]. States and local governments have the primary responsibility for regulating noise, but the EPA has authority

Figure 6-23 Numbers of People in Areas of Significant Noise Exposure Around U.S. Airports: 2000–2023



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics*, table 4-47, available at https://www.bts.gov/content/number-people-residing-areas-significant-noise-exposure-around-us-airports.

to study noise and its impacts and evaluate the effectiveness of noise regulation under the Noise Control Act of 1972 and the Clean Air Act of 1990 [USEPA 2024g]. The Federal Aviation Administration conducts wideranging research on aircraft noise and abatement, and on its impacts. A recent analysis of the impacts of aircraft noise on housing values indicated that every 10 percent reduction in noise exposure increased housing values by approximately 2.5 percent [FAA 2023]. Although data for 2022–2023 were not available at the time of writing, exposure to aircraft noise increased in 2021 from a COVID-19 related low in 2020 as air traffic increased (Figure 6-23), and may have increased or remained nearly constant in 2022 and 2023 as air travel returned to pre-COVID-19 levels. Highway noise is abated by constructing noise barriers. Each year, 75–100 miles of noise barriers are constructed, the vast majority for new or expanded highways [BTS 2024b].

Emerging Issues

Achieving the national goal of a net zero GHG emission economy by 2050 will likely require capturing CO_2 emissions from some industrial and electricity generating point sources, and transporting CO_2 to sites where it can be stored indefinitely [USDOS 2021]. Although there is considerable uncertainty about how much CO_2 will need to be transported and its origins and destinations, the volumes could be on the order of 65 million metric tons per year by 2030 and may approach one billion tons by 2050. As required by the U.S. Congress, the DOE in collaboration with the Department of Transportation assessed the ability of the U.S. freight transportation system to provide such large-scale CO_2 transportation [USDOE 2024e]. While the study found that the current freight system is capable of handling expected volumes of CO_2 transport through 2030, creating a cost-effective, large-scale CO_2 transport system capable of handling the anticipated future growth of demand will require research, planning, and new infrastructure

Data Gaps

Although in many areas enhanced data on transportation's energy use, efficiency and environmental effects would be valuable, as noted in the main body of this chapter, three areas stand out as especially important and timely. The importance of the security and cost of critical minerals in the supply chain for EVs is noted although it is not highlighted in this section because it is an active area of research and analysis by other agencies (e.g., USDOE [2024a], USGS [2024], USDOC [2024]).

Electric Vehicles and Charging Infrastructure

More comprehensive, national data are needed on EV charging behavior and preferences, the circumstances and options for households lacking "home-based" charging, and the economics of public charging systems. As EV sales and ownership increase, data are needed to develop policies and plans to create a convenient, reliable, cost-effective and equitable recharging infrastructure. There are currently important data gaps in three key areas:

- **Home-based charging infrastructure, use, cost, potential and options.** At present, EV owners do the great majority of charging where their vehicle is parked overnight (its home base). The National Renewable Energy Laboratory estimates that when EVs are 10 percent of vehicles in use, 78 to 98 percent of charging will still be done at the vehicle's home base. However, when 90 percent of vehicles in operation are EVs, 35 to 75 percent of EVs are expected to lack consistent access to home-based charging [Ge et al. 2021]. Not only is the range of uncertainly very large, but little is known about the potential to provide home-based charging to households currently lacking access.

- **Economics and performance of public charging.** While there is comprehensive data on public charging stations, their locations, charging speeds and ports, less is known about their cost, reliability and convenience [Lommele et al. 2024].

- **Real-world EV energy intensities.** Previous TSARs have noted the need for better data on the in-use or real-world fuel economy of conventional vehicles. Even less is known about the difference between the test cycle and in-use fuel economy of plug-in EVs. Such data are needed to accurately estimate future demands for electricity and other impacts on the grid, as well as the upstream environmental effects of future EVs.

Useful surveys and analyses have been conducted in California [Tal et al. 2020] and other states and localities [Borlaug et al. 2023]. The electronic VIUS (eVIUS) by BTS, forthcoming in 2025, will provide important, additional national information [BTS 2024h]. However, the EV charging market is dynamic, growing and changing. An ongoing effort is needed to develop the information to guide public and private decision making.

Information to Support Planning and Integration of Emerging Urban Transportation Modes

More information is needed on the synergies among public transit, micromobility, and active transportation modes and supporting infrastructure. The lack of adequate supporting infrastructure such as bike lanes, sidewalks, over and underpasses, parking and storage facilities, and much more (e.g., USDOT [2024a, 2024b]) hinders active and micromobility adoption and its synergistic benefits with public transit. More information is needed on the deployment, choice and use of these modes, their interoperability, the extent and effects of key infrastructure, and the resulting system energy use and environmental impacts.

Freight Transport Energy Efficiencies

Data on the energy efficiency of freight transport is inadequate to evaluate the role efficiency improvements can play in reducing GHG emissions and reducing energy costs. In the past, highly aggregated estimates of freight modal energy intensities were available from Oak Ridge National Laboratory's Transportation Energy Data Book [Davis, Boundy 2022, table 2.16]. However, this year even those estimates were unavailable. Basic waterborne energy intensities per-ton-mile are lacking, as are energy intensities of truck freight ton-mile energy intensities by vehicle type and operational factors. For all freight modes, data on energy intensities and emissions by category of freight and length of haul are lacking.

The 2021 VIUS [BTS 2024g] will provide a great deal of useful data for trucks, such as MPG, average operating weight, and annual miles. Ton-mile energy intensity estimates may become available as the survey results are analyzed and estimation methods are developed. However, estimating detailed truck freight energy use per ton-mile estimates will be a challenge. Such data are important to understanding how, for example, last mile delivery trends are affecting energy use (e.g., DOE [2024f]).

Energy efficiencies of air freight transport are not available because a large fraction of air freight is carried as belly freight in commercial passenger flights. A range of plausible and useful estimates could be developed by (1) estimating only the effect of the additional weight of belly freight on energy use and (2) sharing total energy consumption between passenger and freight based on share of their combined weight. In addition, energy use per ton-mile estimates could be developed for all freight air carriers. Such information would be useful for analyzing the effects of air freight on GHG emissions and for refining estimates of air energy use per passenger mile by subtracting freight energy use.

References

Alliance for Automotive Innovation. 2024. "Automotive Recycling," Available at https://www.autosinnovate.org/initiatives/energy-and-environment/automotive-recycling.

American Public Transportation Association (APTA). 2024. "Ridership Report Archives," Accessed 8/15/2024, Available at https://www.apta.com/research-technical-resources/transit-statistics/ridership-report/ridership-report-archives/.

American Public Transportation Association. 2023. "2023 Public Transportation Fact Book: Fact Book Data in Excel: Appendix A," Available at https://www.apta.com/research-technical-resources/transit-statistics/public-transportation-fact-book/.

Aredah, A., J. Du, M. Hegazi, G. List and H. Rakha. 2024. "Comparative analysis of alternative powertrain technologies in freight trains: A numerical examination towards sustainable rail transport," *Applied Energy, 356*, 122411. Available at https://doi.org/10.1016/j.apenergy.2023.122411.

Association of American Railroads (AAR). 2024. *Freight Rail: Reducing Locomotive Emissions*. Available at https://www.aar.org/article/research-investments-driving-tomorrows-sustainable-locomotive-fleet/#:~:text=A%20recent%20study%20concluded%20a,emissions%20by%20at%20least%2010%25.

Bikeleague: League of American Bicyclists, 2024. "National: Rates of Biking and Walking," Available at https://data.bikeleague.org/data/national-rates-of-biking-and-walking/.

Borlaug, B., F. Yang, E. Pritchard, E. Wood, and J. Gonder. 2023. "Public electric vehicle charging station utilization in the United States," *Transportation Research D, 114*. Available at https://doi.org/10.1016/j.trd.2022.103564.

Borlaug, B., S. Salisbury, M. Gerdes, and M. Muratori. 2020. "Levelized Cost of Charging Electric Vehicles in the United States," *Joule 4*(7): 1,470–1,485.

Bureau of Transportation Statistics (BTS)

——2022. *National Transportation Statistics*, Table 1-11, "Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances."

——2024a. VIUS PUF Tabulation Tool, 8/12/2024, Available at https://data.bts.gov/stories/s/VIUS-PUF-Draft/mc6b-y96m/.

——2024b. *National Transportation Statistics*, Table 4-56 "Highway Noise Barrier Construction."

——2024c. *National Transportation Statistics*, Table 4-6, "Energy Consumption by Mode of Transportation."

——2024d. *National Transportation Statistics*, Table 1-40, "U.S. Passenger Miles". Available at https://www.bts.gov/sites/bts.dot.gov/files/2024-07/table_01_40_072324.xlsx.

——2024e. *National Transportation Statistics*, Table 1-50, "U.S. Ton-Miles of Freight". Available at https://www.bts.gov/sites/bts.dot.gov/files/2024-07/table_01_50_072324.xlsx.

——2024f. *National Transportation Statistics*, Table 4-2, "U.S. Consumption of Energy from Primary Sources by Sector". Available at https://www.bts.gov/sites/bts.dot.gov/files/2024-07/table_04_02_072324.xlsx.

——2024g. Vehicle Inventory and Use Survey (VIUS). Available at https://www.bts.gov/vius.

——2024h. eVIUS - The Electric Vehicle Inventory and Use Survey. Available at https://www.bts.gov/browse-statistical-products-and-data/surveys/evius/evius-electric-vehicle-inventory-and-use-survey.

California Energy Commission. 2024. "New ZEV Sales in California." Available at https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics-collection/new-zev.

Chargelab. 2024. "Industry survey: 500 EV drivers on public charging," *Winter Edition 2024*. Available at https://chargelab.co/lp/ev-driver-survey-winter-2024.

Cherry, C., S. Dietz, E. Sauber-Schatz, S. Russell, J. Proctor, and D. Buttke. 2019. "Characteristics of animal-related motor vehicle crashes in select National Park Service units – United States, 1990-2013," *Traffic Injury Prevention: 20*(1): 58–63.

Davis, S., and R. Boundy. 2022. *Transportation Energy Data Book*, Edition 40. ORNL/TM-2022/2376, Oak Ridge National Laboratory. Available at https://tedb.ornl.gov/.

Edmunds

——2024a. "How many electric cars are there in the U.S.?" Available at https://www.edmunds.com/electric-car/articles/how-many-electric-cars-in-us.html#:~:text=1/5/2024(updated,million%20EVs%20on%20U.S.%20roads.

——2024b. "Edmunds EV Charging Test: How fast does each EV charge?" Available at https://www.edmunds.com/car-news/electric-car-charging.html.

Energy Information Administration (EIA)

——2024a. *Monthly Energy Review*. July 29, 2024. Table 2.5 Transportation Sector Energy Consumption, Table 3.1 Petroleum Overview. Available at https://www.eia.gov/totalenergy/data/monthly/.

——2024b. *U.S. electricity consumption by light-duty vehicles likely surpassed rail in 2023*, May 23, 2024, Available at https://www.eia.gov/todayinenergy/detail.php?id=62083#:~:text=Estimated%20annual%20electricity%20consumption%20by,about%20the%20same%20in%202018.

——2024c. *Electric Power Monthly*, data for May 2024, Table D.1 and Appendix D. Electric Vehicle Consumption. Available at https://www.eia.gov/electricity/monthly/pdf/AppendixD.pdf.

——2024d. Annual Energy Outlook 2024, Tables 36 and 37, Available at https://www.eia.gov/outlooks/aeo/tables_ref.php.

——2024e. *Monthly Energy Review*. August 2024. Tables 3.7c and 10.2c, Available at https://www.eia.gov/totalenergy/data/monthly.

——2024f. "U.S. production capacity for sustainable aviation fuel to grow." Available at https://www.eia.gov/todayinenergy/detail.php?id=62504.

——2024g. "How much shale (tight) oil is produced in the United States?" Available at https://www.eia.gov/tools/faqs/faq.php?id=847&t=6.

——2024h. Petroleum Supply Monthly, "U.S. Field Production of Natural Gas Liquids." Available at https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=m_epl2_fpf_nus_mbbld&f=m.

Energy Institute. 2024. *Statistical Review of World Energy*. Available at https://www.energyinst.org/statistical-review.

Fanijo, E., J. Kolawole, A. Babafemi, and J. Liu. 2023. "A comprehensive review on the use of recycled concrete aggregate for pavement construction: Properties, performance, and sustainability," *Cleaner Materials 9*: 100199. Available at https://doi.org/10.1016/j.clema.2023.100199.

Federal Aviation Administration (FAA)

——2023a. *Accelerating to the Future: The FAA's CLEEN Research Initiative.* Available at https://www.faa.gov/sustainability/accelerating-future-cleen-research.

——2023b. *NextGen Annual Report Fiscal Year 2023*. Available at https://www.faa.gov/nextgen/NextGen-Annual-Report-2023.pdf.

Federal Highway Administration (FHWA)

——2023. *Traffic Volume Trends*, December 2023, table 23dctvt Data. Available at https://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm.

——2008. *Wildlife-Vehicle Collision Reduction Study: Report to Congress*, FHWA-HRT-08-034. Available at https://www.fhwa.dot.gov/publications/research/safety/08034/.

Ge, Y., C. Simeone, A. Duvall, and E. Wood. 2021. *There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure,* Technical Report NREL/TP-5400-81065, National Renewable Energy Laboratory. Available at https://www.nrel.gov/docs/fy22osti/81065.pdf.

Greene, D. L., C. B. Sims, and M. Muratori. 2020. "Two trillion gallons: Fuel savings from fuel economy improvements to US light-duty vehicles, 1975–2018," *Energy Policy, 142*:111517. Available at https://doi.org/10.1016/j.enpol.2020.111517.

Hertz, J. 2024. "Solid-State Battery Breakthrough for Ships and Aircraft," *EEPower*. Available at https://eepower.com/news/solid-state-battery-breakthrough-for-ships-and-aircraft/#.

Hynes, M., A. Krippen, K. Lemons, and E. Varnell. 2024. *Zeroing in on Zero-Emission Buses*, CALSTART. Available at https://calstart.org/wp-content/uploads/2024/02/Zeroing-in-on-ZEBs-2024_Final-022324a.pdf.

IIHS HLDI. 2024. "Fatality Facts 2022: Collisions with fixed objects and animals," June 2024. Available at https://www.iihs.org/topics/fatality-statistics/detail/collisions-with-fixed-objects-and-animals.

International Maritime Organization (IMO). 2023. "2023 IMO Strategy on Reduction of GHG Emissions from Ships," *Resolution MEPC, 377*(80) adopted July 7, 2023. Available at https://www.imo.org/en/OurWork/Environment/Pages/IMO-Strategy-on-reduction-of-GHG-emissions-from-ships.aspx.

International Energy Agency (IEA)

——2024. "Trends in Electric Cars," *Global EV Outlook 2024*. Available at https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-cars.

——2021. *The Role of Critical Minerals in Clean Energy Transitions*. Available at https://www.iea.gov/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

International Tanker Owners Pollution Federation (ITOPF). 2024. "Oil Tanker Spill Statistics 2023." Available at https://www.itopf.org/knowledge-resources/data-statistics/statistics/.

Jin, R., and Q. Chen. 2015. "Investigation of concrete recycling in the U.S. construction industry," *Procedia Engineering, 118*: 894–901.

Johnson, A., and J. Jacobs. 2024. "The Missing Midstream: Identifying Investment Challenges for American Critical Minerals Processing." Bipartisan Policy Center. Available at https://bipartisanpolicy.org/report/the-missing-midstream-identifying-investment-challenges-for-american-critical-mineral-processing-projects/.

Joint Office of Energy and Transportation (JOET). 2023. "Electrifying he U.S. Transportation System with the Joint Office." Available at https://driveelectric.gov/files/electrifying-transportation-system.pdf.

Kaushal, S., G. Likens, M. Pace, and M. Grese. 2018. "Freshwater salinization syndrome on a continental scale," *Proceeding of the National Academy of Sciences, 115*(4), E574–E583. Available at https://doi.org/10.1073/pnas.1711234115.

Khatib, M. 2024. "EV drivers in 36 states pay a surplus of fees each year," *EVHub*, Atlas Public Policy. Available at https://www.atlasevhub.com/data_story/ev-drivers-in-36-states-pay-a-surplus-of-fees-each-year/.

Lee, J., D. Chakraborty, S. Hardmann, and G. Tal, 2020. “Exploring electric vehicle charging patterns: Mixed usage of charging infrastructure,” *Transportation Research D: Transport and the Environment, 79*: 102249.

Lommele, S., R. Desai, C. Johnson, A. Snelling, A. Brown, M. Singer, J. Bennett, J. Cappellucci, J. Levene, and C. Hoehne. 2024. *Assessment of Alternative Fueling Infrastructure in the United States*, Technical Report NREL/TP-5400-88513. Available at https://research-hub.nrel.gov/en/publications/assessment-of-alternative-fueling-infrastructure-in-the-united-st.

Manzi, P. 2023. “NADA Market Beat: 2023 New Light-Vehicle Sales Reach 15.46 Million Units.” National Automobile Dealers Association. Available at https://www.nada.org/nada/nada-headlines/nada-market-beat-2023-new-light-vehicle-sales-reach-1546-million-units.

Münzel, T., M. Molitor, M. Kuntic, O. Hahad, M. Röösli, N. Englemann, M. Basner, A. Daiber, and M. Sørensen. 2024. “Transportation Noise Pollution and Cardiovascular Health,” *Circulation Research, 134*(9): 1,113–1,135.

North American Bikeshare and Scootershare Association. 2024. *5th Annual Shared Micromobility State of the Industry Report*. Available at https://doi.org/10.7922/G2DF6PKP.

National Asphalt Pavement Association. 2024. *Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage*, Information Series 138. Available at https://napanow.org/2024/05/13/napa-publishes-latest-recycling-wma-survey-results/.

National Association of City Transportation Officials. 2023. “130 Million Trips: Shared Micromobility in the U.S. and Canada.” Available at https://nacto.org/publication/shared-micromobility-in-2022/.

National Highway Traffic Safety Administration (NHTSA)

——2024. “Corporate Average Fuel Economy Standards for Passenger Cars and Light Trucks for Model Years 2027 and Beyond and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030 and Beyond,” *Federal Register, 89*(121), 52540–52954.

——2022. “Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks,” *Federal Register, 87*(84), 25731–26092.

——2012. “2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards,” *Federal Register, 77*(199), 62624–63200.

National Oceanographic and Atmospheric Administration (NOAA). 2024. L*argest Oil Spills Affecting U.S. Waters Since 1969*. Available at https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/largest-oil-spills-affecting-us-waters-1969.html.

National Renewable Energy Laboratory (NREL). 2022. *2022 Standard Scenarios Report: A U.S. Electricity Sector Outlook*. Available at https://www.nrel.gov/docs/fy23osti/84327.pdf.

Nerd Collective. 2024. “Electric Bicycle Market Insights From Industry Experts.” Available at https://www.peopleforbikes.org/news/electric-bicycle-market-insights-2024.

Pan, S., Z. Li, and Y. Ju. 2024. “LFP batteries extend dominance over NCM batteries in China,” Fastmarkets. Available at https://www.fastmarkets.com/insights/lfp-batteries-extend-dominance-over-ncm-batteries-china/.

Rogers, E. M. 1962. *Diffusion of Innovations*. The Free Press, Macmillan, New York.

Rosenberg, A. and A. M. Leitão. 2024. “Mapping of Zero-Emission Pilots and Demonstration Projects,” *Global Maritime Forum*. Available at https://globalmaritimeforum.org/report/mapping-of-zero-emission-pilots-and-demonstration-projects-fifth-edition/.

State Farm. 2023. “New State Farm™ data reveals the likelihood of hitting an animal while driving in every state.” Available at https://newsroom.statefarm.com/likelihood-of-hitting-an-animal-while-driving/.

Tal, G., et al. 2020. *Advanced Plug-in Electric Vehicle Travel and Charging Behavior Final Report,* U.C. Davis Plug-in Hybrid and Electric Vehicle Research Center. Available at https://csiflabs.cs.ucdavis.edu/~cjnitta/pubs/2020_03.pdf.

U.S. Department of Commerce (USDOC). 2024. “About the Critical Minerals Subcommittee.” Available at https://www.criticalminerals.gov/pages/about.

U.S. Department of Energy (USDOE)

——2024a. “Sector Spotlight: Critical Minerals,” Loan Programs Office. Available at https://www.energy.gov/lpo/articles/sector-spotlight-critical-minerals.

——2024b. “Petroleum Equivalent Fuel Economy Calculation,” *Federal Register, 89*(62), 22041–22060. Available at https://www.govinfo.gov/content/pkg/FR-2024-03-29/pdf/2024-06101.pdf.

——2024c. “Alternative Fueling Station Locator,” Alternative Fuels Data Center. Available at https://afdc.energy.gov/stations#/analyze?country=US&fuel=ELEC&ev_levels=dc_fast&access=public&access=private&tab=fuel&region=US-CA.

——2024d. “Renewable Diesel,” Alternative Fuels Data Center. Available at https://afdc.energy.gov/fuels/renewable-diesel.

——2024e. *Cost-Effective Freight Transport of Carbon-Dioxide – Status and Opportunities,* Report to Congress, Office of Fossil Energy and Carbon Management.

——2024f. “Freight and Last-Mile Delivery,” Alternative Fuels Data Center. Available at https://afdc.energy.gov/conserve/freight.

U.S. Department of State, Executive Office of the President. 2021. *The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050*. Available at https://www.whitehouse.gov/wp-content/uploads/2021/10/us-long-term-strategy.pdf.

U.S. Department of Transportation (USDOT)

——2024a. "Community Benefits of Urban Mobility Electrification." Available at https://www.transportation.gov/urban-e-mobility-toolkit/e-mobility-benefits-and-challenges/community-benefits.

——2024b. "Active Transportation." Available at https://www.transportation.gov/mission/office-secretary/office-policy/active-transportation/active-transportation.

——2022. "USDOT Announces New Vehicle Fuel Economy Standards for Model Year 2024–2026." Available at https://www.transportation.gov/briefing-room/usdot-announces-new-vehicle-fuel-economy-standards-model-year-2024-2026#:~:text=Strong%20fuel%20economy%20standards%20strengthen%20U.S.%20energy%20independence,approximately%205%20million%20barrels%20a%20day%20since%20then.

U.S. Environmental Protection Agency (USEPA)

——2024a. "What is Sustainability." Available at https://www.epa.gov/sustainability/learn-about-sustainability. 8/8/2024.

——2024b. *2023 Automotive Trends Report*. Available at https://www.epa.gov/automotive-trends/explore-automotive-trends-data.

——2024c. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2022*. Available at https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf.

——2024d. "Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles—Phase 3," *Federal Register, 89*(78), 29440–29831. Available at https://www.govinfo.gov/content/pkg/FR-2024-04-22/pdf/2024-06809.pdf.

——2024e. "Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light- Duty and Medium-Duty Vehicles," *Federal Register, 89*(76), 27842–28215. Available at https://www.govinfo.gov/content/pkg/FR-2024-04-18/pdf/2024-06214.pdf.

——2024f. *Our Nation's Air: Trends Through 2023*. Available at https://gispub.epa.gov/air/trendsreport/2024/#home.

——2024g. "Clean Air Act Title IV – Noise Pollution." Available at https://www.epa.gov/clean-air-act-overview/clean-air-act-title-iv-noise-pollution.

——2024h. "Underground Storage Tanks (USTs)." Available at https://www.epa.gov/ust.

——2024i. *Final Standards to Reduce Greenhouse Gas Emissions from Heavy-Duty Vehicles for Model Year 2027 and Beyond*. Available at https://www.epa.gov/system/files/documents/2024-04/420f24018.pdf.

——2020. "Advancing Sustainable Materials Management: 2018 Fact Sheet." Available at https://www.epa.gov/sites/default/files/2021-01/documents/2018_ff_fact_sheet_dec_2020_fnl_508.pdf.

——2017. "Processing End-of-Life Vehicles," EPA530-R-15-007. Available at https://www.epa.gov/sites/default/files/2020-10/documents/eol_vehicle_guide_final_english.pdf.

U.S. Geological Survey (USGS)

——2024. "SALT," *Mineral Commodities Summaries*. Available at https://pubs.usgs.gov/periodicals/mcs2024/mcs2024.pdf.

——2000. *Recycled Aggregates—Profitable Resource Conservation*, Fact Sheet FS-181-99. Available at https://pubs.usgs.gov/fs/fs-0181-99/fs-0181-99so.pdf.

U.S. Tire Manufacturers Association. 2022. "2021 US Scrap Tire Management Summary." Available at https://www.ustires.org/tire-recycling-markets.

Usman, T., L. P. Fu, and L. F. Miranda-Moreno. 2010. "Quantifying safety benefit of winter road maintenance: accident frequency modeling." *Accident Analysis and Prevention, 42*: 1878-87.

Vault Consulting. 2023. *National Recycling Rate Study*. Available at https://batterycouncil.org/resource/national-recycling-rate-study/.

Villamagna, A., E. Laflamme, and H. Kim, 2024. *Wildlife Vehicle Collisions Data Gathering and Best Management Practices*, FHWA-NH-RD-42372I. Available at https://mm.nh.gov/files/uploads/dot/remote-docs/nhdot-research-42372i-2024-report.pdf.

Vosper, R. 2024. "Vosper: E-bikes step up in a down market," *Bicycle Retailer and Industry News*. Available at https://www.bicycleretailer.com/opinion-analysis/2024/03/11/vosper-e-bikes-step-down-market.

White House. 2021. *Fact Sheet: Biden Administration Advances the Future of Sustainable Fuels in American Aviation*. Available at https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/09/fact-sheet-biden-administration-advances-the-future-of-sustainable-fuels-in-american-aviation/.

Yeh, S., D. Burtraw, T. Sterner, and D. Greene. 2021. "Tradable performance standards in the transportation sector," *Energy Economics, 102*. Available at https://doi.org/10.1016/j.eneco.2021.105490.

CHAPTER 7

STATE OF TRANSPORTATION STATISTICS

The transportation community is embracing data-based decision making, embodied in the Foundations for Evidence-Based Policymaking Act [Pub. L. 115-435], as it confronts the rapidly evolving issues and challenges described in the preceding chapters 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.

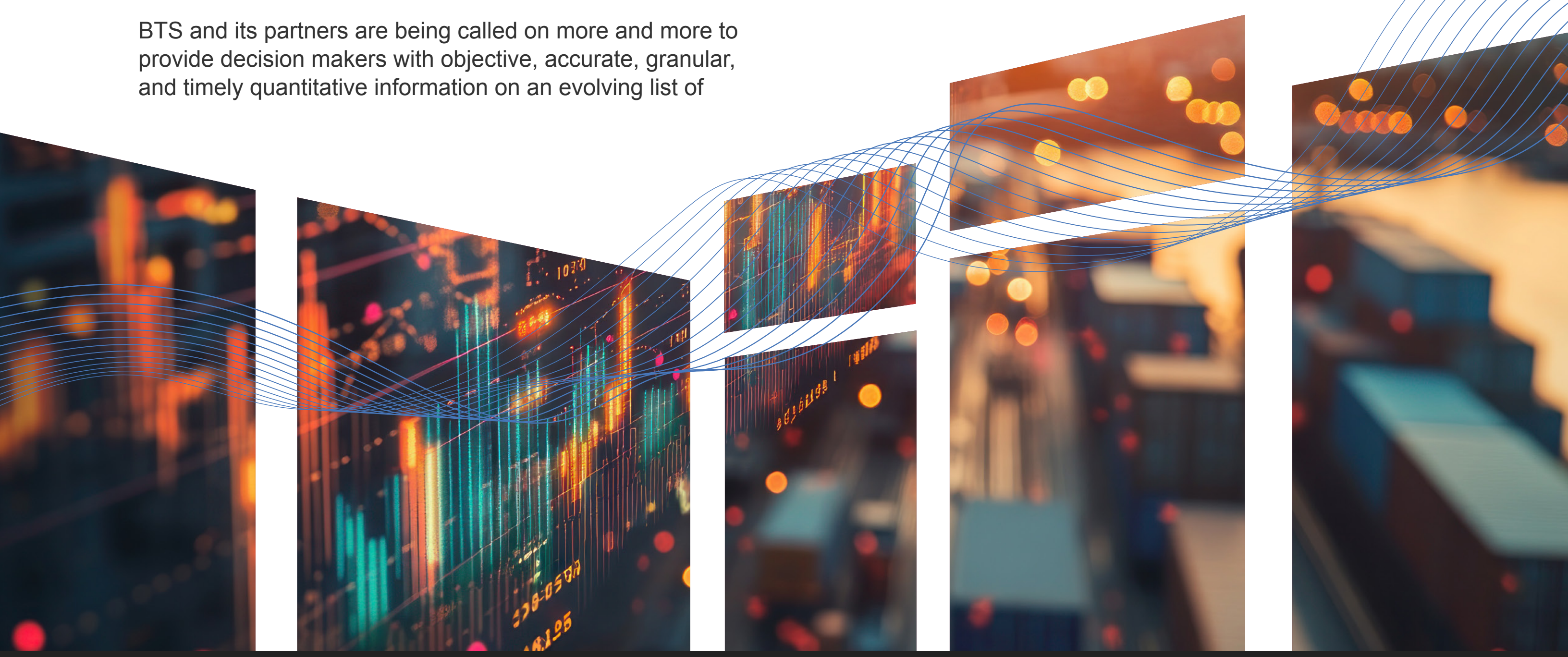
This information includes the changing logistical demands of the economy and households—demands that are altering traditional patterns of freight movement and passenger travel. Increased concerns with transportation for historically underserved areas place a renewed emphasis on statistics about transportation users and the effects of transportation on surrounding communities. Disruptions, like those that resulted from the Key Bridge collapse, underscore long-standing concerns with transportation system vulnerability and resilience, adding to the enduring needs for data on 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.

Progress Toward Meeting Information Needs

BTS and its partners are being called on more and more to provide decision makers with objective, accurate, granular, and timely quantitative information on an evolving list of transportation concerns. For example, decision makers need such information to deal with the changing logistical demands of the economy and households that affect traditional patterns of freight movement and passenger travel. Increased concerns with transportation for historically underserved areas place a renewed emphasis on statistics about transportation users and the effects of transportation on surrounding communities. Weather-related disruptions and cyber issues highlight the need for data on vulnerability and resiliency, adding to the long-standing needs for data on transportation system condition and performance.

Transportation System and Resilience

The state of the transportation system includes the connectivity provided by transportation facilities, equipment, and services; the condition of facilities and equipment, which affects the future connectivity of the transportation



system; the use of the transportation system for moving freight and passengers throughout the Nation; and the resilience of the system to resume services and operations after disruptions. The state of the transportation system also includes the health impacts of its use and whether the system can provide sustainable mobility and geographic accessibility in the future.

In 2023, BTS launched the Transportation Vulnerability and Resilience (TVAR) Data Program. TVAR aims to provide data and tools to help local and state agencies assess and respond to natural, manufactured, and cybersecurity threats to transportation infrastructure. The TVAR program responds to the Transportation Research Board's 2021 Consensus Study Report, which recommended the development and dissemination of data and tools to support decision-making for infrastructure resilience [TRB 2021].

How effective transportation systems move people and goods between locations depends partially on the spatial locations of transportation facilities and services, urban infrastructure, and land use. When spatial information on transportation facilities and services is superimposed with demographic information, such as the location of electric car charging stations in rural counties, it becomes possible to measure the system's effects on neighborhoods and neighboring locations. As such, spatial information for transportation modal networks and intermodal terminals is crucial.

From multiple sources, BTS compiles a set of nationwide geographic datasets of transportation facilities, transportation networks, and associated infrastructure in the National Transportation Atlas Database (NTAD). These datasets include spatial information for transportation modal networks and intermodal terminals as well as related attribute information for these features. In 2024, NTAD had about 90 datasets, including 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 NTAD, BTS created the National Transportation Noise Map, with data showing potential exposure at state and county levels to aviation, highway, and rail noise across the country. All NTAD layers are updated on a continuous basis.

Several statistical shortcomings and spatial data gaps must be addressed to properly inform investments in transportation infrastructure, equipment, and services:

- Data, particularly artificial intelligence (AI)-responsible data, and standards are crucial for the development of the high-density (HD) maps. HD mapping is core for the safe deployment of future highly automated transportation systems.

- Data on infrastructure, from truck parking availability to refueling and recharging stations, are essential for understanding how vehicles can make full use of the Nation's extensive highway network.

- Data on the deployment of traffic control devices and connected vehicle infrastructure enhance our understanding of how these technologies affect the capacity of highway infrastructure.

- 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.

Passenger Transportation

To guide and support investments in passenger transportation and passenger transportation services management, decision makers and the public need statistics to answer three basic questions:

1. Is the transportation system 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 develops or supplements statistics from the Federal Highway Administration (FHWA) for household travel patterns, the Census Bureau for commuting data, and the Bureau of Labor Statistics (BLS) for household expenditures on personal travel with the following:

- An extensive set of statistics on passenger travel on commercial aviation, including the monthly number of passengers by flight and airport, costs of airline tickets, and flight delay and cancellations by cause [BTS 2024i].

- Numbers of people crossings the Canadian and Mexican borders [BTS n.d.a].
- Travel patterns on the Nation's ferry system [BTS n.d.c].

To understand how households with different socioeconomic characteristics are affected by transportation expenses, BTS estimated transportation costs by combining data from several sources [BTS n.d.e]. BTS also publishes statistics on average airline ticket fares by airport pairs [BTS 2024a] and estimates transportation's share of inflation [BTS n.d.d].

BTS and its partners have been experimenting with new types of data, such as anonymized location-based services information 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 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 the characteristics of residents in the presumed home of the traveler. Access to data from mobile devices may be precluded 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 demographic and economic characteristics of travelers, even with declining response rates.

Despite the progress and the experiments with new types of data and innovative analytics, transportation statistics are still needed to provide the following:

- Comprehensive measures on long-distance travel (including travel by foreign visitors), which are essential to understand the demand for intercity and local transportation facilities and services.

- Statistics to understand changes in daily travel potentially caused by the evolving patterns of work at home (WAH). Lack of this understanding hinders the management of the Nation's transportation systems to mitigate recurring congestions and the implementation of strategies to encourage transit usage.

- Estimates of trips not taken because of concerns over availability, safety, personal security, costs, or other aspects of transportation and the value of that lost demand to the affected individuals and to goods and services providers.

- Estimates of travel affected by disruptions to the transportation system and the impact of those disruptions on consumer satisfaction and on system vulnerability and resilience assessments.

Freight Transportation and Supply Chains

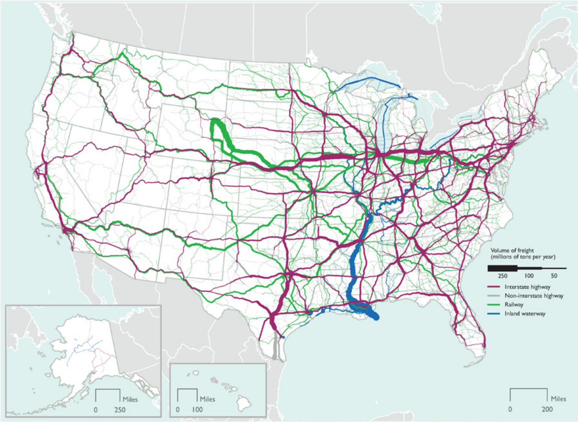
To guide and support investments in freight transportation and supply chain resilience, decision makers and the public need basic and detailed statistics on the quantity and value of freight movement by commodity type and geography, the cost and timeliness of freight movement, and the economic activities served.

Specifically, statistics are needed to understand the following:

- Whether the logistical needs of society and the economy are being met effectively.
- Whether the transportation system is strengthening interstate commerce, national defense, and international competitiveness.
- Whether freight movement is impeding passenger travel, affecting safety, or contributing to environmental health problems and related issues.
- Whether the freight transportation system and supply chains can sustain and recover from disruptions from all hazards.

To answer these questions, BTS made significant progress over the years in freight data programs, such as the following:

- Freight Analysis Framework (FAF) Program estimates an annual comprehensive picture of the value and weight of 42 different commodity categories moved within the United States. In addition to the value and weight, FAF estimates from where to where and by what modes each commodity category is moved [BTS 2024c].



Source: Highway—U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.3.1, 2015. Rail—Based on Surface Transportation Board, Annual Carload Waybill Sample and rail freight flow assignment done by Oakridge National Laboratory, 2018. Inland Waterway.

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

- FAF program is based on integrating multiple data sources, one of which is the Commodity Flow Survey (CFS). The CFS, conducted every 5 years by BTS in collaboration with the Census Bureau, measures 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 [BTS 2024b]. Another data source for FAF is the Transborder Freight Data Program, which provides a detailed picture of freight movement at border crossings with Canada and Mexico [BTS 2024h]. For air cargo, FAF uses monthly air cargo tonnage, categorized by flight and airport, collected by BTS [BTS 2021].

- On maritime freight, BTS' Port Performance Freight Statistics program provides information on the throughput and capacity of the Nation's top 25 ports by value and volume of goods moved [BTS 2024f].

- In response to the 2021 supply chain disruptions, the U.S. Department of Transportation (USDOT) and freight industry initiated an information sharing program where supply chain stakeholders voluntarily contribute data to BTS on import and export containers and the availability of assets to move those containers. The program is called Freight Logistics Optimization Works (FLOW). Data shared with BTS by FLOW participants is treated confidentially and protected by BTS under the Confidential Information Protection and Statistical Efficiency Act of 2018 (CIPSEA), codified as amended at Title 44 U.S.C. §§ 3561–3583 and enacted as title III of the Foundations for Evidence-Based Policymaking Act of 2018, Pub. L. 115-435 (Evidence Act). Confidential data will be anonymized before evidence is built to inform decisions. Experience with the FLOW initiative should provide opportunities to create comprehensive statistics on timeliness, reliability, or cost of freight movement for the freight system.

- As a parallel effort during the 2021 supply chain disruptions, BTS led an interagency group to compile over 40 weekly or monthly measures to monitor how the disruptions impact supply chain activities, ranging from port congestion inside and outside the gate to transportation labor and capacity shortage [BTS 2024e].

The ability to answer basic questions from decision makers and the public is limited by the following:

- Lack of freight flow estimates for geographic granularity smaller than metropolitan regions.
- Limited data on the domestic transportation of U.S. foreign trade.
- Limited data on freight shipping costs.
- Limited data on last-mile freight movements.
- Limited data on freight system performance.
- Partial data on the availability of transportation equipment and labor to move freight.

Planned improvements to FAF will increase the geographic granularity of statistics (the level of detail or precision at which geographic data is collected) on the value and weight of commodities being moved by mode and region. Models are under development that will assign freight flows among regions to the multimodal freight network. These developments 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 passes through a region and affects local infrastructure needs.

Safety

Safety is an issue that transcends the passenger and freight transportation systems. Every modal administration within USDOT has major safety data programs or supports safety data programs across the country. While extensive data exist on most transportation crashes and their consequences, data is limited for the following:

- Data 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; travel during unsafe conditions around sunrise, sunset, and bad weather; and travel on new micromobility options and by pedestrians.
- Precursor (i.e., close call) 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 [BTS n.d.b]. BTS also collects data on the conversion of the railroad tank car fleet to safer equipment standards [BTS 2024d]. Most importantly, BTS deploys its special capabilities to protect respondent confidentiality in order to obtain sensitive information on precursor safety, including close calls and near misses [BTS 2024j].

Title III of the Evidence Act, also known as CIPSEA [Pub. L. 115-435], authorizes BTS and its agents to protect respondents to BTS data collections from direct or indirect identification. BTS uses this confidentiality protection in its near-miss and other precursor safety data programs 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.[1] The safety precursor data collects data on information about near miss events, which include narrowly avoided accidents (i.e., close calls) that could have occurred but did not. With an original focus on the railroad and airline industries, the program has been expanded to include transit and maritime.

The Washington Metropolitan Area Transit Authority (WMATA), the regional bus and rail transit operator for the Nation's capital, has sponsored the program since 2012. The program has identified and rectified precursor safety problems, preventing more serious incidents (e.g., fatalities) from happening. BTS is working with the Southeastern Pennsylvania Transit Authority to implement a version of the WMATA safety precursor data program in Philadelphia. These safety data precursor programs inspired a similar program for the maritime industry: SafeMTS. SafeMTS, a collaboration with the USDOT's Maritime Administration, empowers maritime industry to voluntarily and confidentially share information about near miss events, which include narrowly avoided collisions or other accidents that could have occurred but did not. SafeMTS helps all participants identify early warnings of safety problems and develop strategies to avoid more serious incidents.

Transportation Economics and Financial Statistics

The consequences of transportation for the economy and global competitiveness is another issue that transcends the passenger and freight transportation systems. The share of the national economy attributable to transportation is well documented, but the production of goods, services, and jobs that are stimulated by transportation investments and services is only partially understood.

In collaboration with the BLS and the Bureau of Economic Analysis (BEA), BTS provides major sources 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 [BTS n.d.g]. A cornerstone of economic statistics is the Transportation Satellite Account, which extends the national accounts produced by BEA to include in-house freight activity (e.g., the trucking operations of grocery stores) and household transportation to create a more complete picture of transportation's role in the economy.

Transportation activities have a strong relationship to the economy, and freight transportation has been characterized as a potential leading indicator of economic activity. The Transportation Services Index gauges that relationship by estimating total for-hire freight activities [BTS n.d.f].

Major shortcomings in current statistics include the following:

- 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.
- Timely statistics on government revenue and expenditures related to transportation.
- An effective accounting of innovative finance in transportation, such as public–private partnerships.

To address some of these shortcomings, BTS embarked on an initiative to improve financial statistics. A new Transportation Public Finance Statistics program uses forecasting techniques as a first step in improving the timeliness of financial data [BTS 2024g]. BTS is also participating in a governmentwide effort to update the Standard Occupation Classification system for improved employment statistics.

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" [Title 44 U.S.C. § 3561]. At least three elements are crucial to evidence building: (1) data and related statistical quality issues, (2) analytical methods, and (3) workforce capacity.

Data Sources and Analytical Methods

The need to inform decisions with timely statistical data in the face of increased survey costs and declining survey response rates compels BTS and other statistical agencies to explore alternatives and supplements to surveys, such as electronic administrative records and sensor-based data. 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

1 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.

join traditional disciplines of statistics, economics, geography, and information and library science as necessary skills for evidence building.

Many of the new methods for understanding patterns, trends, and insights from massive or unstructured data fall under the label of AI. Data science, AI, and related methodological developments are extending traditional methods of statistical analysis with new opportunities to extract useful information from large amounts of structured and unstructured data.

BTS and its partners are exploring and applying AI and other data science techniques that include, but are not limited to, improving data quality and website content search, reducing reporting burden of various surveys, and extracting insights from the vast flow of messages streaming through the air traffic control system. Specifically, BTS is experimenting with new analytics technology that could enable analysts to find and extract key statistics from multiple data files and thousands of documents in seconds. Speech recognition and large language models can turn a spoken question into a sophisticated data query, achieving the science fiction vision of person-computer interaction imagined decades ago in the television show *Star Trek*™.

Statistical Quality Issues

While new data sources and new analytical methods offer great promise, they require experimentation and careful evaluation to uncover potential biases and other pitfalls. Does a cluster of cell phone tracks indicate a group of travelers or a single traveler with multiple devices? How to develop AI-ready data? How do biases in the data used to train models based on machine learning propagate through applications of the models? Can queries of complex transportation datasets generated from a spoken sentence incorporate nuances of the data that are captured in carefully tailored tabulation routines developed by transportation experts?

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 novel analytical methods, and to understand the fitness of use for those statistics [FCSM 2020]. BTS foresees many challenges in developing safe and responsible AI applications and understanding the quality of those applications.

The quality of the statistics cited in this report involves more than the coverage and granularity that are featured. Are the statistics relevant to decision makers and the public? Do the statistics capture what they are intended to measure? Are the statistics timely, especially when measuring a rapidly changing phenomenon? Are the statistics accurate and precise? Are the statistics free of bias and from politically motivated adjustments?

The data and analytical methods that underlie most statistics involve tradeoffs among dimensions of quality. The president of the University of Wisconsin, T.C. Chamberlin, touched on tradeoffs in data quality when he wrote in 1890:

> It may be better, in the gross affairs of life, to be less precise and more prompt. Quick decisions, though they may contain a grain of error, are often better than precise decisions at the expense of time. [Chamberlin 1890]

Professor Chamberlin's philosophy is reflected in Federal Statistical System's consideration of accuracy, timeliness, relevance, and other aspects of data quality [FCSM 2020]. To support quick decisions through prompt statistics, BTS shifted from carefully measured monthly and annual statistics to weekly approximations that identified rapid and large changes in transportation during the COVID-19 pandemic. Senior officials in the department relied heavily on the weekly approximations that proved more than adequate to reflect changing transportation conditions. To improve data timeliness, BTS developed models to produce preliminary estimates, significantly reduced the time lapse.

Statistics are only useful if decision makers and the public trust the numbers to be relevant and timely, credible and accurate, and objective. Useful statistics also require the trust of voluntary respondents to data collection requests that the confidentiality of their information will be protected. BTS adheres to these principals as one of the principal federal statistical agencies covered by the Evidence Act and the Trust Regulation [Fed. Reg. 2024-23536].

Workforce Capacity

The expanded skills required to meet these challenges are 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 are" [USDOT 2022, p. 11].

Meeting State and Local Data and Analytics Needs

Historically, BTS focuses its programs to meeting national 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.

Looking Ahead

Throughout its history, BTS has collaborated 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. The COVID-19 pandemic encouraged the evolution of BTS from a focus on annual statistics published through printed reports to a focus on rapid statistics continuously updated and released online. 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.

While continuing to face long-standing challenges in responding to the data limitations outlined in this report, BTS and its partners face new challenges brought about by the widespread adoption of digital technologies that alter our travel behavior and connect thousands of assets to each other and to infrastructure, the potential “new normal” post COVID-19, and the digital transformation where transportation is evolving to a system of highly automated networks and systems. Challenges brought about by that evolution demand BTS and its partners transform their mindsets in designing statistical products and methods—changes that are needed to inform an ever evolving decision making process, to safeguard the development of AI responsible data, and to measure and mitigate AI bias in building future evidence.

References

Bureau of Transportation Statistics (BTS)

——no date a. Border Crossing Data. Available at https://data.bts.gov/stories/s/jswi-2e7b.

——no date b. *National Transportation Statistics*. Available at https://www.bts.gov/topics/national-transportation-statistics.

——no date c. Passenger Travel. Available at https://www.bts.gov/topics/passenger-travel.

——no date d. “Inflation and Transportation,” *Transportation Economic Trends*. Available at https://data.bts.gov/stories/s/f9jm-cqwe.

——no date e. “Transportation Cost Burden: Cost Burden Concepts,” *Transportation Economic Trends*. Available at https://data.bts.gov/stories/s/Transportation-Cost-Burden-Concepts/bpj8-8amm/.

——no date f. “Transportation as an Economic Indicator: Transportation Services Index,” *Transportation Economic Trends*. Available at https://data.bts.gov/stories/s/Transportation-as-an-Economic-Indicator/9czv-tjte.

——no date g. Transportation and the Economy. Available at https://www.bts.gov/topics/transportation-and-economy.

——2024a. Air Fares. Available at https://www.bts.gov/air-fares.

——2024b. Commodity Flow Survey. Available at https://www.bts.gov/cfs.

——2024c. Freight Analysis Framework. Available at https://www.bts.gov/faf.

——2024d. “Fleet Composition of Rail Tank Cars Carrying Flammable Liquids Annual Reports.” Available at https://www.bts.gov/surveys/annual-tank-car-facility-survey/fleet-composition-rail-tank-cars-carrying-flammable-liquids.

——2024e. “Latest Supply Chain and Freight Indicators.” Available at https://www.bts.gov/freight-indicators.

——2024f. “Port Performance Freight Statistics Program.” Available at https://www.bts.gov/ports.

——2024g. “Transportation Public Finance Statistics (TPFS).” Available at https://www.bts.gov/tpfs.

——2024h. “TransBorder Freight Data.” Available at https://data.bts.gov/stories/s/myhq-rm6q.

——2024i. ”Quick links to popular air carrier statsitics.” Available at https://www.bts.gov/topics/airlines-and-airports/quick-links-popular-air-carrier-statistics.

——2024j. “Close Call Data Program.” Available at https://www.bts.gov/close-call.

——2021. ”Air Cargo.” Available at https://www.bts.gov/topics/freight-transportation/air-cargo.

Chamberlin, T.C. 1890. “The Method of Multiple Working Hypotheses,” *Science*.

Federal Committee on Statistical Methodology (FCSM). 2020. *A Framework for Data Quality*. Available at https://www.fcsm.gov/assets/files/docs/FCSM.20.04_A_Framework_for_Data_Quality.pdf.

Federal Register 2024-23536. Fundamental Responsibilities of Recognized Statistical Agencies and Units. Available at https://www.federalregister.gov/documents/2024/10/11/2024-23536/fundamental-responsibilities-of-recognized-statistical-agencies-and-units.

Public Law 115-435, Foundations for Evidence-Based Policymaking Act of 2018. Available at https://uscode.house.gov/statutes/pl/115/435.pdf.

Public Law 117-58, Infrastructure Investment and Jobs Act. Available at https://uscode.house.gov/statutes/pl/117/58.pdf.

Title 44 U.S.C. § 3561, Definitions. Available at https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title44-section3561&num=0&edition=prelim.

Transportation Research Board (TRB). 2021. *The Role of Transit, Shared Modes, and Public Policy in the New Mobility Landscape* (Consensus Study Report). Available at https://nap.nationalacademies.org/catalog/26053/the-role-of-transit-shared-modes-and-public-policy-in-the-new-mobility-landscape.

U.S. Department of Transportation (USDOT). 2022. *Capacity Assessment*. Available at https://www.transportation.gov/mission/budget/capacity-assessment.

APPENDIX A

LEGISLATIVE RESPONSIBILITIES

The Bureau of Transportation Statistics compiles these and other statistics as required by Title 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.
XII. Consequences of transportation for the human and natural environment.

B

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 the Bureau of Transportation Statistics, 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 the Bureau of Transportation Statistics 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 (NHTSA), 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 report does not include the 3,100 motor vehicle deaths that occur outside public roadways [e.g., 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 from 1988 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 NHTSA's *Overview of the 2022 Crash Investigation Sampling System*.[1]

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.

1 NHTSA. 2023. *Overview of the 2022 Crash Investigation Sampling System*, Report No. DOT HS 813 526. Available at https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813526.

U.S. Department of Transportation

Office of the Secretary of Transportation

Bureau of Transportation Statistics

Printed on paper containing recycled postconsumer waste paper