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Report to the Subcommittee on Transportation, Housing and Urban Development, and Related Agencies, Committee on Appropriations, U.S. Senate

March 2019

AUTOMATED TRUCKING

Federal Agencies Should Take Additional Steps to Prepare for Potential Workforce Effects

Accessible Version

GAO-19-161

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GAO Highlights

Highlights of GAO-19-161, a report to the Subcommittee on Transportation, Housing and Urban Development, and Related Agencies, Committee on Appropriations, U.S. Senate

Why GAO Did This Study

Automated vehicle technology may eventually make commercial trucking more efficient and safer, but also has the potential to change the employment landscape for nearly 1.9 million heavy and tractor-trailer truck drivers, among others. GAO was asked to examine the potential workforce effects of automated trucking.

This report addresses (1) what is known about how and when automated vehicle technologies could affect commercial trucks; (2) what is known about how the adoption of automated trucks could affect the commercial trucking workforce; and (3) the extent to which DOT and DOL are preparing to assist drivers whose jobs may be affected. GAO reviewed research since 2014 on automated trucking technology, viewed demonstrations of this technology, and analyzed federal data on the truck driver workforce. GAO also interviewed officials from DOT and DOL, as well as a range of stakeholders, including technology developers, companies operating their own trucking fleets, truck driver training schools, truck driver associations, and workforce development boards.

What GAO Recommends

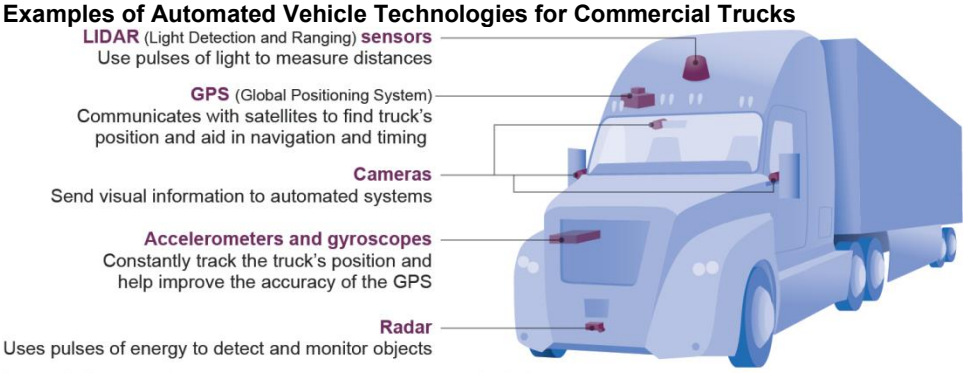
GAO is making four recommendations, including that both DOT and DOL should continue to convene key stakeholders as the automated trucking technology evolves to help the agencies analyze and respond to potential workforce changes that may result. DOT and DOL agreed with the recommendations.

View GAO-19-161. For more information, contact Cindy S. Brown Barnes or Susan A. Fleming, (202) 512-7215 or brownbarnesc@gao.gov or flemings@gao.gov.

What GAO Found

Automated trucks, including self-driving trucks, are being developed for long-haul trucking operations, but widespread commercial deployment is likely years or decades away, according to stakeholders. Most technology developers said they were developing trucks that can travel without drivers for part of a route, and some stakeholders said such trucks may become available within 5 to 10 years. Various technologies, including sensors and cameras, could help guide a truck capable of driving itself (see figure). However, the adoption of this technology depends on factors such as technological limitations and public acceptance.

Examples of Automated Vehicle Technologies for Commercial Trucks



Source: GAO analysis of interviews with technology developers. | GAO-19-161

Stakeholders GAO interviewed predicted two main scenarios for how the adoption of automated trucks could affect the trucking workforce, which varied depending on the future role of drivers or operators. Technology developers, among others, described one scenario in which self-driving trucks are used on highway portions of long-haul trips. Stakeholders noted this scenario would likely reduce the number of long-haul truck drivers needed and could decrease wages because of lower demand for such drivers. In contrast, groups representing truck drivers, among others, predicted a scenario in which a truck would have an operator at all times for complex driving and other non-driving tasks, and the number of drivers or operators would not change as significantly. However, stakeholders lacked consensus on the potential effect this scenario might have on wages and driver retention. Most stakeholders said automated trucking could create new jobs, and that any workforce effects would take time—providing an opportunity for a federal response, such as any needed policy changes.

The Department of Transportation (DOT) is consulting with the Department of Labor (DOL) to conduct a congressionally-directed analysis of the workforce impacts of automated trucking by March 2019. As part of this analysis, DOT and DOL have coordinated to conduct stakeholder outreach. However, they do not currently plan to convene stakeholders on a regular basis to gather information because they have focused on completing this analysis first. Continuing to convene stakeholders could provide the agencies foresight about policy changes that may be needed to prepare for any workforce effects as this technology evolves.

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Abbreviations

BLS	Bureau of Labor Statistics
CDL	commercial driver's license
DOL	Department of Labor
DOT	Department of Transportation
LIDAR	Light Detection and Ranging
O*NET	Occupational Information Network
WIOA	Workforce Innovation and Opportunity Act

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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March 7, 2019

The Honorable Susan Collins
Chairman
The Honorable Jack Reed
Ranking Member
Subcommittee on Transportation,
Housing and Urban Development
and Related Agencies
Committee on Appropriations
United States Senate

Emerging automated and self-driving vehicle technology has the potential to change the employment landscape for the commercial motor carrier industry, including for the nearly 1.9 million people who drive heavy and tractor-trailer trucks in the United States.[1] This technology may eventually create opportunities to decrease the roughly 4,000 traffic fatalities that involve large trucks annually and may make trucking more efficient, as well as easier on drivers. However, the prospective deployment of this technology also raises questions about its future effects on employment in the industry, including on the numbers of drivers and types of skills that will be needed to operate and maintain these newer trucks. Recent media reports have highlighted these questions about the over $700 billion-a-year U.S. trucking industry, with some reports suggesting large-scale, imminent job loss. However, addressing these questions entails making some assumptions both about how the technology might continue to develop and how, once adopted, it could affect the workforce.

You asked us to examine the potential workforce impacts of automated trucking technology, and how federal agencies are preparing to assist workers whose jobs may be affected. This report examines: (1) what is

[1]As detailed below, this 1.9 million figure includes over 1.7 million heavy and tractor-trailer truck drivers, as well as approximately 150,000 self-employed truck drivers, such as owner-operators. The Department of Transportation reported that, in 2016, there were 3.2 million commercial motor vehicle drivers who operated interstate and held commercial driver's licenses. These 3.2 million drivers include those who drive tractor-trailer trucks, as well as drivers of buses and straight trucks. Department of Transportation, Federal Motor Carrier Safety Administration, *2018 Pocket Guide to Large Truck and Bus Statistics* (Washington, D.C.: August 2018). For the purposes of our report, we focus on the nearly 1.9 million people who drive heavy and tractor-trailer trucks.

known about how and when automated vehicle technologies could affect commercial trucks; (2) what is known about how the adoption of automated trucks could affect the commercial trucking workforce; and (3) the extent to which the Department of Transportation (DOT) and the Department of Labor (DOL) are preparing to assist drivers whose jobs may be affected by automated trucking.[2]

To describe how and when automated vehicle technologies could affect the current fleet of commercial trucks, we conducted a review of key research since 2014 related to automated vehicle technologies for commercial trucks. We visited California, where we viewed demonstrations of this emerging technology and interviewed representatives of one truck manufacturer and four automated truck technology developers. We selected California because it had the largest number of these developers that we identified through our research efforts.[3] We also interviewed officials from DOT and selected stakeholders, including researchers; representatives from truck manufacturers and companies operating their own trucking fleet; and representatives of national industry organizations and a national safety organization. The views of the stakeholders we interviewed are illustrative examples and may not be generalizable. For more information about how we selected stakeholders, see appendix I.

To describe how the adoption of automated trucks could affect the current and future trucking workforce, we analyzed 2017 employment level and wage data from DOL's Bureau of Labor Statistics (BLS) and 2017 demographic data from the Census Bureau. Additionally, we reviewed key research on possible employment effects of automated trucking technology. We also interviewed organized labor representatives, industry stakeholders, and representatives of four truck driver training schools. We selected these schools in part based on recommendations from an association of truck driver training schools, and included two accredited

[2]This report uses the phrase "automated trucking" to refer generally to industry deployment of automated trucking technology.

[3]In total, we interviewed representatives of five technology developers, including one that we did not visit in California. In July 2018, Uber Advanced Technologies Group, one of the five developers we spoke with, announced that it would stop developing automated trucks. An Uber Advanced Technologies Group representative said the company made the decision to focus its self-driving development on its primary business of passenger vehicles before revisiting self-driving truck technology.

and two nonaccredited schools in our selection.[4] We interviewed officials from four local workforce development board as well. We selected three of these boards due to the prevalence of trucking jobs in their areas and one board because it was in an area that several stakeholders suggested could be early to adopt automated trucking technology. In addition, we interviewed officials from the Departments of Education, Labor, Transportation, and Veterans Affairs.

To determine the extent to which DOT and DOL are preparing to assist current and future drivers, we interviewed federal officials, local workforce development board officials, and representatives from a national association of state and local workforce organizations. We compared agencies' efforts against their strategic plans as well as *Standards for Internal Control in the Federal Government*.[5] Additionally, for all the objectives, we reviewed relevant federal laws and regulations, as well as agency documentation. See appendix I for more information on our objectives, scope, and methodology.

We conducted this performance audit from August 2017 to March 2019 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[4]The primary purpose of accreditation is to help ensure that schools provide a quality education to students. Accrediting agencies work with the Department of Education and states to oversee postsecondary schools participating in federal student aid programs authorized under Title IV of the Higher Education Act. The Department of Education certifies schools' eligibility to participate in federal student aid programs, and recognizes accrediting agencies it determines to be reliable authorities on assessing academic quality. See GAO, *Higher Education: Expert Views of U.S. Accreditation*, GAO-18-5 (Washington, D.C.: December 2017).

[5]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: September 2014).

Background

Trucking Industry

In 2016, commercial trucks transported about 70 percent of all U.S. freight, and over 250,000 heavy trucks were sold in the same year.[6] These trucks operate within a diverse industry that can be distinguished in several ways:

- **Long-haul vs. local-haul.** Long-haul trucking operations are so named because the drivers frequently drive hundreds of miles for a single route and can be on the road for days or weeks at a time. For these operations, freight is usually shipped from a single customer and may fill an entire trailer by either space or weight. Long-haul trucking also includes "less-than-truckload" freight shipments, or freight combined from multiple customers.[7] In comparison, local-haul trucking operations may involve delivering packages and shipments between a customer and a freight company's drop-off point, where they are combined with other shipments in preparation to move them over longer distances. This type of operation also includes local cement trucks, as well as moving shipping containers at ports and moving freight a short distance from a train that has transported it long-distance to near its destination.[8]
- **For-hire vs. private (in-house).** Different types of companies—or carriers—engage in long-haul and local trucking and are known either as "for-hire" (those that transport goods for others) or "private" (those that transport their own goods in their own trucks). For instance, J.B. Hunt is a for-hire carrier that transports goods for clients, while Walmart is a private carrier that uses its in-house fleet of trucks to

[6]Department of Transportation, *2018 Pocket Guide to Large Truck and Bus Statistics* (Washington, D.C.: August 2018) and Department of Energy, Oak Ridge National Laboratory, *2016 Vehicle Technologies Market Report* (Oak Ridge, TN: May 2017).

[7]Parcel delivery services, such as UPS and FedEx, use a similar process to less-than-truckload shipments.

[8]Steve Viscelli, *Driverless? Autonomous Trucks and the Future of the American Trucker* (Berkeley, CA.: U.C. Berkeley Center for Labor Research and Education and Working Partnerships USA, September 2018), accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

transport its own goods between its distribution centers and its stores.[9]

- **Carrier size.** In addition, carriers vary in size, with fleets ranging from one truck to tens of thousands of trucks. For example, a person might own and drive one for-hire truck; these are known as "owner-operators." By contrast, the largest for-hire trucking companies in the country can have fleets of over 20,000 tractors and even more trailers.
- **Operating costs.** Driver compensation represents either the largest or second-largest cost component for truck carriers, depending on the price of fuel; each typically accounts for about one-third of total operating costs. Other operating costs include purchasing truck tractors and trailers, as well as repair and maintenance of the trucks and trailers, and insurance.

Truck Drivers

BLS data indicate that in 2017, the United States had nearly 1.9 million truck drivers categorized as "heavy and tractor-trailer truck drivers," who operate trucks over 26,000 pounds.[10] This category includes many different kinds of drivers, including long-haul and local-haul, along with cement or garbage truck drivers and drivers of specialty loads, such as trucks transporting cars, logs, or livestock.[11] The number of heavy and tractor-trailer truck drivers has increased over the last 5 years, from fewer than 1.6 million in 2012, and is projected to increase to about 2 million drivers by 2026. The trucking industry has also had high annual driver turnover, according to industry reports—approaching 100 percent for large, truckload carriers, though it can be less for small, truckload carriers.[12] This turnover includes drivers who move to other carriers and

[9]Walmart may also use for-hire carriers for some of its shipping needs.

[10]This figure includes approximately 150,000 self-employed truck drivers, such as owner-operators, which BLS estimates raise the total of heavy and tractor-trailer truck drivers from over 1.7 million drivers to nearly 1.9 million drivers. The self-employed truck driver number is from 2016 and the 1.7 million driver number is from 2017.

[11]BLS has two related categories for drivers: one, "light truck or delivery services" drivers (nearly 900,000 drivers), who drive light vehicles like a truck or van weighing less than 26,000 pounds and might deliver packages, for example; and two, "driver/sales workers," (over 400,000 drivers) such as a pizza delivery driver.

[12]For example, in the first quarter of 2018, turnover at large fleets was 94 percent, while the turnover at smaller fleets was 73 percent, according to industry data. Turnover at less-than-truckload carriers was 10 percent, according to industry data.

others who leave the field altogether or retire. Some companies that experience lower turnover rates are able to provide drivers with predictable schedules and coordinate around the various obligations the drivers may have. Firms must balance the costs of scheduling drivers to return home more frequently with the costs of high turnover rates.

Industry reports have noted that companies find it difficult to hire and retain sufficient numbers of long-haul drivers, even with wages reportedly rising for many drivers. Heavy and tractor-trailer truck drivers make more on average—$44,500 in 2017—than other types of drivers, according to BLS data.[13] Many drivers, including most drivers working in long-haul trucking, are compensated on a per-mile basis rather than a per-hour basis.[14] The per-mile rate varies from employer to employer and may depend on the type of cargo and the experience of the driver.[15] Some long-haul truck drivers are paid a share of the revenue from shipping.

Truck Driver Training

In order to operate certain commercial vehicles, including heavy trucks and tractor-trailers, drivers must obtain a state-issued commercial driver's license (CDL).[16] DOT administers the federal CDL program through the Federal Motor Carrier Safety Administration by setting federal standards

[13]In 2017, light truck or delivery services drivers—who drive light trucks within a local region or urban area—had a mean annual income of $35,610; driver/sales workers' mean annual income was $29,090, according to BLS data. Wages for heavy and tractor-trailer truck drivers have increased from $43,094 in 2012 (adjusted for inflation).

[14]This mileage-based compensation may be complemented by bonuses.

[15]Truck drivers' total compensation may also vary depending on whether they are union-affiliated. For example, truck drivers in unions may also participate in defined benefit retirement plans. In 2016, over 60,000 workers in the trucking industry, including drivers, worked in employment covered by the Central States, Southeast and Southwest Areas Pension Fund, established in 1955 to provide pension benefits to trucking industry workers. See GAO, *Central States Pension Fund: Investment Policy Decisions and Challenges Facing the Plan*, GAO-18-106 (Washington, D.C.: June 4, 2018).

[16]49 C.F.R. § 383.1. Drivers are granted CDLs for the particular classes of vehicles they drive. Classes of vehicles are defined by type and weight. For example, Class A vehicles include heavy tractor-trailer trucks; Class B vehicles include school buses and dump trucks; and Class C vehicles include small passenger buses or small vehicles transporting specified quantities of hazardous materials. 49 C.F.R. § 383.5. See GAO, *Commercial Driver's Licensing: Federal Oversight of State Programs Could be Improved*, GAO-15-607 (Washington, D.C.: July 15, 2015).

for knowledge and driving skills tests, among other requirements.[17] CDL applicants must have a state motor vehicle driver's license and must be at least 21 years old to operate in interstate commerce.[18] Prior to receiving a CDL, applicants must first pass the knowledge test and meet other federal requirements, after which they are eligible to pursue a commercial learner's permit.[19] After receiving the learner's permit, applicants must wait at least 14 days before taking the skills test.[20] During this period, applicants may train on their own with a CDL holder, with a truck driver training school—a private school or public program run through a community college, for example—or with a motor carrier to prepare for the skills test. Applicants must pass all three parts of the skills test—pre-trip inspection, basic control skills, and an on-the-road driving test—in the type of vehicle they intend to operate with their license.[21] Apart from the CDL requirements, some truck driving jobs (such as those that involve handling hazardous materials) require additional endorsements, and some employers require on-the-job training.[22]

DOL and other federal agencies administer programs that can be used to provide training for truck drivers. For example, DOL administers federal employment and training programs, such as those funded through the Workforce Innovation and Opportunity Act (WIOA), which provide training dollars that can be used by prospective truck drivers, among others. Likewise, the Department of Education provides federal student aid funds that can be used at eligible accredited trucking schools, and DOT and the Department of Veterans Affairs both operate programs that can assist veterans interested in becoming truck drivers.

[17]49 C.F.R. §§ 383.110, .111, and .113. The Federal Motor Carrier Safety Administration also establishes processes and regulations for state driver licensing agencies and oversees state CDL programs. Section 12005 of Commercial Motor Vehicle Safety Act of 1986, Pub. L. No. 99-570, title XII, 100 Stat. 3207, 3207-170(1986), and 49 C.F.R. pts 383 and 384.

[18]49 C.F.R. § 391.11(b)(1), (b)(5).

[19]49 C.F.R. § 383.25(a)(3).

[20]49 C.F.R. § 383.25(e).

[21]49 C.F.R. § 383.113.

[22]49 C.F.R. § 383.121.

Federal Regulation of Trucking

Federal regulation of trucking is focused primarily on interstate trucking activity; states can have separate regulations related to intrastate motor carriers.[23] DOT is the lead federal agency responsible for overall vehicle safety, including commercial truck safety.[24] The agency also regulates other aspects of commercial trucking, such as the maximum number of hours truck drivers are allowed to drive.[25] For example, under current hours of service regulations, a truck driver may drive a maximum of 11 total hours within a 14-hour window after coming on duty.[26] In addition, DOT regulates CDL standards and the maximum weight of trucks allowed on the Interstate Highway System, among other things.[27] Until recently, DOT's National Highway Traffic Safety Administration led automated vehicles policy with a focus on passenger vehicles. However, DOT's October 2018 federal automated vehicles policy was developed by the Office of the Secretary of Transportation and includes several different modes of transportation, including automated commercial trucks.[28]

[23]For example, Texas hours of service regulations state that truck drivers engaged in intrastate commerce in Texas may work a 15-hour shift that includes 12 hours of driving time before taking a required 8-hour break, which differs from federal hours of service. Additionally, while federal law requires all states to allow gross vehicle weights of 80,000 pounds on the Interstate Highway System, Michigan has laws allowing for weights greater than 80,000 pounds on its highway system.

[24]49 U.S.C. § 31101.

[25]49 C.F.R. Part 395.

[26]49 C.F.R. Part 395.

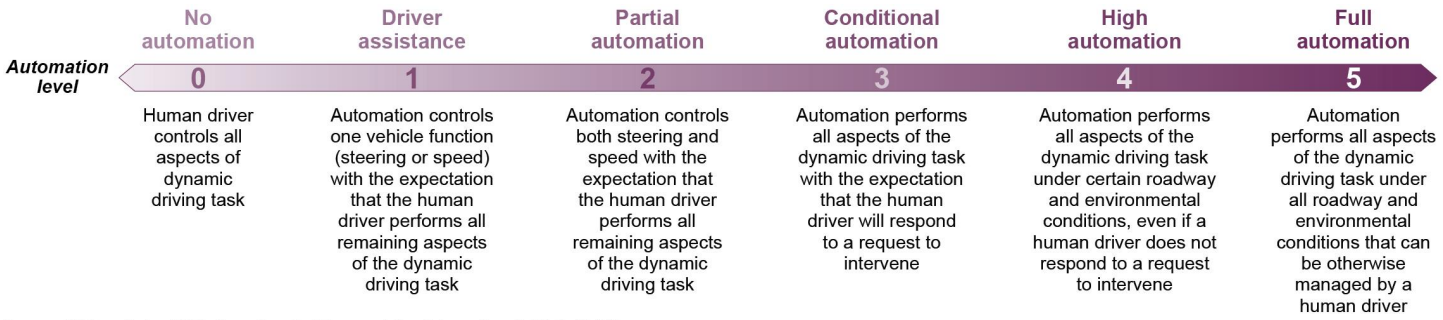
[27]49 C.F.R. Part 383, 23 U.S.C. § 127.

[28]DOT has released three versions of its *Federal Automated Vehicles Policy*, in 2016, 2017, and 2018. Department of Transportation, National Highway Traffic Safety Administration, *Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety* (Washington, D.C.: September 2016); Department of Transportation, National Highway Traffic Safety Administration, *Automated Driving Systems 2.0: A Vision for Safety* (Washington, D.C.: September 2017); and Department of Transportation, *Preparing for the Future of Transportation: Automated Vehicles 3.0* (Washington, D.C.: October 2018).

Automated Trucks

Automated vehicles can perform certain driving tasks without human input.[29] They encompass diverse automated technologies ranging from relatively simple driver assistance systems to self-driving vehicles. Certain automated features, like adaptive cruise control, can adjust vehicle speed in relation to other objects on the road and are currently available on various truck models. DOT has adopted a framework for automated driving developed by the Society of Automotive Engineers International, which categorizes driving automation into 6 levels (see fig. 1).[30]

Figure 1: Levels of Driving Automation Used by the Department of Transportation



Source: GAO analysis of U.S. Department of Transportation information. | GAO-19-161

Commercial trucks with Level 0 and 1 technologies, as outlined in figure 1, are already available for private ownership and are currently used on

[29]We have previously reported on developers' efforts to develop and test automated vehicles. See GAO, *Automated Vehicles: Comprehensive Plan Could Help DOT Address Challenges*, GAO-18-132 (Washington, D.C.: November 30, 2017).

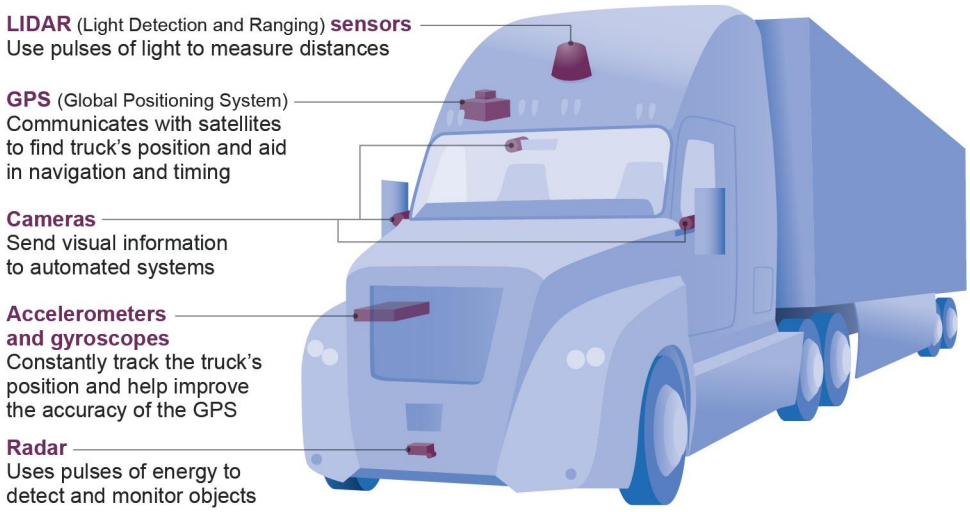
[30]The Society of Automotive Engineers International is a global association of engineers and technical experts in the aerospace, automotive, and commercial-vehicle industries. One of its stated goals is to provide consensus-based standards to advance quality, safety, and innovation. DOT's 2016 *Federal Automated Vehicles Policy* applied to Levels 2 to 5 vehicles and referred to Levels 3 to 5 vehicles as "Highly-Automated Vehicles." The 2017 *A Vision for Safety* replaced the *Federal Automated Vehicles Policy* and focuses on Levels 3 to 5 vehicles. The 2018 *Preparing for the Future of Transportation* builds upon the voluntary guidance in *A Vision for Safety*, according to DOT, and addresses Levels 1 to 5 automated technologies and vehicles. Throughout this report, we use the term "automated trucks" to refer to trucks at any level of automation.

public roadways.[31] Level 0 encompasses conventional trucks where a human driver controls all aspects of driving and technologies can warn drivers of safety hazards, such as lane departure warning, but do not take control away from the driver and are not considered automated. Level 1 technologies incorporate automatic control over one major driving function, such as steering or speed, and examples include adaptive cruise control and automatic emergency braking.

The Society of Automotive Engineers International categorizes vehicles with Level 3, 4, and 5 technologies as Automated Driving Systems. At Level 3, the system can take full control of the vehicle in certain conditions. However, a human driver must maintain situational awareness at all times to ensure the vehicle is functioning safely. At Level 4, automation controls all aspects of driving in certain driving conditions and environments, such as on highways in good weather. In these particular driving conditions and environments, a human driver would not be required to take over the driving task from the automated vehicle and the system would ensure the vehicle is functioning safely. At Level 5, the vehicle can operate fully, in any condition or environment, without a human driver or occupant. There are various automated vehicle technologies that could help guide a vehicle capable of driving itself, including cameras and other sensors (see fig. 2).

[31]Passenger vehicles with Level 2 technologies are already available for private ownership and currently operate on public roadways. At Level 2, automated systems can control both steering and lane positioning in certain conditions, though the human driver must maintain situational awareness to ensure safe functioning.

Figure 2: Examples of Automated Vehicle Technologies for Commercial Trucks



Source: GAO analysis of interviews with technology developers. | GAO-19-161

Widespread Deployment of Platooning and Self-Driving Long-Haul Trucks Is Likely Years Away, and Several Factors Will Affect Timeframes

Platooning and Self-Driving Trucks Are Being Developed, Generally for Long-Haul Trucking

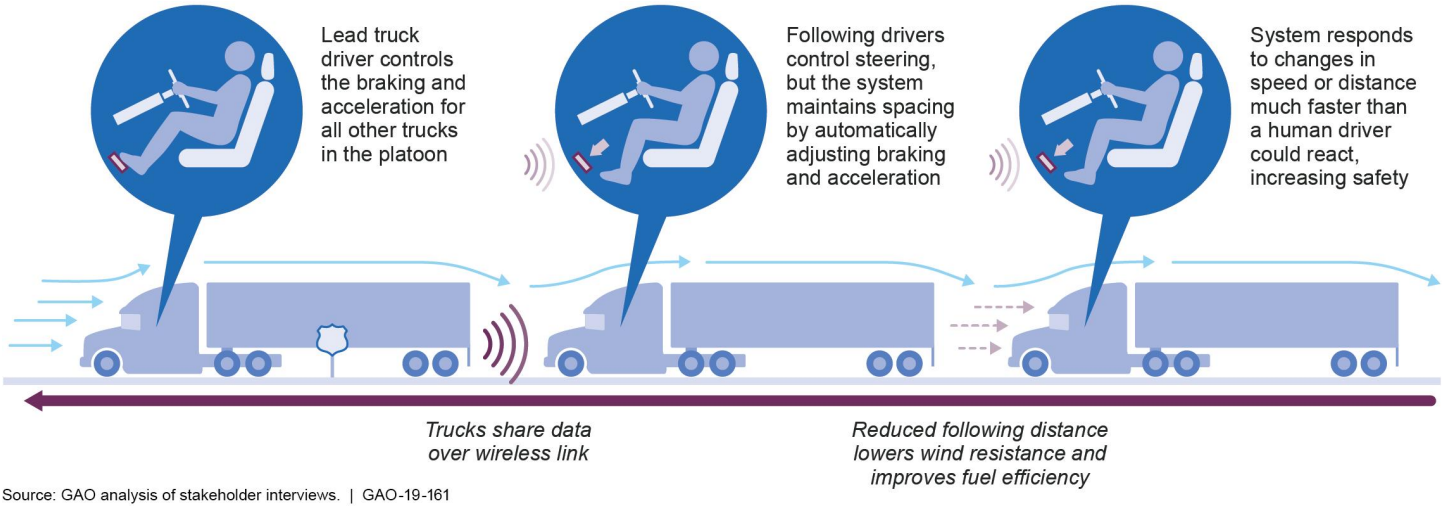
According to stakeholders we spoke with and literature we reviewed, automated trucks, including self-driving trucks, are being developed, generally for long-haul trucking.[32] Specifically, we found there could be various types of automation for long-haul trucks, including platooning, self-driving for part of a route, and self-driving for an entire route.

- **Platooning.** Technology developers and researchers told us there is ongoing development and testing of truck platoons, which involve one

[32]We focus on long-haul trucking in our report because stakeholders generally stated that long-haul trucking would be the first part of the trucking industry to adopt automated trucks. Automated trucks, including self-driving trucks, might also be developed for use on local-haul and other routes, such as from a port to a warehouse.

or more trucks following closely behind a lead truck, linked by wireless—or vehicle-to-vehicle—communication (see fig. 3).[33]

Figure 3: Illustration of Commercial Trucks Platooning



Source: GAO analysis of stakeholder interviews. | GAO-19-161

In a platoon, the driver in the lead truck controls the braking and acceleration for all of the connected trucks in the platoon, while the driver in each following truck controls its own steering.[34] Several stakeholders we interviewed and three studies we reviewed identified potential benefits

[33]For example, in September 2017, DOT's Federal Highway Administration and the Federal Motor Carrier Safety Administration held a demonstration of platooning technologies on a stretch of highway in Virginia using three heavy trucks.

[34]One technology developer we spoke with and two studies we reviewed also described a version of platooning with a human driver in the lead truck and no human drivers in the following trucks. Neither the technology developers nor manufacturers we interviewed told us they were currently developing technologies for this type of truck platoon. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/ and International Transport Forum, Organisation for Economic Co-operation and Development, *Managing the Transition to Driverless Road Freight Transport* (Paris, France: 2017), 15.

from platooning, including fuel savings and increased safety, for example, due to the trucks' faster reaction times for braking.[35]

- **Self-driving for part of a route.** Most of the technology developers we spoke with said they were developing automated trucks that will be self-driving for part of a long-haul route, such as exit-to-exit on highways (see fig. 4).

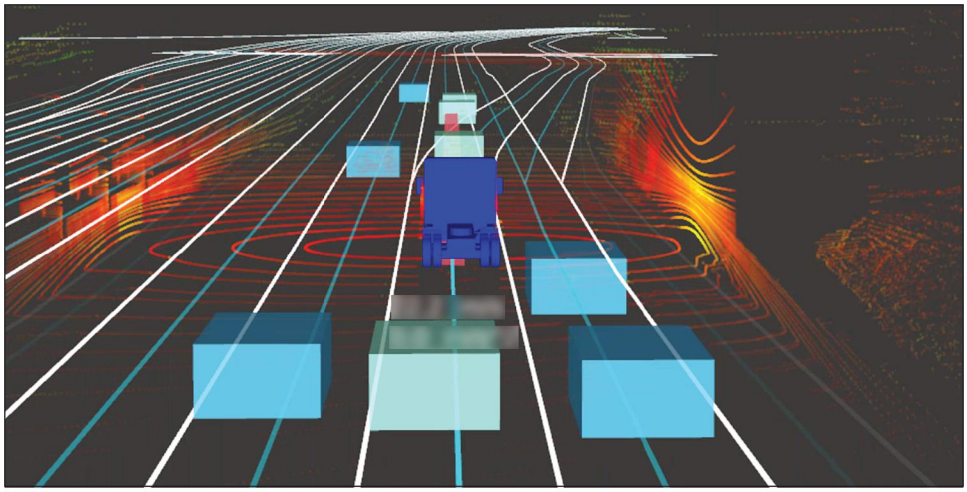
Figure 4: Illustration of Commercial Truck Self-Driving for Part of a Long-Haul Route

Source: GAO analysis of stakeholder interviews. | GAO-19-161

Representatives from one developer explained that their truck uses self-driving software installed on the truck. The software instructs the truck what to do, such as to steer or brake. In addition, cameras and other sensors on the truck's exterior provide the self-driving software with a view of the truck's surroundings to inform the software's instructions. For example, Light Detection and Ranging (LIDAR) sensors use lasers to map a truck's surroundings (see fig. 5).

[35]Erica Groshen, Susan Helper, John Paul MacDuffie, and Charles Carson, *Preparing U.S. Workers and Employers for an Autonomous Vehicle Future* (Washington, D.C.: Securing America's Future Energy, June 2018), accessed on August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/; Magnus Hjälmdahl, Stas Krupenia, and Birgitta Thorslund, *Driver behaviour and driver experience of partial and fully automated truck platooning – a simulator study*, SpringerLink, accessed on February 27, 2018, https://link.springer.com/article/10.1007/s12544-017-0222-3; and International Transport Forum, *Managing the Transition*, 15.

Figure 5: Example of Light Detection and Ranging (LIDAR) Sensors' View of Self-Driving Truck's Surroundings on a Highway



Source: Technology developer photo. | GAO-19-161

Note: This display shows a dark blue truck in the center that is using LIDAR to detect objects around it, including the highway lanes, shown by white lines, and other vehicles, shown by light blue and teal cubes.

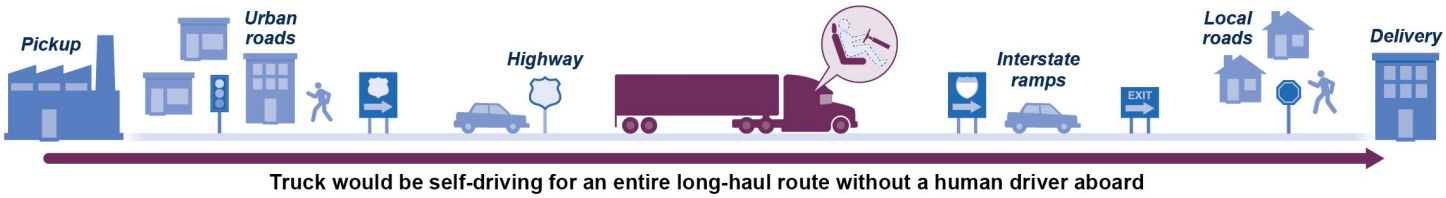
Such trucks would operate with no driver intervention under favorable conditions, such as on highways in good weather. Two developers said that in their business models a driver would be in the truck for the first and last portions of the route to assist with picking up and dropping off trailers at hubs outside urban areas. Alternatively, one developer said a remote driver—one not in the truck but operating controls from another location—would drive the first and last portions of a route. Stakeholders identified potential benefits of self-driving for part of a route, such as increased safety, labor cost savings, and addressing what they said is a truck driver shortage. Research funded by industry also suggests that an automated truck could improve productivity by, for example, continuing to drive to a destination while a human in the truck conducts other work or rests.[36] In addition, one study noted that the most likely scenario for widespread adoption of

[36]Jeffrey Short and Dan Murray, American Transportation Research Institute, *Identifying Autonomous Vehicle Technology Impacts on the Trucking Industry* (Arlington, Va.: November 2016), 17.

automated trucks is the one in which trucks are capable of self-driving from exit-to-exit.[37]

- **Self-driving for an entire route.** None of the technology developers we interviewed told us they are planning to develop automated trucks that are self-driving for an entire route (see fig. 6).

Figure 6: Illustration of Commercial Truck Self-Driving for an Entire Long-Haul Route



Source: GAO analysis of stakeholder interviews. | GAO-19-161

Such trucks would be able to drive under all weather and environmental conditions. A person would not be expected to operate these trucks at any time. The potential benefits of these kinds of trucks are similar to those of trucks that are self-driving for part of a route, with higher potential labor savings because a person would not need to drive the first and last portions of a route.

Widespread Deployment of Automated Trucks May Be Years to Decades Away, Depending on Technological, Operational, and Other Factors

Anticipated Timeframes

Stakeholders we spoke with generally indicated that it will be years to decades before the widespread deployment of automated commercial trucks (see text box). However, many stakeholders also noted the uncertainty of predicting a specific timeframe for particular technologies.

[37]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

- **Platooning.** Many stakeholders said that platooning will likely deploy within the next 5 years and will be the first automated trucking technology to be widely available. Notably, one company that is developing platooning technology said it could begin deployment in 2019. In addition, DOT officials told us that truck platoons are currently being tested, but that it would be difficult to estimate when there might be widespread adoption of platooning technology.
- **Self-driving for part of a route.** Automated trucks that are self-driving for part of a route may become available for commercial use within the next 5 to 10 years, according to several stakeholders, including technology developers.[38] While such trucks may begin appearing on roads in that timeframe, other stakeholders, including two researchers, said widespread deployment may take more than 10 years. DOT officials noted that multiple variables make it difficult to develop a precise estimate for the deployment and widespread adoption of trucks that are self-driving for part of a route.
- **Self-driving for an entire route.** Although none of the technology developers told us they are developing trucks that would be self-driving for an entire route, other stakeholders we spoke with said such trucks could become available in more than a decade. However, most stakeholders either did not provide a timeframe for, or said they did not know, when such trucks might become available. Similarly, at a listening session in August 2018, DOT officials told attendees that it will be decades before large trucking operations replace their fleets of conventional trucks with trucks that self-drive for an entire route.

One Stakeholder's Description of Anticipated Timeframes for Overall Automated Truck Adoption

One researcher described an anticipated timeframe for automated truck adoption in which there is an initial, long period of development and testing, which would include making technological adjustments. This period would then be followed by a period of automated truck adoption—i.e., when such trucks replace human drivers. At that point, technology developers and truck manufacturers would also encounter scenarios in which it may not be desirable to use an automated truck, such as for the transport of hazardous materials, according to the researcher. Such scenarios would limit the extent to which automated trucks could replace human drivers.

Source: GAO analysis of stakeholder interview. | GAO-19-161

[38]There are specific conditions under which a given driving automation system is designed to function, and these conditions may vary from system to system. For example, an Automated Driving System may be designed to operate a vehicle only on fully access-controlled freeways and in low-speed traffic, high-speed traffic, or both.

Factors That May Affect Timing

Stakeholders we interviewed and the literature we examined identified technological, operational, infrastructure, legal, and other factors that may affect automated truck development and deployment.

Technological

Stakeholders and literature identified several technology-related limitations that may affect the timing of automated truck deployment. Specifically, several stakeholders and a study noted that automated trucks may require simpler operating environments, such as highways, in the near term because they are less complex for the technology to navigate than roads in an urban setting, for example.[39] Even so, a highway presents its own challenges, several stakeholders said. For instance, a developer, a manufacturer, and a researcher we spoke with told us that Light Detection and Ranging (LIDAR)—a costly and complex technology—may not be as useful at higher speeds due to its limited range and its inability to process information about the surrounding environment as quickly as needed at these speeds. Further, one manufacturer told us that LIDAR is not as durable as it needs to be for commercial trucking—for example, able to withstand dirt and debris. Stakeholders also discussed the need to have backup systems built into trucks' automated systems in case of technology failures, including the ability to guide the truck to a safe stop.

Operational

Stakeholders identified several operational factors that may pose challenges for the deployment of automated trucks. For example, several stakeholders said that there may be challenges with self-driving trucks with no person inside when responding to a tire blowout or other mechanical problems. Likewise, several stakeholders said there must be ways for a self-driving truck to respond to required safety inspections and communicate with inspectors.[40] Representatives from a safety organization noted that a truck could potentially communicate a unique identification number through an electronic device. This number would

[39]International Transport Forum, *Managing the Transition*, 14-15.

[40]Commercial trucks and their loads are subject to safety inspections. 49 C.F.R. § 396.9(a). In 2017, federal and state inspectors conducted over 3.4 million inspections of commercial motor vehicles, which include commercial trucks.

give the inspector information about the truck, such as safety information from the sensors on automated trucks. Additionally, several stakeholders said platooning may not be practical for logistical reasons, for instance, if trucks are not traveling on the same routes or if cargo is not ready to depart at the same time. In addition, according to stakeholders we spoke with and literature we reviewed, the lead truck in a platoon will save less on fuel than the following trucks. If trucking fleets adopt platooning systems that work on commercial trucks across different companies—i.e., systems that are interoperable—distributing fuel savings in a manner agreeable to all parties involved may be challenging. Representatives from two fleet owners and one industry association we spoke with raised concerns about platooning across different companies, including that companies might not partner with other fleets to platoon trucks because they would be primarily concerned with their own fuel savings, not with saving fuel for their competitors. In addition to these operational factors, stakeholders noted that automated trucks may be prohibitively expensive for some smaller fleet owners, including owner-operators, particularly when these trucks are first deployed.

Infrastructure

Several stakeholders and relevant literature noted that certain infrastructure factors may affect the development, testing, and deployment of automated trucks. For example, a few stakeholders said if one truck picks up or drops off trailers for another truck at a location near highways, land acquisition near these highways may be an issue. Representatives from a developer that planned to acquire land for its business model said the land acquisition could take 5 to 10 years. The representatives explained that they found enabling direct access to freeways is more difficult than simply acquiring vacant land. They planned to partner with states to create hubs on under-utilized land with existing freeway access by, for example, repurposing abandoned rest stops. In addition to land acquisition, two technology developers and a study identified the need for widely available data connectivity and the related ability to use connected vehicle technologies as an infrastructure challenge.[41] Connected technologies allow vehicles to communicate with other vehicles (vehicle-to-vehicle), roadway infrastructure (vehicle-to-

[41]International Transport Forum, *Managing the Transition*, 12.

infrastructure), and personal communication devices.[42] Connectivity has potential implications for, among other things, the maps self-driving trucks use to navigate routes and obstacles, as well as the ability for trucks in a platoon to communicate with one another effectively. However, because the ability for vehicles to communicate with infrastructure is not ubiquitous, two of the developers we spoke with are not taking into account connected infrastructure as they develop and test their automated trucks. Two stakeholders also expressed concern about platooning trucks and the stress they could place on bridges, for example, that were not designed to hold the weight of two or more heavy trucks at once. In addition, stakeholders noted that automated trucks may encounter difficulties with things like road work or construction zones. This may be because the truck relies on pre-built maps, in addition to sensors, that would potentially be outdated or might not reflect current road conditions, including any recent or temporary changes.

Legal

Several legal factors may affect the timing of development, testing, and deployment for automated trucks, according to our stakeholder interviews and literature review. Many stakeholders expressed concern about the possibility of a "patchwork" of state laws related to automated trucks that could affect interstate trucking, with some saying they would like to see a shared national framework. For example, one technology developer said that this emerging patchwork can make it difficult for an automated truck to travel across the country without a driver, because some states specifically prohibit self-driving vehicles, including trucks. However, this same developer said that some states are less restrictive regarding the need for a driver in a self-driving truck, and that others have ambiguous regulations. Several stakeholders we spoke with and two studies we reviewed noted that liability issues may arise and become more complex

[42]See GAO, *Intelligent Transportation Systems: Vehicle-to-Infrastructure Technologies Expected to Offer Benefits, but Deployment Challenges Exist*, GAO-15-775 (Washington, D.C.; September 15, 2015) and *Intelligent Transportation Systems: Vehicle-to-Vehicle Technologies Expected to Offer Safety Benefits, but a Variety of Deployment Challenges Exist*, GAO-14-13 (Washington, D.C.: November 1, 2013). Vehicle-to-vehicle systems rely on in-vehicle equipment that transmits data between vehicles, enabling applications that can warn drivers of road conditions and hazards. Vehicle-to-infrastructure systems transmit data between vehicles and roadway infrastructure, such as signage and signal lights. These technologies typically communicate using Dedicated Short Range Communications, a technology similar to Wi-Fi that offers a link through which vehicles and infrastructure can transmit messages over a range of about 300 to 500 meters. Currently, these technologies are still being tested.

for automated trucks.[43] This may be because, for example, more parties may become involved. One of these stakeholders—a fleet owner—said that these parties could include the software developer, the truck manufacturer, the owner of the truck, and, if applicable, the truck driver. These issues could be addressed under the current liability system, and courts would decide the various liability issues on a case-by-case basis.

In addition, several stakeholders have requested that DOT clarify whether existing regulations require that human drivers always be present in automated trucks, particularly those capable of Level 4 and 5 driving automation, in which at least some of the driving is done by the automated truck. Two technology developers have requested that DOT confirm that regulations that apply to human drivers do not apply to automated trucks, and one of these developers also requested confirmation that a truck capable of at least Level 4 automation is allowed to operate without a human on board, which could permit testing without a person in the truck. In *Preparing for the Future of Transportation: Automated Vehicles 3.0*, DOT's automated vehicles voluntary guidance, the agency laid out its approach to its automated vehicles policy. DOT's guidance stated that, going forward, DOT will interpret and, consistent with all applicable notice and comment requirements, adapt the definitions of "driver" and "operator" to recognize that such terms do not refer exclusively to a human, but may include an automated system.[44] In the same guidance document, DOT also noted that regulations will no longer assume that the driver of a commercial truck is always human or that a human is necessarily present inside of a truck during its operation.

A few stakeholders also said that DOT may have to clarify the hours of service rules if a human driver is in an automated truck that is self-driving for part or all of a route.[45] This is because under current hours of service regulations, a human driver may drive a maximum of 11 total hours within a 14-hour window after coming on duty.[46] However, if a truck self-drives for at least part of a route, it is unclear if a human driver would need to

[43]Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/ and International Transport Forum, *Managing the Transition*, 25.

[44]DOT, *Preparing for the Future of Transportation: Automated Vehicles 3.0.*

[45]49 C.F.R. Part 395.

[46]49 C.F.R. § 395.3.

comply with the existing hours of service requirements and, if not, how the driver would account for worked time. For example, if the human driver is not actively engaged in the driving task, whether monitoring the automated driving system or even sleeping, there could be a question about whether that time would be counted toward "driving," according to the requirements. For a list of potential legal factors identified by stakeholders or in literature that may affect timing for the development and deployment of automated commercial trucks, and related DOT information, see appendix II.

Other Factors

Stakeholders and relevant literature identified several other factors, such as public perception and cybersecurity, that could affect timing for the development and deployment of automated trucks. Several stakeholders we interviewed and a study we reviewed noted that public acceptance concerning the safety of platooning and self-driving trucks may pose a challenge to the deployment of these trucks.[47] One researcher we spoke with said interactions between truck platoons and cars may be problematic, because drivers may need to speed in order to change lanes around the platoons of trucks following each other closely. Similarly, other stakeholders told us that it may be difficult for the public to accept large automated commercial trucks. Two of these stakeholders said this is particularly true for a heavy truck without a human driver on board—implying that vehicle size and weight play roles in the public's acceptance of these types of automated vehicles.[48] Several stakeholders also expressed concerns about cybersecurity and automated trucks' reliance

[47]International Transport Forum, *Managing the Transition*, 23.

[48]Public perception was an important factor for one of the private carriers we interviewed as well. A company representative said that safety is the company's primary concern because their trucks are "53-foot billboards" for their business. They said that, given highway speeds, self-driving trucks must undergo more testing before they would feel comfortable allowing their drivers to remove their hands from a steering wheel or to look away from the road.

on wireless communication and self-driving software. They said connectivity could leave automated trucks vulnerable to cyberattacks.[49]

Workforce Changes Due to Automated Trucking Will Depend in Part on the Role of Future Drivers or Operators, and Will Take Time to Develop

Workforce Effects of Automated Trucking Could Include Changes to Employment Levels, Wages, Retention, and Skills

Predicting workforce changes in light of future automated trucking is inherently challenging, as it is based on uncertainties about how the trucking industry will respond to new technologies that face operational, regulatory, and other factors that could affect deployment. Many of the stakeholders we interviewed declined to predict various possible workforce effects, because they said to do so was too speculative. However, stakeholders we spoke with and literature we reviewed presented two main scenarios for the future trucking workforce: one in which trucks would be self-driving for part of a route, without a driver or operator, and the other in which trucks would require a driver or operator in the truck for the entire route.[50] An operator would monitor truck operations and may not always function as a traditional driver. Because most stakeholders agreed that the prospect of using fully self-driving trucks for an entire route is either unlikely or at least several decades into the future—and no developer we spoke with was planning to develop a fully self-driving truck—we do not discuss the workforce effects of that scenario in this report.

[49]We have previously reported on the need to secure automated vehicles from malicious cyberattacks. See GAO, *Technology Assessment: Artificial Intelligence: Emerging Opportunities, Challenges, and Implications*, GAO-18-142SP (Washington, D.C.: March 28, 2018) and *Vehicle Cybersecurity: DOT and Industry Have Efforts Under Way, but DOT Needs to Define Its Role in Responding to a Real-world Attack*, GAO-16-350 (Washington, D.C.: March 24, 2016).

[50]We conducted an extensive search for literature on possible employment effects of automated trucking technology; out of more than 250 articles and studies, four studies were most relevant for the work discussed in this objective and met our standards for reliability. More detail on these studies and our methodology is in appendix I.

Potential Effects If Truck Has No Driver or Operator for Part of Route

Technology developers we spoke with generally envisioned trucks that are self-driving for part of a route, which they said would potentially lead to significant workforce changes.[51] Several technology developers and researchers, along with two studies, said trucks that are self-driving for part of a route could decrease the number of long-haul drivers, and perhaps decrease wages and affect retention as well.[52] Additionally, any displaced drivers may need new skills if they change jobs, according to several stakeholders we spoke with and studies we reviewed.

- ***Employment levels****:* Technology developers we interviewed generally predicted the number of long-haul jobs would decrease with the adoption of trucks that are self-driving for part of a route.[53] Drivers constitute a significant operational cost, so part of the reported

[51]As noted earlier, most developers said they were working toward a model that would have self-driving trucks travel exit-to-exit on a highway, with a driver—either in the truck or remotely—taking control for the first and last portions of a route. Additionally, three studies we reviewed noted that this scenario was a likely or plausible outcome. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/; International Transport Forum, *Managing the Transition*, 15. Although two studies noted the possibility of a platoon with a driver in the lead truck and no drivers in following trucks, no developer we spoke with was currently planning to develop such a system. Therefore, we do not explore it at length in this report. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; International Transport Forum, *Managing the Transition*, 15. However, one study stated that such a system could yield higher-paying jobs for the lead driver, along with a decrease in other long-haul driving jobs. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

[52]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

[53]Two studies also noted that trucks that are self-driving for part of a long-haul route were the most likely initial scenario. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/. Several stakeholders and studies also noted that similar technology could be used in controlled environments, such as mining. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/; International Transport Forum, *Managing the Transition*, 7. We did not focus on that application because technology developers we spoke with said that long-haul trucking was the focal point for their development.

economic rationale for self-driving trucks is to employ fewer drivers, allowing companies to transport the same amount of freight—or more—at lower labor costs.[54] Several studies have analyzed the potential number of driving jobs that might be eliminated in this scenario, but the studies specifically noted the speculative, long-term nature of those estimates and the inability to identify the number of current long-haul truck drivers whose jobs could be lost sometime in the future.[55] Estimates in the studies we reviewed ranged from under 300,000 driver jobs lost to over 900,000 jobs lost—out of a total of nearly 1.9 million heavy and tractor-trailer truck driver jobs, according to BLS data[56]—and in each case over periods of 10 to 20 years or more.[57]

Although long-haul jobs would decrease in this scenario, local-haul jobs could increase and offset those losses, according to a study and several stakeholders, including two technology developers.[58] The

[54]Generally, driver compensation accounts for about one-third of trucking carriers' operational costs.

[55]These estimates are for driver jobs only and do not include other potential job losses; for example, two stakeholders noted that related jobs such as those at truck stops could be affected as well. Several stakeholders and one study noted that currently available BLS data include long-haul truck driving jobs in the broader occupational category of heavy and tractor-trailer truck drivers, making more precise estimates of current long-haul truck drivers difficult. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/. BLS officials said they do not plan on collecting separate information on long-haul truck drivers specifically. Studies used several different methods to arrive at their estimates, including estimating a percentage of heavy and tractor-trailer truck driving jobs that could be lost and relying in part on industry information for specific types of long-haul trucking jobs such as parcel carriers. See, e.g., Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

[56]These BLS data include approximately 150,000 self-employed truck drivers, such as owner-operators.

[57]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/. In addition, a 2016 report from the Executive Office of the President estimated that between 80 percent and 100 percent of heavy and tractor-trailer truck driver jobs were threatened to be lost—up to nearly 1.7 million jobs (an estimate based on 2015 BLS data that did not include self-employed drivers)—though that included jobs that could be substantially altered and not simply displaced. Executive Office of the President, *Artificial Intelligence, Automation, and the Economy* (Washington, D.C.: December 2016).

[58]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

study, for example, said that automated trucking would drive long-haul trucking costs down, leading more companies to use trucking to ship goods. As a result, demand for trucking could increase, leading to an increased demand for local-haul truck drivers on either end of the long-haul routes, two studies noted.[59]

Several stakeholders we spoke with agreed that any decrease in long-haul jobs would likely not affect many current drivers because most will have voluntarily left driving for a different job or retired by the time self-driving trucks are widely deployed.[60] According to the Census Bureau's American Community Survey data, the average age of truck and sales delivery drivers from 2012 through 2016 was 46.[61] Many stakeholders also said that trucking fleets are currently having difficulty hiring and retaining qualified drivers, and two technology developers said automation could help move goods in an environment in which it is difficult to find workers.

Technology developers also told us they are focusing the initial development of automated trucking technology in the southwest United States because of its good weather and long highways. As a result, any future job losses could first occur there. Additionally, BLS data show that the estimated concentration of truck driving jobs varies

[59]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

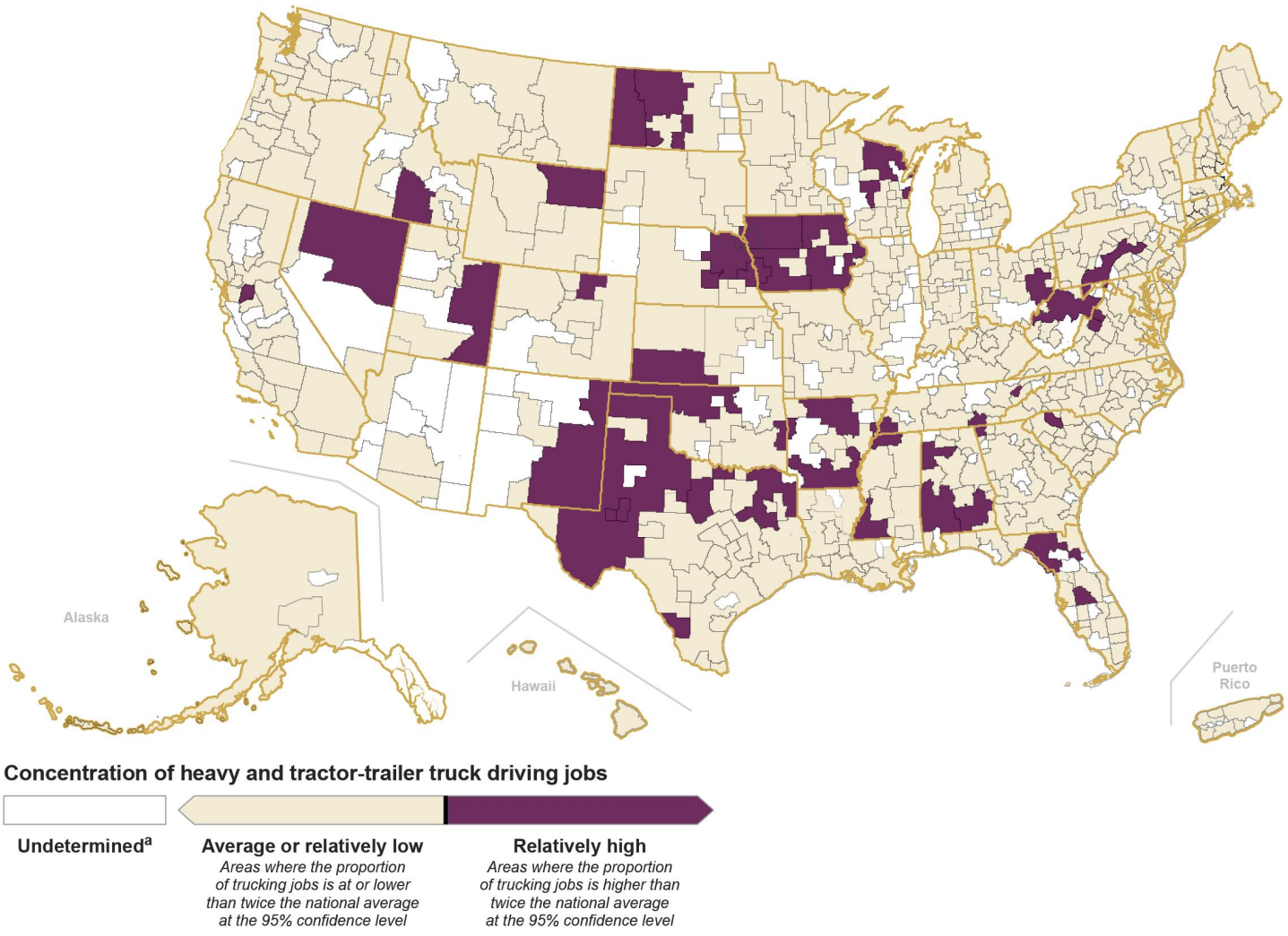
[60]DOL officials noted that workers separate from an occupation because of retirements or other labor force exits, as well as transferring to other occupations. Officials noted BLS estimates that over 6 percent of heavy and tractor-trailer truck drivers will leave driving annually from 2016 to 2026 to pursue another occupation, with another 4 percent exiting the labor force annually. A trucking industry organization said that the vast majority of the turnover—which it estimates to be nearly 100 percent for some industry segments—is due to drivers switching to different trucking fleets in a given year.

[61]Further, 56 percent of these drivers from 2012 through 2016 were at least 45 years old, according to the most recent 5-year data from the American Community Survey; given that workers generally become eligible for Social Security retirement benefits at age 62, a large number of current drivers might retire over the next 10-15 years. By contrast, these data show that 44 percent of all other workers—not these drivers—are over 45 years old. All estimates related to the trucking population in this report have a margin of error of 5.4 percent or less, and all estimates related to the rest of the workforce have a margin of error of 1 percent or less. These data come from the American Community Survey's occupation series 533030, which includes several more finely-defined occupations: driver/sales workers; heavy and tractor-trailer truck drivers; and light truck or delivery services drivers. We refer to these drivers in the report as "truck and sales delivery drivers." See appendix I for more detail about the American Community Survey data.

in different areas of the country (see fig. 7). One study noted that trucking job losses in more regionally concentrated occupations are likely to pose more challenges for workers, because more workers with similar skills in the same labor markets will be out of work at the same time, and thus the whole local economy will be more likely to suffer.[62]

[62]Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

Figure 7: Estimated Geographic Concentration of Heavy and Tractor-Trailer Truck Driving Jobs



Source: GAO analysis of data from the May 2017 Occupational Employment Statistics (OES). | GAO-19-161

Notes: The map depicts the relationship between the proportion of each local geographic area's heavy and tractor-trailer truck driver jobs compared to the national proportion of employment of heavy and tractor-trailer truck drivers—in other words, how great an extent to which a local geographic area relies on heavy and tractor-trailer truck driver jobs for the employment of its population, relative to other areas. Local geographic areas include both metropolitan statistical areas and nonmetropolitan areas. The 2017 Occupational Employment Statistics data estimates are based on surveys conducted over the prior 3-year period.

[a]We classify an area's proportion as "undetermined" when data were unreliable because the 95 percent confidence interval margin of error for the estimated number of truck drivers was larger than 30 percent of the estimate itself, or if data were unavailable for the area.

- ***Wages:*** If the truck is self-driving for parts of a route, wages for long-haul drivers could decrease because there would be lower demand

for—or greater supply of—such drivers, according to several stakeholders. Moreover, one study noted that average long-haul wages could decrease because the jobs most likely to be automated include those that tend to be unionized and have higher wages and benefits, such as jobs at parcel delivery companies and some private carriers.[63] Similarly, drivers changing occupations might face significant wage reductions in new occupations that do not require retraining, according to a researcher and one study.[64] Wages for local-haul drivers—generally lower than for long-haul drivers—could decrease as well, because transitioning long-haul drivers could increase competition for those jobs, according to two studies.[65] One technology developer presented a different perspective, saying that wages for local-haul drivers could increase from current levels due to increased overall demand for trucking.[66]

- ***Retention:*** Overall, retention of truck drivers could improve if the long-haul portion of the route becomes self-driving, lessening time drivers spend away from home—a key reason long-haul drivers leave the profession, according to many stakeholders.[67] However, retention may depend on several factors, including wages, time at home, and other working conditions, making it more difficult to predict self-driving trucks' effect on retention.

[63]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

[64]One study we reviewed estimated that heavy and tractor-trailer truck drivers who lose their jobs could experience a loss in their lifetime earnings, which would not be recovered even after eventual re-employment. This study noted, as an example, that former truck drivers could have few options for other employment without retraining, such as loading or unloading trucks or serving fast food. However, the study also noted that there has been some upgrading of jobs for high school graduates, such as fulfillment center e-commerce jobs. Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

[65]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/; Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

[66]These officials noted that automated trucking could drive long-haul trucking costs down, leading to more companies using trucking to ship goods. As a result, demand for trucking could increase, possibly increasing wages for local-haul truck drivers.

[67]One study noted that remote operation of long-haul trucks might attract drivers who had previously left the field because they would not need to work far away from home. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

- ***Skills:*** Long-haul drivers have skills that would transfer to local-haul routes, so additional training may not be needed for those who move to local-haul routes. However, displaced long-haul drivers seeking to move to a different occupation or industry may need additional training, according to several stakeholders and two studies. From 2012-2016, the highest level of education attainment for almost 65 percent of truck and sales delivery drivers was high school or its equivalent.[68]

Potential Effects If Driver or Operator Remains in Truck

Most officials from truck driver training schools, organizations representing truck drivers, and workforce development boards envisioned automated trucks as continuing to need either a driver or some kind of operator in the truck, with several noting that drivers may need to do non-driving tasks. Automated trucking with an operator in the truck would have a more limited effect on the numbers of truck drivers, but would still result in workforce changes, according to several stakeholders.[69] As with the driverless scenario, many stakeholders said future developments were so uncertain that they could not predict how automated trucking would affect various aspects of the workforce, such as wages or retention.

- ***Employment levels:*** Under this scenario, automated trucking would have a more limited effect on employment levels. Several stakeholders noted, for example, that a person would still be needed in the truck to manage emergencies, repair flat tires, and secure cargo, among other duties. (See text box.) For example, one study noted that even for trucking jobs identified as the most likely to be automated, driving may represent only about half of drivers' total work time.[70] Additionally, particular kinds of long-haul trucking may present

[68]American Community Survey data for truck and sales delivery drivers, compared to 36 percent for all other workers (not these drivers). These data do not reflect the training required to receive a commercial driver's license.

[69]While several stakeholders and studies said that having a driver in the truck was the most likely path for the foreseeable future, one study noted that there are numerous obstacles that make it unlikely for most segments of the industry. Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

[70]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

different non-driving tasks that could make automating those driving jobs more difficult.[71]

- ***Wages:*** If the truck has an operator, several stakeholders said that wages might increase if increased skills are needed to operate more sophisticated equipment. However, several other stakeholders said wages might not change significantly or could decrease with fewer driving tasks. Two studies noted that wage changes were difficult to predict and could be affected by specific policy interventions.[72]

Truck Drivers: Responsible for More than Just Driving

Truck drivers have many responsibilities other than driving a truck. Non-driving tasks for heavy and tractor-trailer truck drivers can include:

- checking vehicles to ensure that mechanical, safety, and emergency equipment is in good working order;
- loading or unloading trucks, including checking contents for any damage;
- inspecting loads to ensure that cargo is secure; and
- performing basic vehicle maintenance tasks, such as adding fuel or radiator fluid; performing minor repairs; or removing debris from loaded trailers.

Source: GAO analysis of Occupational Information Network (O*NET) database. | GAO-19-161

- ***Retention:*** Many stakeholders said new technology could help the trucking industry bring in and retain more people—such as women and younger workers—if it could, for example, make truck driving safer, less stressful, and less physically demanding.[73] Others

[71]Experts who participated in a National Science Foundation-sponsored workshop on the potential workforce effects of automated trucking noted several kinds of trucking that involve significant work for the driver beyond driving tasks, such as for flatbed haulers, tanker drivers, and oversize freight drivers. This workshop was funded by the National Science Foundation and organized by the Virginia Tech Transportation Institute in June 2018. According to workshop organizers, the goal of the workshop was to identify the most critical unanswered questions related to the effects that automated trucks will have on the U.S. economy and the current and future truck driver workforce, and any opinions, findings, and conclusions or recommendations expressed during the workshop were those of the workshop participants and do not necessarily reflect the views of the National Science Foundation. Attendees of the workshop included engineers, computer scientists, regulators, truck drivers, economists, lawyers, insurers, psychologists, and sociologists, among others.

[72]Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/; Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

[73]From 2012 to 2016, roughly 6 percent of all truck and sales delivery drivers (not just long-haul truck drivers) were women, compared to about half of the rest of the U.S. workforce, according to American Community Survey data for truck drivers and sales/delivery drivers. Additionally, about 24 percent of truck and sales delivery drivers were under 35 years old, compared to 36 percent of workers in other occupations, according to American Community Survey data.

cautioned that automated technology may not decrease truck operators' time away from home, because they would still have to be in the truck for the entirety of long-haul routes. One stakeholder, who was also a truck driver, said that many truck drivers enjoy driving, so automating aspects of that task would not necessarily entice those drivers to stay in the job. Two other stakeholders noted that some drivers may not want to learn how the new technology works and could leave the field rather than drive automated trucks.

- ***Skills:*** Future truck operators may need new skills to work with automated technology that assists rather than replaces them, many stakeholders noted. For example, operators may need to adapt to technology that takes over a number of the standard driving functions, such as braking, staying in a designated lane, and keeping a safe distance from other vehicles. Operators may also need to understand how to monitor software and hardware used to automate the driving function and how to make appropriate use of advanced safety systems. Furthermore, officials from many truck driver training schools and workforce development boards said additional certification beyond the standard CDL may be needed in order to demonstrate an understanding of how to operate the technology in automated trucks. In some instances, the skills needed may vary across trucking companies and trucks, requiring further on-the-job training.

New Trucking-Related Jobs

Regardless of their vision for how automated trucking might materialize, many stakeholders said there could be new trucking-related occupations, such as specialized technicians, mechanics, and engineers, which will accompany the deployment of automated trucks. For example, one study noted that these jobs could include producing the technology used by automated trucks, in addition to jobs created as a result of potential greater spending on other consumer goods and services, in the event that automated trucking decreases overall industry transportation costs.[74] Another study noted that autonomous trucks, e-commerce, and economic growth are together poised to create many new trucking jobs.[75] However, new jobs may be located in different geographical areas than any jobs lost, and as noted above, may require different skills than the prior jobs.

[74]Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

[75]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/.

One study noted this development could potentially leave lower-skilled workers competing for jobs that pay little and have few opportunities for advancement.[76]

Stakeholders Said the Anticipated Timeframe for Automated Trucking's Effects on the Workforce Provides an Opportunity for a Federal Response

While many stakeholders we spoke with and several studies we reviewed stated that the potential workforce effects of automated trucking were difficult to predict, they generally agreed that any effect would not occur for at least 5 to 10 years. Several stakeholders and two studies said this time horizon provides an opportunity for federal agencies and workers to prepare for potential workforce changes. One of these studies noted that trucking policy is complex; any changes could take a long time to fully materialize.[77] That same study suggested that now is the appropriate time for policy research and debate. The other study and several stakeholders stated that potential workforce effects are not set in stone, and that public policy could influence specific workforce outcomes.[78] That study said that with advance planning, the federal government and other stakeholders could realize the possible benefits of automated trucks and other vehicles while mitigating potential workforce effects and other costs.

[76]Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

[77]Viscelli, *Driverless*, accessed September 5, 2018, http://laborcenter.berkeley.edu/driverless/. For example, a 2012 law required the Secretary of Transportation to consider requiring stability enhancing technology on motorcoaches. After several reconsiderations, the regulation was eventually finalized on October 30, 2017, and went into effect on November 29, 2017.The same law mandated that the Secretary of Transportation adopt regulations to require electronic logging device use in commercial motor vehicles, including trucks, involved in interstate commerce—when operated by certain types of drivers. The final electronic logging device rule was published in December 2015 and full compliance with the rule is not required until December 2019.

[78]The study recommended ensuring that researchers have the data to allow for the best possible analysis by convening research, practitioner, and statistical agency experts to discuss data needs and how to make data available. The study also suggested that future research topics could include investigating productivity benefits from reducing driving time and increasing other work-related uses of time on the road, and identifying geographic areas and demographic groups most at risk for automated trucking job losses. Groshen et al., *Preparing U.S. Workers*, accessed August 9, 2018, https://avworkforce.secureenergy.org/economist-reports/.

DOT and DOL Could Take Additional Steps to Fully Consider Automated Trucking's Potential Workforce Effects, as Technology Evolves

DOT Has Gathered Stakeholder Perspectives to Inform Potential Regulatory Changes, and DOL Has Incorporated Technology Changes into Employment Projections

DOT and DOL have both taken some steps to prepare for the potential workforce effects of automated trucking. DOT has held events to obtain stakeholder perspectives on automated vehicles policy, including how it affects commercial long-haul trucks. For example, DOT had public listening sessions in 2017 and 2018 to solicit information on the design, development, testing, and integration of Automated Driving Systems, and requests for comment to inform potential rulemaking efforts for the Federal Motor Carrier Safety Regulations.[79] DOT officials said their role during these discussions was to hear stakeholder concerns. They also said that their ongoing goal is to identify barriers in their regulations to safe deployment of automated driving technology. Stakeholders have raised concerns about the potential workforce effects of automated trucks at DOT's listening sessions. For example, after participants questioned potential job losses at a listening session in August 2018, DOT officials said that automation may eventually change the role of a truck driver from driver to technician and that any changes would probably not be immediate. DOL officials said they have participated in some of DOT's listening sessions.

For its part, DOL has taken steps to study how automated trucking may affect the near-term demand for truck drivers as part of their standard, biennial employment projections for all occupations. DOL officials said they consulted experts and economic studies prior to publishing their

[79]These regulations include requirements for commercial truck drivers, including the maximum hours drivers can work and commercial driving license certification, among others.

most recent projections, covering 2016 to 2026, and included information on possible effects of automation in projections for heavy and tractor-trailer truck drivers.[80] The projections state that the demand for these drivers is expected to grow by 5.8 percent between 2016 and 2026, with an average of over 200,000 job openings each year, of which 10,000 are projected to be new jobs.[81] DOL's analysis anticipated that automation will not reduce the number of drivers by 2026.[82] DOL officials said that they expect automation to assist drivers rather than displace them in the near term. Unlike estimates developed by other researchers, these numbers do not include potential job losses after 2026, though DOL officials noted that the agency's next projections, for 2018 to 2028, will incorporate information on how automated trucking technology has evolved since the 2016-2026 projections.[83] Additionally, officials said the agency is transitioning to annual updates of projections to more quickly incorporate developing information.

Congress has directed DOT to consult with DOL to study the workforce impacts of automated trucking technology. Specifically, the Explanatory Statement accompanying the Consolidated Appropriations Act, 2018[84] instructs the Secretary of Transportation to consult with the Secretary of Labor to conduct a comprehensive analysis of the effect of advanced driver-assistance systems and highly automated vehicle technology on drivers and operators of commercial vehicles, including commercial

[80]DOL officials said that they also review historical data and externally-produced projections as part of the process to develop the agency's employment projections.

[81]DOL's projections include jobs created to meet additional trucking demand as well as job openings due to truck drivers changing occupations and leaving the labor force.

[82]According to DOL officials, workforce projections of more than a decade have data reliability issues.

[83]As discussed in the previous section on workforce effects, other researchers project longer-term job losses for long-haul trucking but acknowledge the speculative nature of those estimates. DOL's projections are for heavy and tractor-trailer truck drivers more generally.

[84]The Chairman of the House Committee on Appropriations filed an explanatory statement in the Congressional Record of March 22, 2018 regarding H.R. 1625. Under Section 4 of the Consolidated Appropriations Act, 2018, this explanatory statement shall have the same effect with respect to the allocation of funds and implementation of divisions A through L of the Act as if it were a joint explanatory statement of a committee of conference. For purposes of this report, we are referring to this statement as the Explanatory Statement accompanying the Consolidated Appropriations Act, 2018.

trucks.[85] Congress directed DOT to include stakeholder outreach in its analysis and provide information on workers who may be displaced as a result of such technology, as well as minimum and recommended training requirements for operating vehicles with these systems. DOL officials told us that they have begun collaborating with DOT on this study by consulting with organized labor and other stakeholders. In October 2018, DOT issued a request for information to solicit comments on the scope of this analysis and detailed several potential research questions, including which commercial drivers are likely to be affected and what skills might be needed to operate new vehicles or transition to new jobs.[86] DOT also announced that it is planning to coordinate with the Departments of Commerce and Health and Human Services, in addition to consulting with DOL to conduct this analysis. The Explanatory Statement directs DOT to conduct this analysis by March 23, 2019, and DOT officials told us they expect to meet this deadline and report on the analysis by that date.

DOL and DOT Do Not Have Plans to Gather and Share Information about the Potential Workforce Effects of Automated Trucking as Technology Evolves

[85]DOT officials told us that they will defer to the industry to determine which Society of Automotive Engineers International levels of automation refer to advanced driver-assistance systems and highly automated vehicle technology for this analysis. They also said that industry typically views advanced driver-assistance systems as Levels 0 to 2 and highly automated vehicle technology as Levels 3 to 5.

[86]For example, some of the questions on which DOT sought comments include: (1) When should stakeholders anticipate widespread introduction of automated vehicle technology that would directly impact the driver workforce? (2) What are the defined segments of commercial drivers in the United States? (3) Which of these segments are most likely to be impacted, negatively or positively, and to what extent? (4) As commercial and non-commercial drivers transition into other transportation, or even unrelated, positions, what are new likely opportunities and what are the minimum levels of training and skills necessary to occupy those positions? and (5) What are the training/skills requirements for those jobs most in demand? Office of the Secretary, U.S. Department of Transportation; *Notice of Request for Comments: Scope of the Study on the Impact of Automated Vehicle Technologies on Workforce*, 83 Fed. Reg. 50,747(Oct. 9, 2018). Although DOT outlined general tasks that it plans to undertake in order to answer each proposed research question, DOT's statement of work does not include a detailed methodology for how the agency plans to answer these questions.

Convening Key Groups of Stakeholders on an Ongoing Basis to Gather Information

DOL and DOT have taken some steps to convene stakeholders to inform DOT's analysis of automated trucking in advance of March 2019. However, DOL and DOT have not made plans to continue collaborating to convene key groups of stakeholders as the technology evolves to gather information about potential workforce effects of automated trucking.[87] Insofar as automated trucking technology is still evolving, convening stakeholders solely to inform the March 2019 analysis will not provide agency officials with sufficient information about important developments that may occur after the analysis is completed. This analysis will be an important step. However, DOT must complete it before potential workforce effects can be more fully predicted. After its completion, developers will likely continue to test their technologies, and issues related to operational and other factors that will affect the deployment of automated trucks may change or be resolved. For the agencies to more fully understand these developments and clarify the range of associated workforce effects, they would need to collaborate and to continue to gather information in the future, for example by continuing to convene key groups of stakeholders as the technology evolves. The majority of stakeholders we spoke with, including representatives from local workforce development boards, truck driver training schools, technology developers, and groups representing truck drivers, told us it would be helpful for federal agencies to play a convening role so that DOL and DOT can better anticipate and understand any potential workforce changes. Several stakeholders also said that convening stakeholders would enable DOL and DOT to surface different parties' concerns. Additionally, our recent report on emerging technologies found that federal agencies can play an important role in convening stakeholders to gather information in areas where technology is still under development,

[87]We have noted the importance of stakeholder outreach in our prior work. Including relevant participants is a leading practice in agency collaboration. Relevant participants can include other federal agencies, state and local entities, and organizations from the private and nonprofit sectors. See GAO, *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms,* GAO-12-1022 (Washington, D.C.: September 27, 2012).

including information on the research plans of industry stakeholders and ways to address national needs.[88]

Continuing to convene stakeholders could also help agencies to identify any information or data gaps that may need to be addressed to understand the potential workforce effects of automated trucking. DOL officials said that because the technology is still advancing, the related workforce effects, including the magnitude of any job losses, are uncertain. They also said they do not have information to identify the number of long-haul truck drivers, whose jobs may be the most likely to be affected by automation. Specifically, the occupational code DOL uses to classify heavy and tractor-trailer truck drivers captures drivers who operate any type of heavy truck. Along with long-haul drivers, this code includes other drivers whose jobs may be harder to automate, such as tow truck operators.[89] Experts who participated in the National Science Foundation-sponsored workshop on the potential workforce effects of automated trucking also identified information gaps.[90] They noted that more information is needed in several areas, including a better understanding of current truck drivers' skills beyond driving, how those skills might translate to other occupational areas, and new jobs and skills that will be required with the deployment of automated trucks. DOL officials said that the agency provides information on knowledge, skills, and abilities for various driver occupations, as well as detailed work activities, on its Occupational Information Network (O*NET). However, that information is based on surveys to current workers and therefore

[88]See GAO, *Science and Technology: Considerations for Maintaining U.S. Competitiveness in Quantum Computing, Synthetic Biology, and Other Potentially Transformational Research Areas,* GAO-18-656 (Washington, D.C.: September 26, 2018).

[89]The federal government is trying to capture some information on the use of automation by U.S. firms, including the workforce effects of such technologies. For example, in addition to the DOL efforts noted above, the Census Bureau has made recent efforts to collect information on automation. The Census Bureau and National Science Foundation currently administer the Annual Business Survey to firms regarding their use of advanced technology, such as automated guided vehicles.

[90]As noted previously, this workshop was funded by the National Science Foundation and organized by the Virginia Tech Transportation Institute in June 2018. Any opinions, findings, and conclusions or recommendations expressed during the workshop were those of the workshop participants and do not necessarily reflect the views of the National Science Foundation.

does not include what skills future drivers may need as automated technology evolves.[91]

DOL officials told us they do not typically convene stakeholders on an industry-specific basis. They also said that state and local workforce development boards are best positioned to identify and respond to changes in their local economy and employment needs, because these boards include members from the local business community who know which industries are growing in their local labor markets. However, there are close to 1.9 million heavy and tractor-trailer truck drivers across the country, making the trucking industry an important segment of the national workforce.[92] In addition, one of DOL's objectives in its fiscal year 2018-2022 strategic plan is to provide timely, accurate, and relevant information on labor market activity, working conditions, and price changes. While DOL officials said they consider the agency's national labor statistics as the primary tool in understanding macroeconomic changes, they acknowledged that gathering information from local boards and other stakeholders may complement those statistics. DOL officials said they may consider continuing to convene stakeholders to learn more about automated trucking if they find that their current efforts with DOT provide fruitful information, but they currently do not have plans to do so. If DOL waits until the effects of automated trucking on the workforce are widespread enough to affect multiple local economies, the agency will have missed the opportunity to proactively gather information that could help it anticipate large-scale workforce changes in this important industry before they take effect.

DOT officials told us they have likewise not made plans to work with DOL to convene stakeholders on an ongoing basis to gather information. Rather, they said they have concentrated on developing the analysis described by the Explanatory Statement accompanying the Consolidated Appropriations Act, 2018 and they do not plan to update that analysis after it is completed. Nonetheless, one of the objectives outlined by DOT in its fiscal year 2018-2022 strategic plan is to promote economic

[91]DOL completely updates this information every five years based on surveys of workers, and updates technology skills at least annually, according to DOL officials. O*NET's updates are aimed at identifying and maintaining current information on the characteristics of workers and occupations, according to its website.

[92]As noted above, this 1.9 million figure includes 1.7 million heavy and tractor-trailer truck drivers, as well as approximately 150,000 self-employed truck drivers, such as owner-operators.

competitiveness by supporting the development of appropriately skilled transportation workers (including truck drivers who transport freight) and strategies to meet emerging workforce challenges. Working with DOL to gather and analyze information from stakeholders as technology continues to develop could assist DOT in meeting this goal. DOT has previously collaborated with DOL on transportation workforce issues. For example, in 2015, DOT and DOL worked with the Department of Education on a blueprint for aligning investments in transportation, including trucking, with career pathways.[93] The report highlighted potential future growth areas in the transportation industry and identified potential jobs that may be in demand through 2022. Unless DOL and DOT continue to gather information from stakeholders as automated trucking technology evolves, they may be unable to fully anticipate the emerging workforce challenges that may result. DOT's prior efforts to convene stakeholders to address automated vehicles could serve as a model for gathering information from stakeholders about automated trucking. For example, DOT held a series of meetings across the country to gather information, identify key issues, and support the transportation community to integrate automated vehicles onto roads for its National Dialogue on Highway Automation. Further, analyzing information from ongoing meetings with stakeholders could help DOT as it considers potential workforce-related regulatory changes that might be affected by automated truck technologies, such as the requirements to obtain a commercial driver's license or the maximum number of hours commercial truck drivers are permitted to work.

Sharing Information

DOL has not provided information to stakeholders about the potential workforce effects of automated trucking technology, including how the skills needed to operate a truck may change in the future. DOL officials told us they have not done so, in part, because they do not yet know how skills and training needed to be a truck driver might change, if at all.[94] Representatives from all of the truck driver training schools and training associations we interviewed said they expect drivers to need new skills to

[93]Departments of Education, Transportation, and Labor, *Strengthening Skills Training and Career Pathways Across the Transportation Industry: Data Report on Future Transportation Workforce Needs* (August 2015).

[94]DOL officials told us that they provide information about the skills needed for various occupations, including heavy and tractor-trailer truck drivers, in O*NET. They noted that they update O*NET as the skills within an occupation change.

operate or maintain automated trucks, and that future truck drivers may need an additional certification or endorsement to their commercial driver's license. However, in the absence of specific information about future skill changes, they all said they did not know what specific adjustments would be needed to their curriculum. Additionally, nearly all stakeholders we spoke with—including representatives of technology developers, truck driver training schools, and local workforce development boards—told us that federal agencies can help prepare the future workforce by sharing information with stakeholders about impending workforce changes. In particular, some workforce officials we spoke with said they would benefit from information about technology developers' plans that would affect future demand or skills for truck drivers.

Furthermore, DOL officials told us that heavy and tractor-trailer truck driving was the most common type of occupational training funded through the WIOA Adult and Dislocated Worker programs between April 2017 and March 2018, the most recent period for which data are available. Specifically, local workforce development boards provided funding from these programs to roughly 17,000 individuals for heavy and tractor-trailer truck driver training during that year, or about 15 percent of all individuals who received training services that began within that timeframe. This was more than twice as many individuals as those who received funding for nursing assistant training, the second most frequently funded type of training through these programs.

As previously noted, one of DOL's strategic objectives is to provide timely and accurate labor market information. In addition, according to *Standards for Internal Control in the Federal Government*, an agency's management should externally communicate the necessary quality information to achieve the entity's objective.[95] This includes communicating quality information so that external parties can help the entity address related risks. Additionally, our work has shown that federal agencies can play an important role in sharing information. We have noted that such information sharing is important to help maintain U.S. competiveness.[96] DOT's strategic plan highlights the agency's concern that the lack of credentialed workers, combined with projected retirements, threaten to cause significant worker shortages, and that the

[95]GAO-14-704G.

[96]GAO-18-656.

introduction of innovations and new technologies adds additional complexity for workforce development. Consulting with DOT to provide stakeholders with information about how automated technology could affect the number of trucking jobs and the skills needed to drive or operate commercial trucks would better position local workforce development boards, truck driver training schools, and others to adequately prepare the workforce for future needs.

Responding to Potential Job Losses

DOL officials said that existing employment and training programs administered by the agency, usually through grants, are generally designed to respond to economic changes that may result in job losses, including any that may result from automated trucking. In addition, DOL officials said that the agency has several resources to support state and local workforce areas to respond to mass layoffs and help workers upgrade their skills. For example, Rapid Response, which is carried out by states and local workforce development agencies, can provide services to employees after a layoff, including career counseling, job search assistance, and information about unemployment insurance and training opportunities. Additionally, under WIOA, local workforce development boards can use up to 20 percent of their Adult and Dislocated Worker allocations to help fund the cost of providing incumbent worker training designed to help avert potential layoffs or increase the skill levels of employees. While these programs may help mitigate any future job losses due to automated trucking, DOL would be better positioned to help local economies leverage them effectively if the agency continued to convene stakeholders, building on its efforts to gather and share good information on when and how those workforce effects are likely to materialize as technology evolves.

Conclusions

Automated and self-driving technology for commercial trucks could make the industry safer and more efficient, but it also introduces significant uncertainties for the trucking workforce that DOL and DOT, in consultation with other federal agencies and stakeholders, can help navigate. For example, there is uncertainty about the widespread deployment of self-driving trucks as well as what the resulting effects will be on employment levels, wages, and needed skills. Although technology companies generally envision self-driving trucks being used for long-haul routes—which could result in fewer long-haul trucking jobs—other

stakeholders argued that a truck will always need a driver or operator. Stakeholders we interviewed also lacked consensus about what automated trucking might mean for wages and what new skills will be needed to drive or operate automated trucks.

Federal agencies have an opportunity to prepare truck drivers for the possible workforce effects of automated trucking. Many stakeholders noted that the effects would be gradual, giving the government time to act, but studies note the effects could eventually be significant, possibly affecting hundreds of thousands of truck driving jobs.

DOT is taking an important step toward learning about these workforce effects by consulting with DOL and other stakeholders to inform DOT's analysis of these developments. However, these agencies have not made plans to continue to convene stakeholders to gather information on an ongoing basis or update their analysis as the technology evolves and the effects become more apparent. Doing so could allow DOL and DOT the foresight to consider whether additional policy changes are needed to prepare for any possible future workforce effects. Similarly, DOL's publication of routine employment projections and current driver skills and tasks provide useful information. However, DOL has not shared information on what skills drivers might require in the future with other key stakeholders, including technology developers, industry experts, truck driver representatives, training schools, local workforce development boards, and other relevant federal agencies. As a result, those stakeholders may miss an opportunity to better anticipate and plan for changes that may arise from automated trucking technology, including potential labor displacement, wage changes, and the need for new skills.

Recommendations for Executive Action

We are making the following four recommendations, including two for the Department of Labor and two for the Department of Transportation:

1. The Secretary of Labor should collaborate with the Secretary of Transportation to continue to convene key groups of stakeholders to gather information on potential workforce changes that may result from automated trucking as the technology evolves, including analyzing needed skills and identifying any information or data gaps, to allow the agencies to fully consider how to respond to any changes. These stakeholders could include, for example, representatives of other relevant federal agencies, technology developers, the trucking

industry, organizations that represent truck drivers, truck driver training schools, state workforce agencies, and local workforce development boards. (Recommendation 1)

2. The Secretary of Transportation should collaborate with the Secretary of Labor to continue to convene key groups of stakeholders to gather information on potential workforce changes that may result from automated trucking as the technology evolves, including analyzing needed skills and identifying any information or data gaps, to allow the agencies to fully consider how to respond to any changes. These stakeholders could include, for example, representatives of other relevant federal agencies, technology developers, the trucking industry, organizations that represent truck drivers, truck driver training schools, state workforce agencies, and local workforce development boards. (Recommendation 2)
3. The Secretary of Transportation should consult with the Secretary of Labor to further analyze the potential effects of automated trucking technology on drivers to inform potential workforce-related regulatory changes, such as the requirements to obtain a commercial driver's license or hours of service requirements (e.g., the maximum hours commercial truck drivers are permitted to work). This could include leveraging the analysis described by the Explanatory Statement accompanying the Consolidated Appropriations Act, 2018 once it is complete, as well as information the department obtains from stakeholders as the technology evolves. (Recommendation 3)
4. The Secretary of Labor should consult with the Secretary of Transportation to share information with key stakeholders on the potential effects of automated trucking on the workforce as the technology evolves. These stakeholders could include, for example, representatives of other relevant federal agencies, technology developers, the trucking industry, organizations that represent truck drivers, truck driver training schools, state workforce agencies, and local workforce development boards. (Recommendation 4)

Agency Comments and Our Evaluation

We provided a draft of this report for review and comment to the Departments of Education, Labor (DOL), Transportation (DOT), and Veterans Affairs. We received formal written comments from DOL and DOT, which are reproduced in appendices III and IV, respectively. In addition, DOL and DOT provided technical comments, which we have

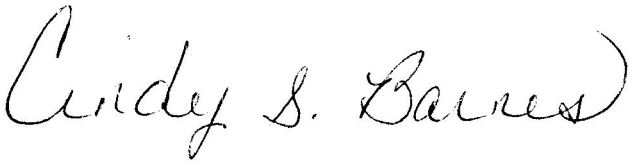
incorporated as appropriate. The Departments of Education and Veterans Affairs did not have comments on our report.

In its written comments, DOL agreed with our recommendations and noted several efforts that it said will help the agency assess and provide information on the potential workforce effects of evolving technologies, such as automated trucking. For example, DOL noted that the agency's employment projections incorporate expert interviews and other information to identify shifts in industry employment. DOL is also currently consulting with DOT to study these workforce effects, and agreed to consider what other information and stakeholder meetings remain necessary after that study—due in March 2019—is completed. Likewise, DOL agreed to share related information as the technology evolves, and the agency noted it currently publishes employment projections and other occupational information. While useful, these efforts alone will not allow DOL to sufficiently anticipate the future workforce effects of automated trucking. For instance, the broad employment projections do not provide estimates specifically for the long-haul truck drivers who could be affected by automated trucking first. Further, DOL's occupational information is based on surveys of current workers, so it does not include the skills future drivers will need as automated trucking evolves. Therefore, we continue to believe that convening stakeholders and sharing information about potential workforce effects in the future will position DOL to better understand and inform key stakeholders of these changes.

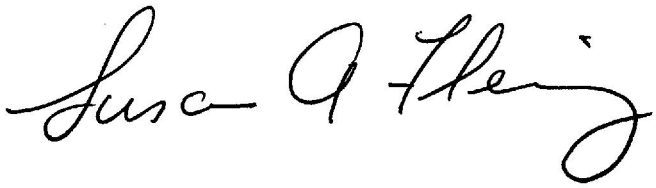
In its written comments, DOT agreed with our recommendations. DOT noted two of its current efforts related to automated trucking technology, namely its October 2018 automated vehicles voluntary guidance, *Preparing for the Future of Transportation: Automated Vehicles 3.0*, and its forthcoming Congressionally-directed research on the impact of automated vehicle technologies on the workforce.

We are sending copies of this report to the appropriate congressional committees, the Secretaries of Education, Labor, Transportation, and Veterans Affairs, and other interested parties. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact us at (202) 512-7215 or brownbarnesc@gao.gov or flemings@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix V.



Cindy S. Brown Barnes, Director
Education, Workforce, and Income Security Issues



Susan A. Fleming, Director
Physical Infrastructure Issues

Appendix I: Objectives, Scope, and Methodology

Our objectives were to examine: (1) what is known about how and when automated vehicle technologies could affect commercial trucks; (2) what is known about how the adoption of automated trucks could affect the commercial trucking workforce; and (3) the extent to which the Department of Transportation (DOT) and Department of Labor (DOL) are preparing to assist drivers whose jobs may be affected by automated trucking.

For all the objectives, we reviewed relevant federal laws and regulations as well documentation from DOT and DOL. To determine the extent to which federal agencies are preparing to assist current and future drivers, we compared DOT and DOL's efforts against their strategic plans as well as *Standards for Internal Control in the Federal Government*.[1] Additionally, we:

- **Conducted Interviews:** We interviewed officials from several federal agencies to obtain relevant information about our objectives, including the Departments of Education, Labor, Transportation, and Veterans Affairs, as well as the National Science Foundation.

  To obtain information about all of our objectives, we also interviewed other selected stakeholders. We used our initial research and interviews to develop a list of stakeholder categories that would provide informed perspectives, which when taken as a whole, provided a balanced perspective to answer our objectives. We selected stakeholders who had a range of perspectives regarding the timing for adoption of automated trucking technology, and how this adoption could affect the truck driving workforce. We used the following criteria to select interviewees:

1. authored a report, article, book, or paper regarding automated trucking technology or its potential workforce effects;

[1]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: September 2014).

2. participated in panels, hearings, or roundtables regarding automated trucking or its potential workforce effects; or
3. was recommended by at least one of our interviewees.

We interviewed organized labor representatives; researchers; and representatives from three truck manufacturers and three companies operating their own trucking fleet; two national industry organizations; one national safety organization; four truck driver training schools; an association of state and local workforce organizations; and four local workforce development boards. We selected the schools in part based on recommendations from an association of truck driver training schools, and included two accredited and two non-accredited schools in our selection. We selected three of the workforce development boards due to the prevalence of trucking jobs in their areas and the other board because it was in an area that several stakeholders suggested could be early to adopt automated trucking technology.

Additionally, we visited California, where we interviewed representatives of four automated truck technology developers and a manufacturer, and viewed demonstrations of automated trucking technology. We selected California because it had the largest number of technology developers that we identified through our research efforts.

We asked all of these stakeholders a core set of questions, as well as tailored questions based on their expertise. Some of the questions we asked stakeholders varied, and some stakeholders chose not to answer every question we asked because they either did not think they had sufficient knowledge about the specific question or did not want to make predictions about future industry developments. Therefore, we generally did not report the specific number of stakeholder responses in this report. The views of the stakeholders we interviewed are illustrative examples and may not be generalizable. For a full list of stakeholders we interviewed, see table 1.

Table 1: List of Stakeholders We Interviewed

Category	Category members
Federal agencies	• Congressional Research Service • Department of Labor • Department of Education • Department of Transportation • Department of Veterans Affairs • National Science Foundation
Truck manufacturers	• Volvo Group • Tesla Motors, Inc. • Daimler Trucks of North America
Technology developers	• Embark Trucks • Peloton Technology • Starsky Robotics • Uber Advanced Technologies Group[a] • Waymo
Researchers	• Dr. Michael Belzer, Wayne State University • Dr. Lee Branstetter, Carnegie Mellon University • Dr. Randall Eberts, W.E. Upjohn Institute for Employment Research • Dr. Jeffrey Hickman, Virginia Tech Transportation Institute • Dr. Steven Shladover, University of California, Berkeley • Dr. Steve Viscelli, University of Pennsylvania
Fleet owners	• Knight-Swift Transportation Holdings, Inc. • United Parcel Service of America • Walmart U.S.
Organized labor	• International Brotherhood of Teamsters
Truck driver associations	• Owner-Operator Independent Drivers Association • Women in Trucking Association
Trucking industry association	• American Trucking Associations
Transportation-related association	• American Association of Motor Vehicle Administrators
Transportation safety association	• Commercial Vehicle Safety Alliance

Category	Category members
Truck driver training schools and associations	• Diesel Driving Academy • Georgia Driving Academy • New England Tractor Trailer Training School • Smith and Solomon Training Solutions • Commercial Vehicle Training Association • National Association of Publicly Funded Truck Driving Schools
Local workforce development boards and related association	• Maricopa County Workforce Development Board (Arizona) • Permian Basin Workforce Development Board (Texas) • South Central Workforce Development Board (SCPa Works) (Pennsylvania) • State Workforce Development Board (Utah) • National Association of Workforce Boards

Source: GAO. | GAO-19-161

[a]In July 2018, Uber Advanced Technologies Group announced that it would stop developing automated trucks.

- **Analyzed federal data.** To examine how the adoption of automated trucks could affect the current and future trucking workforce, we analyzed relevant data from the Bureau of Labor Statistics (BLS) and the Census Bureau on the current trucking workforce. Specifically, we examined BLS's Occupational Employment Statistics to obtain employment level and wage data for heavy and tractor-trailer truck drivers (Standard Occupational Classification code 53-3032). The Occupational Employment Statistics survey is a federal-state cooperative program between the Bureau of Labor Statistics and State Workforce Agencies. The survey provides estimates regarding occupational employment and wage rates for the nation as a whole, by state, by metropolitan or nonmetropolitan area, and by industry or ownership. Data from self-employed persons are not included in the estimates. For our analysis of geographic concentration of heavy and tractor-trailer truck driving jobs, we carried out a one-sided test at the 0.05 percent level of significance of the null hypothesis that a region's concentration is equal to or less than twice the national concentration versus the alternative hypothesis, that the region's concentration is greater than twice the national concentration. We classified the results, excluding any unreliable areas (i.e., areas with a 95 percent confidence level margin of error for the estimated number of truck drivers that was larger than 30 percent of the estimate itself). We used Poisson tests because these are more appropriate for event occurrences in smaller populations or on a small number of cases. In

addition, we analyzed data from the Census Bureau's American Community Survey regarding the education level, sex, and age of current truck drivers and other drivers.[2] The American Community Survey is an ongoing survey that collects information about the U.S. population such as jobs and occupations, educational attainment, income and earnings and other topics. According to the Census Bureau's description of the American Community Survey, this survey uses a series of monthly samples to produce annually updated estimates for the same small areas (census tracts and block groups) formerly surveyed via the decennial census long-form sample.[3] Based on our review of related documents and interviews with knowledgeable agency officials, we found the data to be reliable for our purposes.

- **Synthesized literature.** To explore how and when automated vehicle technologies could affect the current fleet of commercial trucks and gather information about the possible employment effects of this technology, we conducted a review of key research related to automated vehicle technologies for commercial trucks. We searched bibliographic databases for articles that were published between January 1, 2014 and May 22, 2018 and included key terms such as "autonomous", "automated", "driverless", and "truck platoon" to describe the trucking technology. We also asked the researchers we interviewed to identify any studies that may be relevant to our work.

  Our search initially resulted in over 250 articles with potential relevance to our objectives. Two analysts reviewed the abstracts of these articles to determine if the articles in this initial search were germane to our objectives. We excluded any articles that were not relevant to our objectives or did not meet our standards for empirical analysis.

  We included articles that were published in peer review journals, by industry, or by government agencies, as well as articles that were recommended by researchers we interviewed. We identified a final list of 12 studies that met our criteria. Although we reviewed each study's

[2]The data come from the American Community Survey's occupation series 533030, the standard occupation classification code that, according to BLS, includes more finely defined occupations, namely Driver/Sales Workers (53-3031); Heavy and Tractor-Trailer Truck Drivers (53-3032); and Light Truck or Delivery Services Drivers (53-3033).

[3]U.S. Census Bureau *American Community Survey Design and Methodology* (January 30, 2014).

methodological approach, we did not independently assess the evidence in the articles or verify the analysis of the evidence that was used to come to the conclusions these studies reached.

Appendix II: Potential Legal Factors That May Affect Timing of Automated Trucking

Table 2: Potential Legal Factors Identified by Stakeholders or in Literature That May Affect Timing for the Development and Deployment of Automated Commercial Trucks, and Related DOT Information

Legal factor	Type of automated commercial truck potentially affected (platooning, self-driving for part of a route, self-driving for an entire route)	Examples of legal factors identified by selected stakeholders or in literature and related Department of Transportation (DOT) information
Following distance laws	Platooning	One developer we spoke with is working with states to change following distance laws to allow for testing of truck platoons.
Following distance laws	Platooning	In DOT's October 2018 automated vehicles voluntary guidance, *Preparing for the Future of Transportation: Automated Vehicles 3.0*, the agency stated that states should consider reviewing and potentially modifying traffic laws and regulations that may be barriers to automated vehicles, including following distance laws that prohibit trucks from following too closely to each other—effectively prohibiting automated truck platooning.
Liability	Platooning, self-driving for part of a route, and self-driving for an entire route	The law governing liability for traffic accidents is a mixture of state liability and insurance laws. Several stakeholders we spoke with and two studies we reviewed noted that liability issues may arise and become more complex for automated trucks. This may be because, for example, more parties may become involved. One of these stakeholders—a fleet owner—said that these parties could include the software developer, the truck manufacturer, the owner of the truck, and, if applicable, the truck driver.
Liability	Platooning, self-driving for part of a route, and self-driving for an entire route	In *Preparing for the Future of Transportation: Automated Vehicles 3.0*, DOT noted that stakeholders the agency has engaged with also raised concerns regarding insurance requirements and methods for determining liability for automated vehicles.
Need for a human driver to be in an automated truck under existing regulations	Platooning, self-driving for part of a route, and self-driving for an entire route	Several stakeholders have requested that DOT clarify whether or not existing regulations require that a human driver always be present in automated trucks, particularly those capable of higher levels of driving automation—particularly those trucks that are self-driving for either part or all of a route. Two technology developers have requested that DOT confirm that regulations that apply to human drivers do not apply to automated trucks, and one of these developers also requested confirmation that a truck capable of at least Level 4 automation is allowed to operate without a human on board, which could permit testing without a person in the truck.

Legal factor	Type of automated commercial truck potentially affected (platooning, self-driving for part of a route, self-driving for an entire route)	Examples of legal factors identified by selected stakeholders or in literature and related Department of Transportation (DOT) information
Need for a human driver to be in an automated truck under existing regulations	Platooning, self-driving for part of a route, and self-driving for an entire route	In *Preparing for the Future of Transportation: Automated Vehicles 3.0*, DOT indicated that the agency will interpret and adapt, consistent with all applicable notice and comment requirements, the definitions of "driver" and "operator" to recognize that such terms do not refer exclusively to a human, but may include an automated system. In the same guidance document, DOT also noted that regulations will no longer assume that the driver of a commercial truck is always human or that a human is necessarily present inside of a truck during its operation.

Legal factor	Type of automated commercial truck potentially affected (platooning, self-driving for part of a route, self-driving for an entire route)	Examples of legal factors identified by selected stakeholders or in literature and related Department of Transportation (DOT) information
Safety assurance	Self-driving for part of a route and self-driving for an entire route	Currently, manufacturers have the primary responsibility for safety testing and certification of their vehicles. According to one researcher we interviewed, this safety testing and certification process makes sense for mechanical equipment, but DOT should consider whether current safety standards are appropriate for automated trucks.
Safety assurance	Self-driving for part of a route and self-driving for an entire route	According to *Preparing for the Future of Transportation: Automated Vehicles 3.0*, DOT noted that intends to reconsider the necessity and appropriateness of its current safety standards as applied to Automated Driving System-equipped vehicles. The agency stated that it recognizes that the accelerating pace of technological change, especially in the development of software used in Automated Driving System-equipped vehicles, including automated trucks, requires a new approach to the formulation of the Federal Motor Vehicle Safety Standards. For example, the policy states that standards could provide for a range of potential behaviors—e.g., speed, distance, angles, and size—for surrogate vehicles, pedestrians, and other obstacles that Automated Driving System-equipped vehicles would need to detect and avoid.
Hours of service	Self-driving for part of a route and self-driving for an entire route	Currently, a human driver may generally work a 14-hour shift that includes only 11 total hours of driving time before taking a required 10-hour break.[a] A few stakeholders said it may be necessary to clarify the hours of service rules if a human driver is in an automated truck where the system is driving for part or all of a route.
Hours of service	Self-driving for part of a route and self-driving for an entire route	In *Preparing for the Future of Transportation: Automated Vehicles 3.0*, DOT stated that in the case of automated vehicles that do not require a human operator, none of the human-specific Federal Motor Carrier Safety Regulations, including those related to hours of service, apply.
Commercial driver's license (CDL) changes	Platooning, self-driving for part of a route, and self-driving for an entire route	Several stakeholders suggested that, if a person is still needed in an automated truck, there may be a need to add endorsements or certifications to CDLs to allow drivers to drive and maintain automated trucks.
Commercial driver's license (CDL) changes	Platooning, self-driving for part of a route, and self-driving for an entire route	DOT's Preparing for the Future of Transportation: Automated Vehicles 3.0 mentions that the agency will consider whether there is a reasonable basis to adapt its CDL regulations for an environment in which a qualified driver may be an automated driving system, but does not address changes that may affect CDL requirements for a person who drives an automated truck.
Cargo securement	Self-driving for part of a route and self-driving for an entire route	Under current rules, cargo must remain secured on or in the transporting vehicle, under all conditions that could reasonably be expected to occur in normal driving and when a driver is responding in all emergency situations, except when there is a crash.[b] Some stakeholders we spoke with said cargo securement may be an issue if there is no person on board an automated truck to handle, for example, an unforeseen problem with the cargo *en route* to a destination, or in the case of a parked and unattended truck.

Legal factor	Type of automated commercial truck potentially affected (platooning, self-driving for part of a route, self-driving for an entire route)	Examples of legal factors identified by selected stakeholders or in literature and related Department of Transportation (DOT) information
Cargo securement	Self-driving for part of a route and self-driving for an entire route	In March 2018, DOT released a review of the Federal Motor Carrier Safety Regulations as part of the agency's request for comments regarding which of these regulations may be barriers to the testing and deployment of Automated Driving System-equipped commercial motor vehicles, including automated commercial trucks. The review found it may be challenging for automated trucks with no person on board to comply with the requirements that a driver inspect the cargo within the first 50 miles and reexamine the cargo every three hours or 150 miles.

Source: GAO analysis of stakeholder interviews, literature, DOT information, and relevant federal laws and regulations. | GAO-19-161

[a]49 C.F.R. Part 395.

[b]49 C.F.R. Part 393.

Appendix III: Comments from the Department of Labor

U.S. Department of Labor

Office of the Assistant
Secretary for Policy
Washington, D.C. 20210

JAN 2 5 2019

Ms. Cindy S. Brown Barnes
Director
Education, Workforce, and Income Security Issues
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Ms. Barnes:

Thank you for the opportunity to review and comment on the Government Accountability Office's (GAO) draft report titled, *Automated Trucking: Federal Agencies Should Take Additional Steps to Prepare for Potential Workforce Effects* (GAO-19-161, Job Code 102284). We understand that GAO performed this work pursuant to its authority under 31 U.S.C. 717, and a request for the study from Chairwoman Susan Collins and Ranking Member Jack Reed of the Senate Committee on Appropriations, Subcommittee on Transportation, Housing and Urban Development and Related Agencies.

The Department of Labor (Department) appreciates GAO's work to provide information on potential workforce impacts of the still-evolving technologies associated with automated trucking, and the progress and remaining challenges for the Departments of Labor and Transportation (DOT) in continuing to assess these impacts. As GAO found in gathering extensive background information for this study, different experts have estimated different potential impacts on the workforce as a result of new vehicle technologies, and many of these estimates suggest that widespread changes will occur "years to decades" in the future.

The Department is committed to continuing its work with all relevant stakeholders to assess and provide information on projected effects of evolving technologies, and to leverage the best information available to support the alignment of workforce development with skills that are in-

demand, to address current and future skills needs, and to help all Americans become economically self-sufficient.

The Department is using its ongoing Employment Projections to project changes in this context. In developing the Employment Projections, the Department thoroughly reviews qualitative sources, such as scholarly articles, expert interviews, and news stories, and quantitative resources, such as historical data and externally produced projections to identify structural changes in the economy, which are expected to change an occupation's share of industry employment. The Department also engages with professional associations and subject matter experts to develop the *Occupational Outlook Handbook*, which provides duties, education and training, pay and outlook for occupations.

The Bureau of Labor Statistics publishes its biennial Employment Projections and *Occupational Outlook Handbook*; the Employment and Training Administration also incorporates those estimates into online career tools, such as www.ONETOnLine.org, www.MyNextMove.org, and www.CareerOneStop.org, all of which also articulate the skills associated with specific occupations, and help inform job seekers. The Department also uses the best data available to administer multiple workforce programs that prepare job seekers, including apprenticeships and training and employment services delivered through American Job Centers, and to make workforce information available through multiple methods.

The Department is working with DOT on a study of workforce impacts and is working jointly with DOT to hold convenings. These efforts will inform any joint next steps to understand and address the impacts of automated trucking.

GAO made four recommendations, two apply to the Department. The Department agrees with GAO Recommendation 1, that the Department convene key groups of stakeholders to gather information on skill needs. The Department already planned and is actively involved in several activities that will implement this recommendation. The Department has and continues to use ongoing Employment Projections methodologies to obtain information to enable the Department identify shifts in industry employment. The Department is currently consulting with DOT on an ongoing study of workforce impacts, and will consider what other information remains necessary after that report is complete. The Department is also already engaged in joint efforts with DOT to hold stakeholder convenings, and will determine whether further convenings are necessary to complement the information gathered through these methods.

The Department also agrees with GAO Recommendation 4, that the Department should share information with key stakeholders on the potential effects of automated trucking on the workforce as technology evolves. DOL manages multiple publications, such as employment projections and the Occupational Outlook Handbook, which are currently updated every two years, and in the future will be updated annually. The Department will continue to make information from these publications available, to work with states in developing state and local employment projections, and to make the data available in multiple user products, such as career exploration sites sponsored by the Department.

Thank you for the opportunity to respond.

Sincerely,

Stephanie Swirsky
Deputy Assistant Secretary

Appendix IV: Comments from the Department of Transportation

U.S. Department of Transportation

Office of the Secretary of Transportation

1200 New Jersey Avenue, SE
Washington, DC 20590

FEB 13 2019

Susan A. Fleming
Director, Physical Infrastructure Issues
U.S. Government Accountability Office (GAO)
441 G Street NW
Washington, DC 20548

Cindy Brown Barnes
Director, Education Workforce and Income Security
U.S. Government Accountability Office
441 G Street NW
Washington, DC 20548

Dear Mses. Fleming and Barnes:

The U.S. Department of Transportation (DOT) is fully committed to the safe integration of automated trucking technology into our Nation's transportation system. The Department has conducted and is currently pursuing a number of automation-related activities, such as the issuance of *Preparing for the Future of Transportation: Automated Vehicles 3.0* and conducting research on the *Impact of Automated Vehicle Technologies on Workforce*.[1]

We concur with GAO's two recommendations to the Department. Specifically, we plan to (1) continue to collaborate and consult with U.S. Department of Labor to convene key groups of stakeholders to gather information on potential workforce changes that may result from automated trucking; and (2) continue to collaborate with U.S. Department of Labor to further analyze the potential effects of automated trucking technology on drivers to inform potential workforce-related regulatory changes.

We plan to provide a detailed response to each recommendation within 180 days after GAO issues the final report. We appreciate the opportunity to respond to the GAO draft report. Please contact Madeline M. Chulumovich, Director, Audit Relations and Program Improvement, at (202) 366-6512 with any questions or if you would like to obtain additional details.

Sincerely,

Keith Washington
Deputy Assistant Secretary for Administration

[1] A list of the Department's automation related activities, including workforce research, can be found at www.transportation.gov/av and https://www.transportation.gov/av/workforce.

Appendix V: GAO Contacts and Staff Acknowledgments

GAO Contacts

Cindy Brown Barnes or Susan Fleming, (202) 512-7215 or brownbarnesc@gao.gov or flemings@gao.gov.

Staff Acknowledgments

GAO staff who made major contributions to this report include Brandon Haller (Assistant Director), Rebecca Woiwode (Assistant Director), Drew Nelson (Analyst-in-Charge), MacKenzie Cooper, Marcia Fernandez, and Hedieh Fusfield. Additional assistance was provided by Susan Aschoff, David Ballard, James Bennett, Melinda Cordero, Patricia Donahue, Philip Farah, Camilo Flores Monckeberg, David Hooper, Angie Jacobs, Michael Kniss, Terence Lam, Ethan Levy, Sheila R. McCoy, Madhav Panwar, James Rebbe, Benjamin Sinoff, Pamela Snedden, Almeta Spencer, John Stambaugh, Walter Vance, Sonya Vartivarian, and Stephen C. Yoder.

Appendix VI: Accessible Data

Data Tables

Accessible Data for Examples of Automated Vehicle Technologies for Commercial Trucks

- LIDAR (Light Detection and Ranging) sensors: Use pulses of light to measure distances
- GPS (Global Positioning System): Communicates with satellites to find truck's position and aid in navigation and timing
- Cameras: Send visual information to automated systems
- Accelerometers and gyroscopes: Constantly track the truck's position and help improve the accuracy of the GPS
- Radar: Uses pulses of energy to detect and monitor objects

Source: GAO analysis of interviews with technology developers. | GAO-19-161

Accessible Data for Figure 1: Levels of Driving Automation Used by the Department of Transportation

Automation level	Description
0: No automation	Human driver controls all aspects of dynamic driving task
1: Driver assistance	Automation controls one vehicle function (steering or speed) with the expectation that the human driver performs all remaining aspects of the dynamic driving task
2: Partial automation	Automation controls both steering and speed with the expectation that the human driver performs all remaining aspects of the dynamic driving task
3: Conditional automation	Automation performs all aspects of the dynamic driving task with the expectation that the human driver will respond to a request to intervene
4: High automation	Automation performs all aspects of the dynamic driving task under certain roadway and environmental conditions, even if a human driver does not respond to a request to intervene
5: Full automation	Automation performs all aspects of the dynamic driving task under all roadway and environmental conditions that can be otherwise managed by a human driver

Source: GAO analysis of U.S. Department of Transportation information. | GAO-19-161

Accessible Data for Figure 2: Examples of Automated Vehicle Technologies for Commercial Trucks

- **LIDAR** (Light Detection and Ranging) sensors: Use pulses of light to measure distances
- **GPS** (Global Positioning System): Communicates with satellites to find truck's position and aid in navigation and timing
- **Cameras:** Send visual information to automated systems
- **Accelerometers and gyroscopes:** Constantly track the truck's position and help improve the accuracy of the GPS
- **Radar:** Uses pulses of energy to detect and monitor objects

Source: GAO analysis of interviews with technology developers. | GAO-19-161

Accessible Data for Figure 3: Illustration of Commercial Trucks Platooning

1. Lead truck driver controls the braking and acceleration for all other trucks in the platoon
2. Following drivers control steering, but the system maintains spacing by automatically adjusting braking and acceleration
    a. Trucks share data over wireless link
3. System responds to changes in speed or distance much faster than a human driver could react, increasing safety
    a. Reduced following distance between trucks lowers wind resistance and improves fuel efficiency

Source: GAO analysis of stakeholder interviews. | GAO-19-161

Accessible Data for Figure 4: Illustration of Commercial Truck Self-Driving for Part of a Long-Haul Route

1. Human driver handles complex urban environment, including pickup site, complex intersections and urban roads
2. Truck would self-drive for a portion of a long-haul route (Such as "exit-to-exit" on a Highway without a human aboard)
3. Human driver handles delivery, including navigating local roads to delivery site.

Source: GAO analysis of stakeholder interviews. | GAO-19-161

Accessible Data for Figure 6: Illustration of Commercial Truck Self-Driving for an Entire Long-Haul Route

Truck would be self-driving for an entire long-haul route without a human driver aboard, and would navigate urban and local roads, interstate highways, and make its own way to the pickup and delivery sites.

Source: GAO analysis of stakeholder interviews. | GAO-19-161

Accessible Data for Figure 7: Estimated Geographic Concentration of Heavy and Tractor-Trailer Truck Driving Jobs

Map of the United States shows areas where the concentration of heavy and tractor-trailer truck driving jobs is relatively high, which we define as higher than twice the national average at the 95% confidence level. Areas meeting that definition include portions of California, Nevada, Idaho, Utah, Colorado, Wyoming, North Dakota, Nebraska, Iowa, Kansas, Oklahoma, Texas, Arkansas, Mississippi, Alabama, Florida, Ohio, Pennsylvania, West Virginia, Virginia, Tennessee, and South Carolina.

Source: GAO analysis of data from the May 2017 Occupational Employment Statistics (OES). | GAO-19-161

Agency Comment Letters

Accessible Text for Appendix III Comments from the Department of Labor

Page 1

JAN 25 2019

Ms. Cindy S. Brown Barnes Director

Education, Workforce, and Income Security Issues

U.S. Government Accountability Office

441 G Street, N.W.

Washington, D.C. 20548

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Page 2

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Page 3

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Thank you for the opportunity to respond.

Sincerely,

Stephanie Swirsky

Deputy Assistant Secretary

Accessible Text for Appendix IV Comments from the Department of Transportation

Susan A. Fleming

Director, Physical Infrastructure Issues

U.S. Government Accountability Office (GAO)

441 G Street NW

Washington, DC 20548

Cindy Brown Barnes

Director, Education Workforce and Income Security

U.S. Government Accountability Office

441 G Street NW

Washington, DC 20548

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FEB 13 2019

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Keith Washington

Deputy Assistant Secretary for Administration

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