



Report to the Subcommittee on
Transportation, and Housing and Urban
Development, and Related Agencies,
Committee on Appropriations, House of
Representatives

December 2020

AUTOMATED TECHNOLOGIES

DOT Should Take Steps to Ensure Its Workforce Has Skills Needed to Oversee Safety

Accessible Version

GAO Highlights

Highlights of [GAO-21-197](#), a report to the Subcommittee on Transportation, and Housing and Urban Development, and Related Agencies, Committee on Appropriations, House of Representatives

Why GAO Did This Study

Automated technologies in planes, trains, and passenger vehicles are in use today and likely to become increasingly widespread. While these technologies hold promise, accidents involving them demonstrate potential safety challenges. DOT is responsible for overseeing the safety of all modes of transportation.

This report addresses: (1) stakeholders' perspectives on the skills required to oversee automated technologies; (2) the extent to which DOT has identified and assessed the skills it needs to oversee these technologies; and (3) the extent to which DOT has developed strategies to address any gaps in skills. GAO reviewed relevant literature and DOT workforce planning documents, and interviewed DOT human capital officials, selected modal administrations, and stakeholders, including transportation associations and technology developers. GAO selected modal administrations based in part on the prevalence of automated technologies.

What GAO Recommends

GAO is making four recommendations, including that DOT: (1) assess skill gaps in key occupations involved in overseeing automated technologies and (2) regularly measure the progress of strategies implemented to close skill gaps. DOT concurred with three recommendations and partially concurred with one on measuring progress. GAO clarified this recommendation and believes its implementation is warranted.

View [GAO-21-197](#). For more information, contact Heather Krause at (202) 512-2834 or krauseh@gao.gov.

December 2020

AUTOMATED TECHNOLOGIES

DOT Should Take Steps to Ensure Its Workforce Has Skills Needed to Oversee Safety

What GAO Found

Stakeholders GAO interviewed said that federal oversight of automated technologies—such as those that control a function or task of a plane, train, or vehicle without human intervention—requires regulatory expertise as well as engineering, data analysis, and cybersecurity skills. Stakeholders also stated that as automated systems become more common across transportation modes, overseeing them will require understanding vehicle operating systems, software code, and the vast amounts of data produced by these systems to ensure their safety.

Skills Needed to Oversee the Safety of Automated Technologies, according to Stakeholders

 Regulatory expertise Many regulations as written may not account for automated technologies	 Engineering Mechanical systems are increasingly being replaced with electronic and computerized systems	 Data analysis Automated technologies produce vast and disparate data	 Cybersecurity The risk of cyberattack grows with increasing automation
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Source: GAO analysis of stakeholder interviews. | GAO-21-197

The U.S. Department of Transportation's (DOT) Departmental Office of Human Resources Management has identified most skills DOT needs to oversee automated technologies, but it has not fully assessed whether its workforce has these skills. Through its workforce planning efforts, DOT identified many of the skills cited by stakeholders as important for overseeing automated technologies—regulatory expertise, engineering, and data analysis. In 2016 and 2020, DOT surveyed staff in related positions and identified gaps in some of these skills, including regulatory expertise. However, DOT did not survey staff or assess skill gaps in data analysis or cybersecurity positions important to automated technology oversight. As a result, DOT lacks critical information needed to identify skill gaps and ensure key relevant staff are equipped to oversee the safety of these technologies now and in the future.

DOT developed strategies to address some but not all gaps in skills needed to oversee automated technologies. For example, DOT implemented some recruiting strategies and established hiring goals as a means of closing gaps identified in the 2016 survey and plans to continue these efforts in light of the 2020 survey. However, DOT has not tracked the progress of strategies implemented to close skill gaps since the 2016 survey, nor has it implemented training strategies. Accordingly, some skill gaps related to overseeing the safety of automated technologies will likely persist in DOT's workforce.

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Abbreviations

ADS	Automated Driving System
DOT	U.S. Department of Transportation
FAA	Federal Aviation Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
NHTSA	National Highway Traffic and Safety Administration
OPM	Office of Personnel Management
OST	Office of the Secretary of Transportation
OST-R	Office of the Assistant Secretary for Research and Technology
PTC	positive train control
Volpe	Volpe National Transportation Systems Center

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December 18, 2020

The Honorable David Price
Chairman
The Honorable Mario Diaz-Balart
Ranking Member
Subcommittee on Transportation, and Housing and Urban Development,
and Related Agencies
Committee on Appropriations
House of Representatives

Automated technologies—those that control a function or task without human intervention—can be found throughout transportation modes such as in planes, trains, trucks, buses, and passenger vehicles, and their use is likely to become increasingly widespread in the future. Levels of automation in these technologies vary considerably. Technologies may assume some of the tasks of a human driver or operator—such as lane keeping support, which corrects a vehicle’s steering, braking or accelerating if it detects the vehicle is about to move out of its lane—or assume nearly all of the tasks of a human driver or operator, such as in unmanned aircraft systems (referred to as “drones”). While these technologies hold many potentially transformative benefits, accidents involving them—such as Uber and Tesla crashes in 2018 caused in part by the drivers’ overreliance on the automated technologies in the vehicle—demonstrate their potential safety challenges.¹

The U.S. Department of Transportation (DOT) is responsible for overseeing the safety of all modes of transportation, including those with automated technologies.² As such, DOT must have a workforce that can ensure automated technologies are safe and work as intended. This oversight involves staff across DOT whose myriad roles include such skills as researching automated technologies, performing inspections of

¹The 2018 Uber crash involved a vehicle with an Automated Driving System (ADS) being tested with a safety driver. The 2018 Tesla crash involved a vehicle with a lower-level Advanced Driver Assistance System being driven by its owner.

²The mission of the U.S. Department of Transportation (DOT) is “to ensure our Nation has the safest, most efficient and modern transportation system in the world, which improves the quality of life for all American people and communities, from rural to urban, and increases the productivity and competitiveness of American workers and businesses.”

automated technologies that are in-use, analyzing data produced by these technologies, assessing vulnerability to cyber-attacks, and rulemaking. We have previously reported on the need for DOT's workforce to address challenges associated with new vehicle and aviation technologies.³

In addition, we have previously identified strategic human capital management as a high-risk area for federal agencies, particularly because gaps in skills employees need to successfully perform their work impede the government from serving the public and achieving results in a cost-effective manner.⁴

You asked us to examine DOT's oversight of automated technologies. This report examines: (1) skills required to oversee the safety of automated technologies, according to selected stakeholders; (2) the extent to which DOT has identified the skills it needs to oversee the safety of automated technologies and assessed whether its workforce has those skills; and (3) the extent to which DOT has developed strategies to address any gaps in skills needed to oversee the safety of automated technologies.

In addressing these objectives, we focused on automated technologies in transportation, and on four principles for effective workforce planning identified in our previous work that we determined were relevant for overseeing the safety of automated technologies, a focus that is included in one of DOT's strategic goals.⁵ These workforce planning principles include (1) involving management and key stakeholders in developing a strategic workforce plan, (2) determining critical skills needed to achieve future goals and identifying skill gaps, (3) developing strategies tailored to

³GAO, *Automated Trucking: Federal Agencies Should Take Additional Steps to Prepare for Potential Workforce Effects*, [GAO-19-161](#) (Washington, D.C.: Mar. 7, 2019); GAO, *Automated Vehicles: Comprehensive Plan Could Help DOT Address Challenges*, [GAO-18-132](#) (Washington, D.C.: Nov. 30, 2017); GAO, *Vehicle Data Privacy: Industry and Federal Efforts Under Way but NHTSA Needs to Define Its Role*, [GAO-17-656](#) (Washington, D.C.: Jul. 28, 2017); GAO, *Commercial Space Transportation: Improvements to FAA's Workforce Planning Needed to Prepare for the Industry's Anticipated Growth*, [GAO-19-437](#) (Washington, D.C.: May 23, 2019).

⁴GAO, *High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, [GAO-19-157SP](#) (Washington, D.C.: Mar. 6, 2019).

⁵We did not include technologies designed to automate internal DOT processes, such as data entry. In addition, we did not conduct a comprehensive assessment of DOT's workforce planning efforts.

skill gaps, and (4) monitoring and evaluating progress toward closing those gaps.⁶

To address all objectives, we reviewed our previous reports on automated technologies in transportation, including trucks, trains, passenger vehicles, buses, and drones, and developed a working definition of automated technologies based on DOT's use of the term and definitions used by private industry. We used this working definition—technologies that control a function or task without human intervention—to facilitate discussions across multiple industries such as automotive and rail, which generally use industry-specific definitions (e.g., “Level 1” automation in a vehicle or “positive train control” in rail).

To identify skills needed to oversee the safety of automated technologies, we reviewed relevant academic, government, and industry publications.⁷ For example, we reviewed articles from an automotive publication as well as scholarly journals, including those focused on regulatory issues. To obtain a variety of informed perspectives regarding the skills needed to oversee automated technologies, we interviewed a nongeneralizable selection of 15 stakeholders from companies and industry groups, research entities, safety organizations, and state and local entities.⁸ Within each of these four groups, we selected stakeholders: (1) with knowledge of the automotive, trucking, or rail industries, in alignment with our selection of DOT modal administrations (see below); (2) experienced in or focused on automated technologies; and (3) whom we included in our previous report on automated vehicles.⁹ Over the course of our interviews with stakeholders we developed a running list of skills they identified as important. As subsequent interviewees began to identify skills named in earlier interviews, we adjusted our mode of questioning and asked interviewees to identify the skills on our running list that they

⁶We selected four of the five workforce planning-principles that are most applicable to our review. The fifth principle is “building the capability needed to address administrative, educational, and other requirements important to supporting workforce strategies.” Assessing the status of these capabilities at DOT was outside of the scope of this review. See GAO, *Human Capital: Key Principles for Effective Strategic Workforce Planning*, [GAO-04-39](#) (Washington, D.C.: Dec. 11, 2003).

⁷When we refer to “skills” in this report, we are referring to both skills and expertise.

⁸See appendix I for a full list of the stakeholders we interviewed.

⁹[GAO-18-132](#).

saw as important. Stakeholders either identified or confirmed four skills significantly more often than other skills, as noted below.

To assess the extent to which DOT has identified skills needed to oversee the safety of automated technologies and assessed whether its workforce has those skills, we interviewed officials within the Office of the Secretary's (OST) Departmental Office of Human Resources Management (Department of Human Resources) on their agency-wide workforce planning and reviewed related documentation. For example, we reviewed the Department of Human Resources' 2-year *Human Capital Operating Plan*, where it documents its initiatives to identify and build the workforce needed to accomplish the agency's strategic goals. We also reviewed DOT documentation on 2016 and 2020 efforts to identify gaps in its workforce's skills, including those needed to oversee automated technologies. These efforts included surveys the Department of Human Resources sent to staff in certain occupations and summaries describing the results of the surveys.¹⁰ We also interviewed officials from the Office of the Assistant Secretary for Research and Technology (OST-R) and the Office of the Assistant Secretary for Transportation Policy to understand how, if at all, those offices apply their research and policy expertise to agency-wide workforce planning.¹¹

To understand how modal administrations are involved in the Department of Human Resources' workforce planning, and to identify examples of their own separate workforce planning for automated technologies, we selected three modal administrations—the National Highway Traffic Safety Administration (NHTSA), the Federal Motor Carrier Safety Administration (FMCSA), and the Federal Railroad Administration (FRA)—to include in our review. We selected these modal administrations based on prevalence of current and developing automated technologies in each mode, potential effect on the safety of the public, relevance of related ongoing and issued work, and stakeholder recommendations.¹² We compared the Department of Human Resources' workforce planning efforts to key principles for effective strategic workforce planning

¹⁰We did not evaluate the methodology or effectiveness of the surveys.

¹¹The Office of the Undersecretary for Transportation Policy is responsible for recommending overall transportation policy initiatives to the Secretary.

¹²While the Federal Aviation Administration was not one of our selected modal administrations, we included relevant examples from our issued work, as appropriate.

described above, and to the skills stakeholders said would be needed to oversee the safety of automated technologies.¹³

To evaluate the extent to which DOT has developed strategies to address any gaps in skills needed to oversee automated technologies, we reviewed DOT's and selected modal administrations' plans for addressing and closing skill gaps and DOT's monitoring of progress toward closing them. We also reviewed DOT data on the agency's use of special payment authorities that allow federal agencies to offer recruitment, retention, and relocation incentives to attract applicants to certain occupations,¹⁴ as well as DOT data on retirement eligibility, and hiring goals.

We determined these data to be sufficiently reliable for the purposes of documenting DOT's use of special payment authorities and its retirement eligibility rates by:

- interviewing relevant DOT officials and comparing retirement eligibility and hiring goal information between various Department of Human Resources' reports to assess how consistent the information was across sources, and
- reviewing information collected for our previous work on federal human capital challenges on the reliability of federal personnel databases as DOT data on special payment authority, retirement eligibility, and hiring-related data is derived from these databases.

We reviewed our published and ongoing work on agencies' use of special payment authorities, workforce planning for information technology positions, and the Federal Aviation Administration's (FAA) workforce planning efforts, including those related to existing and emerging technologies, such as unmanned aircraft systems and commercial space programs.¹⁵ Finally, we compared the Department of Human Resources'

¹³[GAO-04-39](#).

¹⁴We use the term "special payment authorities" in this report to refer to certain compensation flexibilities available government-wide to federal agencies through Title 5 of the United States Code to recruit, retain, or both recruit and retain needed employees.

¹⁵GAO, *Federal Pay: Opportunities Exist to Enhance Strategic Use of Special Payments*, [GAO-18-91](#) (Washington, D.C.: Dec. 7, 2017); GAO, *Information Technology: Agencies Need to Fully Implement Key Workforce Planning Activities*, [GAO-20-129](#) (Washington, D.C.: Oct. 30, 2019); and GAO, *Aviation Safety: FAA's Office of Aviation Safety Should Take Additional Actions to Ensure Its Workforce Has Needed Skills*, [GAO-21-94](#) (Washington D.C.: Nov. 9, 2020).

efforts to the principles for effective strategic workforce planning noted above.

We conducted this performance audit from September 2019 to December 2020 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.

Background

Automated Technologies in Transportation

Automated technologies vary considerably within and across transportation modes. Many low-levels of automated technologies are currently in use in the transportation industry. For example:

- Some passenger vehicles and commercial trucks have a system that automatically slows or stops the vehicle when it predicts a forward collision.¹⁶
- Positive train control (PTC) is a system designed to automatically slow or stop a train in certain cases where it is not being operated safely.
- Automated technologies can facilitate the transfer and loading of freight at commercial ports.

¹⁶For automated technologies in passenger vehicles and commercial trucks, DOT has adopted a framework for automated driving developed by SAE International, which categorizes driving automation into levels 0 (human driver controls all aspects of operation) to 5 (automation controls all aspects of driving tasks under all roadway and environmental conditions). For this report, we defined automated technologies in passenger vehicles and commercial trucks as those categorized by SAE International as Level 1 and above. These include both “Advanced Driver Assistance Systems” (Level 1 and Level 2) and “Automated Driving Systems” (Level 3 and above). A system that automatically slows or stops a vehicle is considered level 1 because it controls one vehicle function (e.g., speed).

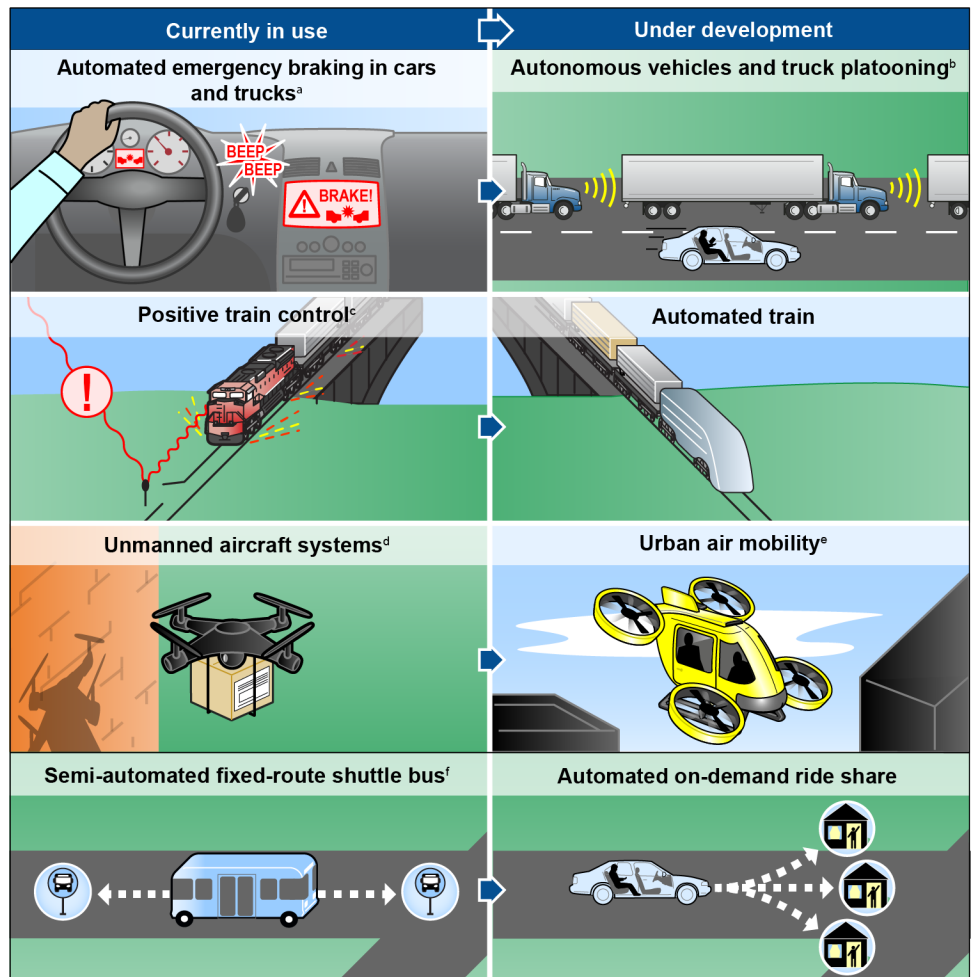
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- Low speed, semi-automated shuttle buses provide transportation on a fixed route.¹⁷

These technologies offer potential benefits such as reducing crashes, easing congestion, and improving efficiency. There are many more automated technologies under development, including automated driving systems in cars and shuttle buses, truck platoons, and trains, as well as public transit automation in maintenance depots, public transit automation that provides driver assistance, and aerial drones that transport people.¹⁸ See figure 1 for some examples of automated technologies currently in use and in development in transportation.

¹⁷DOT officials noted that fully-automated low-speed shuttle buses are not in widespread use, and are likely part of limited research projects or are operated under limited exemption authority and required to have a safety operator on board. DOT officials also noted that another example of an automated technology currently in use is a small fully-automated metro or people-mover system.

¹⁸Truck platoons involve one or more trucks following closely behind a lead truck, linked by wireless—or vehicle-to-vehicle—communication.

Figure 1: Examples of Automated Technologies Currently in Use and in Development



Source: GAO. | GAO-21-197

^aAutomated emergency braking refers to a system that automatically slows or stops a vehicle when it predicts a forward collision.

^bTruck platooning involves one or more trucks following closely behind a lead truck, linked by wireless—or vehicle-to-vehicle—communication.

^cPositive train control (PTC) automatically slows or stops a train in certain cases where it is not being operated safely. Congress mandated the implementation of PTC by certain railroads to prevent train-to-train collision and other types of accidents. Currently this technology is in use on most of the track on which it is required. As of September 30, 2020, PTC technology governed railroad operations on approximately 57,000 route miles—almost 99 percent of the route miles subject to the statutory mandate. However, only ten of the 42 railroads required to implement PTC had fully done so. All railroads are required to fully implement PTC by December 31, 2020.

^dUnmanned aircraft systems (referred to as “drones”) can be used to deliver packages, among other things.

^eDrones that may be capable of providing on-demand passenger air travel around a metropolitan environment are under development.

^fSemi-automated fixed-route shuttle buses currently in-use include those being tested in demonstration projects.

DOT's Role and Workforce

DOT oversees the safety of all modes of transportation through various efforts, including issuing and enforcing regulations, providing grants to state and local government agencies, conducting and funding research, and educating the public on transportation safety. DOT's OST is responsible for coordinating and overseeing the activities of each of DOT's nine modal administrations. Within OST:

- **The Department of Human Resources** carries out agency-wide workforce planning efforts, including those designed to prepare the workforce to meet DOT's strategic goals of safety, infrastructure, accountability, and innovation—the latter goal includes supporting automated technologies. The Department of Human Resources is also responsible for ensuring DOT adheres to Office of Personnel Management (OPM) requirements that federal agencies align their human capital activities with their mission and strategic goals.¹⁹
- **OST-R** coordinates and reviews all DOT research programs and expands opportunities for research collaboration, including on automated technologies. OST-R also oversees several entities that conduct research including:
 - **The University Transportation Centers program** is a grant program through which DOT funds research consortia of colleges and universities to advance transportation research, including research on automated vehicles and systems.
 - **The Intelligent Transportation Systems Joint Program Office** conducts research and education on vehicles, infrastructure, and transportation systems that communicate with each other, including automated and connected vehicles. It also leads agency-wide working groups on these technologies, among other responsibilities.²⁰

¹⁹Personnel Management in Agencies, 81 Fed. Reg. 89,357 (Dec. 12, 2016) (codified, as amended, at 5 C.F.R. pt. 250).

²⁰The Intelligent Transportation Systems Joint Program Office is organizationally located within the Federal Highway Administration.

-
- **The Volpe National Transportation Systems Center (Volpe)** conducts and coordinates research, including on automated systems, for DOT modal administrations and other entities.

Since 2016, DOT has outlined its policy priorities for automated vehicles in a series of voluntary guidance documents. The most recent iteration, published in 2020, “*Ensuring American Leadership in Automated Vehicle Technologies – Automated Vehicles 4.0*,” was jointly authored by the U.S. Secretary for Transportation and the U.S. Chief Technology Officer and outlines guiding principles for federal automated vehicle efforts, such as protecting users and communities and promoting efficient markets.

Each of DOT’s nine modal administrations is generally responsible for activities related to a specific transportation mode (e.g., air, rail, public transit, highways, etc.).²¹ NHTSA, FMCSA, and FRA, which we selected for this review, have the following responsibilities:

- NHTSA oversees the safety of motor vehicles and motor vehicle equipment, including automated vehicles, by developing and enforcing Federal Motor Vehicle Safety Standards²², promoting safety, leading defect and crash investigations, conducting research, and identifying safety trends and countermeasures.
- FMCSA works with state and local partners to reduce crashes, injuries, and fatalities involving commercial motor vehicles (e.g., large trucks and buses)—including those being developed to travel without drivers for part of a route—and regulates the safety of the companies and drivers operating these vehicles.
- FRA oversees the safety of railroad operations, including railroads’ implementation of PTC described above.

Additionally, each modal administration conducts research on ongoing and emerging transportation topics within its mode, often in partnership with the Intelligent Transportation Systems Joint Program Office and Volpe. Modal administrations generally conduct their own workforce planning, which supplements the Department of Human Resources’

²¹DOT’s nine modal administrations are: FAA, Federal Highway Administration, FMCSA, FRA, Federal Transit Administration, Maritime Administration, NHTSA, Pipeline and Hazardous Materials Safety Administration, and the Saint Lawrence Seaway Development Corporation.

²²Federal Motor Vehicle Safety Standards are minimum performance standards established in regulation for new motor vehicles and motor vehicle equipment. 49 C.F.R. part 571.

agency-wide efforts and focuses on skills needed for each transportation mode, such as aviation safety inspectors at FAA.

DOT’s workforce consists of about 55,000 employees. According to data DOT provided, roughly one-third of DOT’s workforce is eligible to retire in the next 5 years. Nearly 40 percent of DOT’s workforce is employed in occupations that have been deemed to be mission-critical—those occupations that most directly affect the agency’s ability to perform its mission. DOT employs staff in government-wide and agency-specific mission-critical occupations. In 2015, OPM designated six occupations, including “information technology” and “economist” as government-wide mission-critical occupations because they have significant programmatic effects across federal agencies. In addition, DOT’s Department of Human Resources officials told us that they updated their list of eight agency-specific, mission-critical occupations, such as “engineering” and “transportation safety specialist,” in 2015 based on DOT’s mission and retirement rates, among other factors. Within each of these mission-critical occupations there are one or more specific occupations. For example, within the engineering mission-critical occupation, there are 17 specific types of engineering occupations, such as electrical engineer and civil engineer. See table 1 for a list of government-wide and DOT-specific mission-critical occupations.

Table 1: Government-wide and DOT Mission-Critical Occupations

Government-wide mission-critical occupations	DOT mission-critical occupations
• Cybersecurity	• Engineering
• Human Resources Specialist	• Community Planner
• Acquisition	• Transportation Safety: Air Traffic Control
• Auditor	• Transportation Safety: Aviation Safety
• Economist	• Transportation Safety: Motor Carrier Safety
• Science, Technology, Engineering, and Mathematics (STEM)^a	• Transportation Safety: Highway Safety
	• Transportation Safety: Railroad Safety
	• Transportation Specialist

Source: GAO analysis of OPM and DOT information. | GAO-21-197.

^aOPM considers occupations in STEM to be mission-critical. DOT officials told us that they consider the other government-wide and DOT-specific mission critical occupations to address STEM occupations. For example, DOT officials said that mission-critical occupations, such as “information technology” and “engineering” are related to STEM.

We have previously made numerous recommendations to address identified challenges related to DOT’s preparation for automated trucks

and vehicles, connected vehicle technologies, and aviation technologies.²³

- On automated trucks, we recommended that DOT work with the Department of Labor to convene stakeholders and share information on the potential workforce effects of automated trucking. Both agencies agreed with the recommendations and are awaiting completion of several efforts related to consulting stakeholders to identify workforce effects.
- Regarding automated vehicles, we recommended that DOT develop and implement a comprehensive plan to manage departmental initiatives related to automated vehicles. DOT agreed with the recommendation but has yet to publish a comprehensive plan that includes, for example, performance measures to monitor and gauge results of its automated vehicle initiatives.
- For connected vehicle technologies, we recommended that NHTSA define, document, and externally communicate the agency's roles and responsibilities in relation to data privacy of connected vehicles—those with technology that wirelessly transmits and receives data. NHTSA implemented this recommendation by launching a Vehicle Data Privacy webpage, which describes and documents NHTSA's authority, roles, and responsibilities with respect to data privacy, and emailed auto industry stakeholders to let them know about the new web page and asking for feedback.
- On aviation technologies, we recommended that FAA's Office of Commercial Space Transportation develop workload metrics and projections, and improve its skills assessment surveys to better prepare for growth and evolution in the commercial space transportation industry. The Office has made some progress developing workload metrics and projections but has not fully addressed these recommendations.

²³[GAO-19-161](#); [GAO-18-132](#); [GAO-17-656](#); and [GAO-19-437](#).

Stakeholders Said Overseeing Automated Technologies Requires Regulatory Expertise and Technical Skills

Selected stakeholders we spoke to from industry, academia, and other sectors identified regulatory expertise and technical skills in engineering, data analysis, and cybersecurity as the primary skills needed to ensure the safety of automated technologies. See figure 2 for brief descriptions of each skill and examples of how DOT might use them when overseeing automated technologies.

Figure 2: Skills Transportation Stakeholders Cited as Important for Overseeing Automated Technologies

Skill		DOT example
Regulatory expertise 	Rapid technological development heightens the need for individuals who can formulate new and revise existing standards.	DOT attorneys, economists and others will need to update existing federal motor vehicle safety standards or adopt new regulations to address vehicles with higher levels of automation.
Engineering 	Computer, electrical, and systems engineering increasingly needed as the operation of mechanical systems (e.g., brakes, steering) is replaced with electronic systems.	A DOT rail engineer must understand the hardware and software of an automated safety system that slows a train, in addition to understanding existing components of the rail system.
Data analysis 	Data analysis and analytics skills needed to manage and interpret the high volume of data produced by automated technologies.	A DOT statistician may analyze data produced by various automated driving systems to assess these systems' safety.
Cybersecurity 	Individuals skilled in cybersecurity increasingly needed as vehicles become more automated, giving computers more authority over a vehicle's operation.	A DOT engineer may need to understand potential cybersecurity risks, such as those that make it possible for attackers to gain access to in-vehicle networks and take control over safety-critical functions such as the brakes.

Source: GAO analysis of stakeholder interviews. | GAO-21-197

Regulatory expertise

Several stakeholders we interviewed said that individuals with regulatory expertise are required to ensure the safety of automated technologies.²⁴ Specifically, this oversight requires individuals such as engineers, economists, and attorneys who know how to propose, evaluate, or amend regulations, policies, and other standards and procedures. According to literature we reviewed and many of our stakeholders, regulating these technologies involves two significant challenges. First, many existing regulations may not account for the introduction of automated technologies. According to a 2016 preliminary report commissioned by NHTSA, nearly half of the 73 Federal Motor Vehicle Safety Standards reference a human driver, which could pose a challenge to the certification of vehicles with Automated Driving Systems (ADS).²⁵ Moreover, while the authors of the report found few barriers to compliance for conventionally designed vehicles with ADS, they found more than 30 standards that could present a compliance problem for ADS-equipped vehicles with less conventional designs, such as no human controls or novel seating arrangements.²⁶

Second, the pace of the statutorily prescribed rulemaking process makes it challenging for DOT's regulatory activity to keep up with the rapid development of automated technologies. As these technologies become more prevalent and states and localities develop their own distinctive standards, demand will likely increase for federal oversight. We and others have identified this pacing challenge. For example, participants in a panel of experts convened for a 2017 review of DOT's organizational structure expressed concern that DOT was falling behind the private sector's need for specific regulations for autonomous vehicles.²⁷ Furthermore, the DOT Inspector General commented in a 2016 report

²⁴"Several" indicates 5 to 10 stakeholders of the 15 we interviewed.

²⁵ADS systems can operate a vehicle either partially or fully without the intervention of a human driver.

²⁶DOT officials said that NHTSA continues working to identify and analyze such barriers.

²⁷GAO, *Department of Transportation: Experts Identified Areas for Operational Improvements without Implementing Organizational Changes*, [GAO-17-478](#) (Washington, D.C.: May 18, 2017).

that keeping pace with rapidly-evolving technologies presents significant regulatory challenges.²⁸

Technical Skills

Engineering. Several stakeholders said engineering is important for overseeing automated technologies, including computer, software, electrical, and systems engineering. For example, one official from the City of Pittsburgh’s Department of Mobility and Infrastructure, which oversees autonomous vehicle testing there, told us it would be ideal for agencies overseeing automated technologies to employ individuals who understand vehicle operating systems, such as computer programmers or software engineers.²⁹ We have previously reported that mechanical systems in vehicles are increasingly being replaced or augmented by electronic systems.³⁰ As more vehicle functions become automated, and therefore controlled by computer systems, the need for DOT to employ staff skilled in varied fields of engineering will continue to increase. For example, FMCSA may require engineers who understand the software that controls an automatic emergency braking system in a commercial truck or bus as well as the physical components of the system. DOT officials noted that FMCSA may also require engineers who understand the capabilities and performance limitations of emerging automated technologies to support decisions over future requests by automated commercial motor vehicle operators for waivers or exemptions from FMCSA’s regulations.³¹

Data analysis. Several stakeholders said data analysis is important for overseeing automated technologies, with some emphasizing predictive analytics and the analysis or management of high volumes of data.³² For

²⁸DOT OIG, *Top Management Challenges for Fiscal Year 2017*, PT-2017-007 (Washington, D.C.: Nov. 15, 2016).

²⁹An operating system is the central software within a computer that controls all the computer’s functions.

³⁰GAO, *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.: Mar. 24, 2016).

³¹FMCSA waivers provide relief from the agency’s regulations for up to 3 months, while according to DOT officials, exemptions provide relief for up to 5 years and may be renewed.

³²“Predictive analytics” applies techniques such as pattern matching, predictive modeling, and forecasting to data to make predictions about future events.

example, a safety specialist at FRA might apply analytics techniques to data produced by freight trains with automated technologies to predict and prevent situations in which trains are at higher risk of derailing or traveling at unsafe speeds. National Transportation Safety Board officials we spoke with said the crash recorders of automated vehicles produce a substantial volume of data, and suggested NHTSA should analyze these data to identify patterns that would help to anticipate and prevent future accidents, a practice that FAA already employs with aircraft.

Cybersecurity. Several stakeholders we spoke with said that skills in cybersecurity are important in overseeing the safety of automated technologies. We have previously reported on the increasing vulnerability of today's motor vehicles to cyberattacks due to the growing presence of electronic systems in vehicles, many of which connect to networks outside of the vehicle via the internet.³³ For example, in a 2015 test, two researchers remotely accessed a Jeep Cherokee's entertainment system and used software code to send commands to the vehicle's steering, braking, and other systems, enabling the researchers to override the driver's actions and bring the Jeep to a complete stop on a busy highway.³⁴ As vehicles become more automated, giving computers more authority over a vehicle's operation, the potential risks associated with cyberattacks grow.

DOT Has Identified Most Skills Needed to Oversee the Safety of Automated Technologies but Has Not Fully Assessed Whether Its Workforce Has These Skills

DOT's Department of Human Resources worked with modal administrations to develop a strategic workforce plan that outlined agency-wide initiatives to help accomplish the agency's strategic goals. Through these efforts, the Department of Human Resources identified most skills cited by stakeholders as important for overseeing automated technologies—such as engineering, regulatory, and data analysis skills. However, the Department of Human Resources did not identify

³³[GAO-16-350](#).

³⁴Charlie Miller and Chris Valasek, *Remote Exploitation of an Unaltered Passenger Vehicle* (Aug. 10, 2015). NHTSA requested a recall in response to this test, which led to the recall of about 1.4 million vehicles.

cybersecurity skills as needed to oversee automated technologies. In 2016 and 2020, the Department of Human Resources surveyed DOT's workforce and identified gaps in skills such as regulation and data analysis. However, neither survey was sent to staff in key occupations that oversee automated technologies, such as statisticians and mathematicians in data analysis positions. See table 2 for a comparison of the Department of Human Resources' efforts to the two principles for effective workforce planning that relate to identifying and assessing skill needs.

Table 2: Comparison of Department of Human Resources’ Practices with Principles of Effective Workforce Planning to Identify and Assess Skill Needs

Principles for effective workforce planning	Department of Human Resources’ workforce planning practices
Principle 1: Involve top management, employees, and stakeholders in creating and implementing a strategic workforce plan to accomplish agency strategic goals.	The Department of Human Resources worked with management and stakeholders from across the agency to develop the strategic workforce plan to accomplish DOT’s strategic goals, which include leading in the development and deployment of innovative technologies, such as automation.
Principle 2: Determine the critical skills needed to achieve current and future goals and assess gaps between these skills and the skills of the existing workforce.	The Department of Human Resources identified most skills cited by stakeholders as needed to oversee the safety of automated technologies, but did not identify cybersecurity skills.

Source: GAO analysis of DOT information and [GAO-04-39](#). | GAO-21-197

Through Its Efforts to Create a Workforce Plan, DOT Identified Most Skills Cited by Stakeholders, but Did Not Identify Cybersecurity

In alignment with federal regulations and leading principles for strategic workforce planning,³⁵ the Department of Human Resources worked with modal administrations to develop a strategic workforce plan.³⁶ This plan, the *Human Capital Operating Plan*, describes the initiatives that DOT will undertake to equip its workforce with the skills needed to meet the agency’s strategic goals, which include overseeing the development and deployment of automated technologies. A key part of this plan is the Workforce Transformation Chart, in which the Department of Human Resources identified skill areas in which the agency needs to “invest” in new talent, or help existing staff “modernize” their skills.³⁷ In this plan, the Department of Human Resources identified three of the key skills cited by stakeholders as needed to oversee the safety of automated technologies. The Department of Human Resources designated economists and data analysts as occupations in which to “invest,” and engineers as those to “modernize.” According to this plan, economists will be needed to evaluate and amend regulations, given the agency’s current emphasis on

³⁵Personnel Management in Agencies, 81 Fed. Reg. at 89357.

³⁶We previously reported that an agency’s strategic workforce planning is most likely to succeed if top program and human capital leaders set the direction and involve employees and stakeholders across the agency. See [GAO-04-39](#).

³⁷The process to develop the Workforce Transformation Chart is separate from OPM and DOT’s efforts to designate occupations as mission-critical. See table 1.

eliminating regulatory barriers, including those to automated vehicle deployment, while data analysts will be needed to analyze high volumes of data, including data produced by automated systems in vehicles.³⁸ Engineers will need training to “modernize” skills to keep pace with changes in technology, such as the widespread use of automated vehicles and drones. As described in table 3 below multiple DOT mission-critical occupations require engineering, regulatory and data analysis skills.

Table 3: Examples of Mission-Critical Occupations That Require Engineering, Regulatory, and Data Analysis Skills

Skill	Description	Mission-critical occupation(s)
Engineering	Includes multiple engineering skills across various engineering disciplines	General engineering, electrical engineering, mechanical engineering
Regulatory	Apply, propose, evaluate, and amend regulations, policies, and other standards and procedures	General engineering, economist, electrical engineering, mechanical engineering, motor carrier safety specialist, railroad safety specialist
Data Analysis	Apply knowledge of various types of data collection techniques and properly analyze data.	General engineering, highway safety specialist

Source: GAO analysis of DOT information. | GAO-21-197

Note: Attorneys are one of several occupations with regulatory expertise, but are not included in this table because they are not designated as a government-wide or agency-specific mission-critical occupation.

While the Department of Human Resources identified three of the skills cited above by stakeholders for overseeing automated technologies, it did not include skills or related occupations needed to ensure the cybersecurity of automated technologies in cars, trucks, trains and other modes. To date, the Department of Human Resources’ workforce planning efforts around cybersecurity have largely focused on identifying the skills and occupations needed to ensure the security of DOT’s internal networks and systems. As such, the Department of Human Resources did not incorporate cybersecurity of automated technologies into its workforce planning efforts, including the *Human Capital Operating Plan* and the Workforce Transformation Chart—the agency’s primary workforce planning documents. Department of Human Resources officials told us that since the development of the Workforce Transformation Chart, they have begun to identify all occupations across the agency that require cybersecurity skills, because they realized the importance of

³⁸For example, in its 2020 federal automated vehicles policy, DOT said it would prioritize modernizing and eliminating “outdated regulations that impede the development of automated vehicles.” In 2019, FMCSA requested comments to identify which regulations may need to be amended, revised, or eliminated to facilitate the safe introduction of commercial motor vehicles equipped with ADS.

these skills in occupations outside of information technology. Some occupations that oversee automated technologies, such as electrical engineer, were identified through this effort.

Department of Human Resources officials said it would take 12 months to finish identifying all cybersecurity-related occupations across the agency, but did not provide documentation of how they are identifying these occupations or timelines for completing this effort. In addition, they have not said how these cybersecurity skills and occupations would be incorporated into existing workforce planning efforts, such as the *Human Capital Operating Plan* and Workforce Transformation Chart.

Officials from selected modal administrations confirmed that engineering, regulatory, and data analysis are needed to oversee the safety of automated technologies in their transportation mode, but also noted that cybersecurity is an important skill. For example, FRA officials told us that rail inspectors will need to understand how to manage and analyze data as automated systems, including PTC, become more prevalent.³⁹ FRA officials told us they work with industry to provide training to inspectors in this area. Similarly, FAA's Office of Human Resource Management reported that it considered the skills needed to oversee unmanned aircraft systems under different development scenarios and in so doing also identified engineering, data analysis, and cybersecurity as necessary skills.

Stakeholders and modal administration officials we spoke to identified cybersecurity as one of the primary skills DOT needs to meet its mission to lead in the development and deployment of automated technologies and oversee their safety. While the Department of Human Resources' efforts to identify cybersecurity occupations across the agency recognize the importance of cybersecurity in overseeing automated technologies, agency officials have not completed these efforts or determined how they will be incorporated into other workforce planning initiatives. We have previously reported that a key principle of effective workforce planning is identifying the workforce skills necessary to achieve an agency's mission and goals. Without identifying and incorporating cybersecurity of automated technologies into its workforce planning efforts, such as the *Human Capital Operating Plan* or Workforce Transformation Chart, the

³⁹As described in figure 1 above, PTC is a system designed to automatically slow or stop a train in certain cases where it is not being operated safely.

Department of Human Resources will be unable to identify and close potential gaps in its workforce's cybersecurity skills.

DOT's Efforts to Assess Skill Gaps Do Not Include Key Occupations That Oversee Automated Technologies

As required by OPM,⁴⁰ the Department of Human Resources conducted an assessment in 2016 and in 2020 to identify any gaps between the skills staff in government-wide and agency-specific mission-critical occupations currently possess and the skills staff should have.⁴¹ This assessment includes engineering, regulatory, and data analysis skills, within some mission-critical occupations (See Table 3). In preparation for each assessment, which it conducts every 3 to 4 years, the Department of Human Resources convened focus groups with subject matter experts from across the agency to identify the skills needed to perform successfully in each mission-critical occupation. The Department of Human Resources asked employees to rate their proficiency in each of these skills and then compared it to their supervisor's rating of their proficiency. The Department of Human Resources is then expected to analyze these ratings and identify mission-critical occupations where employees did not meet the required proficiencies. As of September 2020, the Department of Human Resources was nearing completion of the 2020 gap assessment, but had not yet summarized the results, which it anticipated completing by the end of the year.

The 2016 assessment identified gaps in skills that stakeholders and DOT officials recognized as necessary to oversee automated technologies.⁴² For example, DOT identified gaps in:

- regulatory and data analysis skills across a number of engineering and other occupations, and

⁴⁰OPM requires federal agencies to both develop a human capital operating plan, as discussed above, and identify skill gaps in government-wide and agency-specific mission-critical occupations, among other things.

⁴¹Personnel Management in Agencies, 81 Fed. Reg. at 89,357.

⁴²The same general skills—including communication, problem solving, and judgment—are included for all DOT-specific mission-critical occupations, while technical skills will vary by mission-critical occupation.

-
- general skills, such as “judgment and decision making” and “problem solving” across a number of engineering and transportation safety roles.⁴³

While the 2016 assessment identified some gaps in skills important for overseeing automated technologies, it did not look at key occupations that have a role in overseeing the safety of automated technologies. The same will be true for the 2020 assessment. Department of Human Resources officials told us they only administered the 2016 and 2020 surveys to staff in mission-critical occupations. Department of Human Resources officials did not administer either survey to statisticians, mathematicians, or transportation industry analysts because these are not considered mission-critical occupations, even though these occupations may use data analysis to understand the data produced by automated systems in cars, trucks, and trains, and to ensure the safety of these systems. In addition, although both stakeholders and DOT officials we interviewed identified cybersecurity as important to automated technology oversight, the Department of Human Resources only surveyed cybersecurity staff in those occupations that ensure the security of DOT’s internal networks and systems. Therefore, the Department of Human Resources could not determine if DOT has the cybersecurity skills needed to oversee the safety of automated technologies.

We have previously reported that a key principle of effective workforce planning is assessing gaps between the skills an agency needs to achieve its current and future goals and the skills of its existing workforce. We also noted the importance of doing this across all occupations that may have a programmatic effect on an agency’s mission and goals.⁴⁴ While the Department of Human Resources conducted these assessments in mission-critical occupations, it did not assess skill gaps in key occupations needed to oversee the safety of automated technologies. Department of Human Resources officials told us expanding the scope to all occupations that oversee the safety of automated technologies would be too resource-intensive. However, we identified three non-mission-critical occupations—environmental protection specialist, administrative assistant and financial analyst—included in the 2020 gap assessment. Department of Human Resources officials told us these occupations were

⁴³Department of Human Resources defines “judgment and decision making” as, “making informed and timely decisions based on an analysis of the situation.” DOT defines “problem solving” as, “identifying problems and using sound judgment to generate and evaluate alternatives and develop effective solutions.”

⁴⁴GAO, *High Risk Series: An Update*, [GAO-15-290](#) (Washington, D.C.: Feb. 11, 2015).

included because of the significant number of employees in each and to provide modal administrations with a more complete understanding of existing expertise within their workforces. Likewise, assessing gaps in all relevant data analysis and cybersecurity occupations could help modal administrations better understand the expertise that exists within their workforces related to automated technology oversight. Without assessing gaps across key occupations, such as those with data analysis and cybersecurity skills, the Department of Human Resources lacks critical information that could help it ensure its workforce can effectively oversee the safety of automated technologies now and in the future.

DOT Strategies to Address Skill Gaps through Training and Recruitment Could Leave Gaps Related to Overseeing Automated Technologies

DOT's 2016 assessment resulted in recommendations that DOT use training and recruiting to close skill gaps in three key areas related to automated technology oversight—engineering, regulation, and data analysis. While DOT implemented some recruiting strategies and established hiring goals, it did not implement training and relegated most of the responsibilities for tracking and closing skill gaps, and identifying effective recruitment strategies, to the modal administrations. Officials from selected modal administrations reported that they largely did not implement training or identify recruitment strategies effective in targeting these gaps. See Table 4 for a comparison of DOT's efforts to the two principles for effective workforce planning that focus on addressing skill gaps.

Table 4: Comparison of Department of Human Resources' Practices with Principles of Effective Workforce Planning to Address and Monitor Closure of Skill Gaps

Principles for effective workforce planning	Department of Human Resources' workforce planning practices
Principle 3: Develop strategies tailored to address gaps in critical skills.	Training: The Department of Human Resources largely relied on modal administrations to implement training strategies to address skill gaps. Recruiting: The Department of Human Resources implemented some recruiting strategies, but did not help modal administrations identify strategies effective for recruiting staff with skills needed to oversee the safety of automated technologies.
Principle 4: Monitor progress toward meeting human capital goals.	Training: The Department of Human Resources established a goal to reduce skill gaps, but did not track progress towards that goal, and does not plan to do so between the 2020 skill gap assessment and the next one in 3 to 4 years. Recruiting: The Department of Human Resources established and tracked progress towards hiring goals for some occupations that oversee the safety of automated technologies.

Source: GAO analysis of DOT information. | GAO-21-197

Department of Human Resources Has Not Implemented Training or Regularly Tracked Progress toward Closing Gaps in Skills Needed to Oversee Automated Technologies

Through its workforce planning efforts described above, the Department of Human Resources identified the need for training to close general and technical skill gaps. Specifically, DOT determined through the 2016 assessment that it should implement training to address gaps in mission-critical occupations, including in skills needed to ensure the safety of automated technologies. For example, the gap assessment recommended developing “multi-year training plans” and outlined various examples of formal in-class training and informal on-the-job training and mentoring that could help address skill gaps. The assessment emphasized informal training to address general skill gaps, such as “judgment and decision making” and “problem solving,” and formal training to address technical skill gaps, such as regulation and data analysis. As described above, the Department of Human Resources also identified training needs for engineers (electronic, mechanical and civil) to “expand skills to keep up with changes in...vehicle automation and drones.”

Department of Human Resources officials said that they had not implemented training, and instead expected modal administrations to implement strategies to address skill gaps, including through training. However, selected modal administrations did not implement training as

recommended. For example, the 2016 assessment described gaps in data analysis skills among engineers and other gaps among electrical engineers, yet none of the three selected modal administrations offered training on data analysis or for electrical engineers. Selected modal administrations did offer training in other areas where gaps were identified. For example, NHTSA officials noted that they offered training related to “judgment and decision making”, while NHTSA and FRA reported holding training on regulatory skills. FMCSA did not offer training. According to selected modal administration officials, they did not implement training in response to the gap assessment in part because they did not think it was their responsibility to do so. Department of Human Resources officials said that they provided modal administrations with career path guides that outlined key skills for some occupations, such as “highway safety specialist.” However, while these career path guides listed competencies and behaviors necessary for each occupation—and suggested staff complete training—they did not list training targeted to address gaps in current employees’ skills identified in the 2016 assessment.

In addition, while the Department of Human Resources established a goal in its *Human Capital Operating Plan* to reduce the gaps identified in the 2016 assessment, neither the Department of Human Resources nor modal administrations tracked progress towards that goal and neither has a plan to do so following the 2020 gap assessment. In its *Human Capital Operating Plan*, the Department of Human Resources states that it will, “reduce the number of mission critical occupation [skill] gaps critically by 5 percent in [the next gap assessment] against FY15/16 baseline,” but staff were not able to explain how they calculated that metric. Selected modal administration officials said they also did not track progress towards this goal, and that they thought it was the Department of Human Resources’ responsibility to do so. Further, Department of Human Resources officials said they only measured skill gaps during the assessment period—every 3 to 4 years—and do not assess or measure progress towards closing gaps in between assessment periods, including between the 2020 assessment and the next one. For example, the Department of Human Resources did not regularly track whether they or modal administrations had implemented strategies to close skill gaps recommended in the 2016 assessment.

Developing strategies to address skill gaps and monitoring and evaluating progress towards closing them are key elements of effective workforce planning because they help an agency ensure its workforce can help it accomplish its goals. However, despite the statement in the *Human*

Capital Operating Plan that the Department of Human Resources would “work with [modal administrations] on gap identification and strategies for closure,” the Department of Human Resources did not ensure modal administrations offered training to close such gaps, including those in engineering, regulation, and data analysis. As a result, DOT staff did not receive training in all skills identified as gaps, and it is likely that some related to overseeing the safety of automated technologies persist within mission-critical occupations. Furthermore, the Department of Human Resources has not developed a process to monitor or track progress on strategies implemented to close gaps between assessments, such as on an annual basis. Without this process, the Department of Human Resources is missing crucial information that would allow it to track and evaluate the effectiveness of the strategies being implemented to close skill gaps, including training strategies. Further, without this information or a process going forward to address gaps identified in the 2020 assessment, DOT will be unable to ensure that its workforce’s skills keep pace with those needed to understand rapidly-developing automated technologies.

The Department of Human Resources Has Implemented Some Recruiting Strategies to Address Skill Gaps but Has Not Assessed the Effectiveness of Its Efforts

The Department of Human Resources implemented some recruiting strategies to close skill gaps identified in the 2016 assessment in three areas required to oversee automated technologies—engineering, regulatory and data analysis skills—and plans to continue these efforts following the 2020 assessment. For example, Department of Human Resources’ efforts to recruit candidates with these and other skills in which it wanted to “invest” and acquire new talent included forming a Recruitment Council and making use of social media to conduct outreach. The Recruitment Council was established in 2018 to share information on recruiting practices among modes and includes human resource staff from each modal administration. NHTSA human resource officials told us that the Recruitment Council is a good resource for informally sharing recruiting practices, such as types of materials to use at recruiting events. Officials also said the Department of Human Resources shares information on upcoming recruiting events that could attract staff to engineering or information technology positions, such as recruitment fairs focused on science, technology, engineering, and math. Department of Human Resources officials said they also use social media campaigns

and social networking sites, such as “Handshake,” to recruit on college campuses.

The Department of Human Resources also uses special payment authorities, another recruitment strategy available to federal agencies to recruit and retain employees in certain occupations, including some that oversee automated technologies. For example, officials from the Department of Human Resources, FRA and NHTSA reported using special payment authorities, such as special rates and retention incentives, to attract staff to occupations DOT targeted for investment, including engineers and positions that involve data analysis (statisticians and mathematicians).⁴⁵ Officials from the Department of Human Resources and selected modal administrations also reported using “direct hire,” which refers to an agency’s authority to expedite federal hiring by eliminating typical procedural requirements for hiring in the federal government, such as competitive rating and ranking, veterans’ preference, and other procedures.⁴⁶ However, Department of Human Resources officials were not able to provide data on the specific positions for which they used special payment or direct hire authorities.

Separate from Department of Human Resources’ efforts, modal administrations reported creating new divisions and hiring staff to oversee automated technologies. Specifically, FRA officials reported creating a new division within the Office of Railroad Systems and Technology to oversee automated technologies while NHTSA created a new research division to cover vehicle cybersecurity and adapted some engineering position descriptions to include specific mention of automated

⁴⁵We have previously reported that many agencies make limited use of special payment authorities and often do not document the effectiveness of the special payment authorities they do use. See [GAO-18-91](#).

⁴⁶Direct-Hire Authority “enables an agency to hire, after public notice is given, any qualified applicant and expedites hiring by eliminating competitive rating and ranking, veterans’ preference,” and other procedures. See 5 U.S.C. § 3304(a)(3); 5 C.F.R. subpart B. An agency may request that OPM establish a “special rate” or higher rate of basic pay for an occupation or group of occupations in one or more geographic areas to address existing or likely significant handicaps in recruiting and retaining employees. See 5 U.S.C. § 5305; 5 C.F.R. part 530, subpart C. A retention incentive may be paid to a current employee (or group or category of employees) if the agency determines that the unusually high or unique qualifications of the employee or a special need of the agency for the employee’s services makes it essential to retain the employee and the employee is likely to leave federal service in the absence of such incentive. See 5 U.S.C. § 5754; 5 C.F.R. part 575, subpart C.

technologies.⁴⁷ Officials from NHTSA’s Office of Defects Investigation reported using hiring and training to acquire software and electrical engineering skills. In addition, OST-R will be responsible for staffing the newly created Highly Automated Systems Safety Center of Excellence, which was established by statute to serve as a dedicated source of automated technology oversight skills.⁴⁸ In fiscal year 2020, DOT received an appropriation of \$5 million to staff this center with experts in automation and human factors, computer science, data analytics, machine learning, sensors, and other technologies involving automated systems.⁴⁹

To guide its recruitment efforts, the Department of Human Resources established hiring goals for the mission-critical occupations for which they determined they needed additional staff. In alignment with principles for effective workforce planning, the Department of Human Resources tracked progress towards meeting these goals. Three of these occupations—engineering, economist, and data analysis—have a role in overseeing the safety of automated technologies, as described above. The Department of Human Resources exceeded its hiring goal for engineers, but did not meet its hiring goals for economists or data analysis occupations (See table 5).

Table 5: DOT’s Staffing Goals and Actuals for Three Occupations Related to Oversight of Automated Technologies, Fiscal Year 2018 and 2020

Occupation	Baseline: FY2018 Quarter 2	Goal	Actual: FY2020 Quarter 3
Engineering	4718	4867	4956
Economist	99	125	118
Data Analysis	3419	3522	3340

Source: GAO analysis of DOT data | GAO-21-197

Modal administration officials we interviewed noted challenges competing with private industry for certain positions. For instance, FRA officials said they faced challenges hiring senior technical staff for the Office of Safety’s PTC team, given the private sector’s high demand for such skills,

⁴⁷DOT officials noted that FRA’s new division is called the Engineering Technology, and Automation Division; NHTSA’s is the Electronic Systems Safety Research Division.

⁴⁸Further Consolidated Appropriations Act, 2020, Pub. L. No. 116-94, §105, 133 Stat. 2534, 2938-39 (2019) (codified at 49 U.S.C. § 102 note).

⁴⁹*Id.* at 2934.

ability to offer higher pay, and the comparatively-lengthy federal hiring process. NHTSA reported that in 2020 it had vacancies in related mission-critical occupations such as economists (40 percent); engineers (9 percent); and mechanical engineers (5 percent).⁵⁰ According to data that Department of Human Resources' officials provided, nearly one-third of DOT's workforce—including nearly one-third of NHTSA's engineering workforce—is eligible to retire in the next 5 years.⁵¹

Although the Department of Human Resources used recruitment strategies such as special payment authorities to meet its hiring goals, it did not evaluate how effective these strategies were in closing gaps in skills needed to oversee the safety of automated technologies. As such, the Department of Human Resources lacked information on effective strategies for recruiting staff skilled in these areas, such as electrical or software engineering, regulation, or data analysis, to share with modal administrations. We have previously reported that it is important for agencies to assess which recruiting and hiring strategies, such as special payment authorities, are the most appropriate and effective for managing their workforces and addressing their human capital challenges, and identified key practices to do so.⁵²

Without guidance from the Department of Human Resources on effective recruiting strategies to attract candidates with key skills, modal administrations created their own recruitment plans. For example, FRA and NHTSA recruitment plans stated they would use special payment authorities to attract staff. However, the plans did not specify which special payment authorities to use, and why. NHTSA officials said it would be helpful if the Department of Human Resources provided more information on when and how to use specific payment authorities to attract staff with certain skills. Department of Human Resources officials

⁵⁰NHTSA was the only modal administration we interviewed that provided vacancy rate data. Department of Human Resources officials told us they do not collect agency-wide data on vacancy rates.

⁵¹We have previously reported that the high percentage of federal employees eligible for retirement could produce gaps in institutional knowledge, and aggravate the problems posed by existing skill gaps. See GAO, *Federal Workforce: OPM and Agencies Need to Strengthen Efforts to Identify and Close Mission-Critical Skills Gaps*, [GAO-15-223](#) (Washington, D.C.: Jan. 30, 2015).

⁵²We previously identified six key practices that agencies should implement to use recruiting and hiring "flexibilities," effectively. Hiring flexibilities include recruitment and hiring incentives such as special payment authorities. See: GAO, *Human Capital: Effective Use of Flexibilities Can Assist Agencies in Managing Their Workforces*, [GAO-03-2](#) (Washington, D.C.: Dec. 6, 2002).

said they were creating an agency-wide recruitment plan based on modal administrations' individual recruitment plans. As such, it is unlikely to include information informed by the effectiveness of various recruitment strategies since the modal administrations' plans do not include that information. Without helping modal administrations identify recruitment strategies tailored to attracting staff with skills needed to address the staffing and skills specific to their missions, the Department of Human Resources risks missing opportunities to reach and hire needed staff.

Conclusions

DOT's workforce faces challenges related to overseeing the safety of automated technologies, including the rapid pace of technological advancement and the large number of staff eligible to retire in the near future. To address these challenges, DOT's Department of Human Resources has taken some steps to identify, assess, and close gaps in the skills needed to effectively perform its oversight mission. However, without fully identifying needed skills cited by stakeholders and modal administrations, assessing skill gaps, implementing training, tracking progress toward closing skill gaps, or evaluating strategies to attract staff with needed skills, DOT will have difficulty building a workforce with the expertise to ensure automated technologies are safe for consumers and communities.

Recommendations

We are making the following four recommendations to The Director of DOT's Department of Human Resources.

The Director of DOT's Department of Human Resources should complete efforts to identify all cybersecurity occupations across the agency, and incorporate those related to overseeing the cybersecurity of automated technologies into its workforce planning efforts, such as the Workforce Transformation Chart. (Recommendation 1)

The Director of DOT's Department of Human Resources should assess skill gaps in key occupations that are involved in overseeing the safety of automated technologies. (Recommendation 2)

The Director of DOT's Department of Human Resources should regularly measure the progress of strategies implemented to close skill gaps—such

as on an annual basis—and ensure modal administrations offer training to close those gaps. (Recommendation 3)

The Director of DOT's Department of Human Resources should collect and analyze information on the effectiveness of recruiting strategies, such as special payment authorities, in attracting staff to occupations that oversee the safety of automated technologies, and share effective strategies with modal administrations. (Recommendation 4)

Agency Comments and Our Evaluation

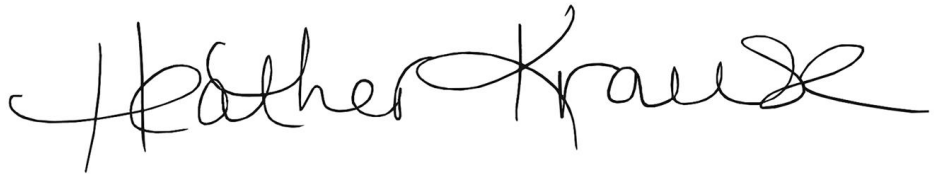
We provided a draft of this report to DOT for comment. DOT provided written comments, which are reprinted in appendix II. DOT also provided technical comments, which we incorporated as appropriate in the report.

DOT agreed with three of the four recommendations and stated that having a workforce with the skills and competencies to meet the challenges of the future is a priority for the agency. DOT partially concurred with our fourth recommendation that the Director of DOT's Department of Human Resources should regularly measure progress toward closing skill gaps—such as on an annual basis—and ensure modal administrations offer training to close those gaps. DOT said that due to the labor-intensive nature of effectively and accurately measuring skill gap closures, conducting a comprehensive assessment every 3 years—rather than on an annual basis—is sufficient.

On the basis of DOT's comments, we have slightly modified our draft recommendation to clarify the need for DOT to regularly assess the progress of implemented strategies in closing skill gaps. While DOT's comprehensive assessment identifies, among other things, gaps in employees' skills every 3 to 4 years, it does not provide the department with interim information on the progress of strategies implemented to close those gaps. For example, without a process to track progress on strategies to close skills gaps identified in its 2016 assessment, DOT was unable to ensure that modal administrations offered recommended training. As a result, DOT staff did not receive training in all areas identified as skill gaps. Measuring interim progress of the implementation of strategies to close skill gaps would help DOT evaluate the effectiveness of those strategies and make course corrections, as needed, between assessments. Accordingly, we believe that DOT should implement this recommendation.

We are sending copies of this report to the appropriate congressional committees, the Secretary of the Department of Transportation, 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 about this report, please contact me at (202) 512-2834 or krauseh@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 III.

A handwritten signature in black ink that reads "Heather Krause". The signature is fluid and cursive, with the first name "Heather" and last name "Krause" clearly distinguishable.

Heather Krause
Director, Physical Infrastructure

Appendix I: Selected Transportation Stakeholders Interviewed

Table 6: List of Stakeholders Interviewed

Advocates for Highway and Auto Safety
Alliance for Automotive Innovation
Association of American Railroads
American Association of State Highway and Transportation Officials
American Trucking Associations
Aptiv
Carnegie Mellon University
Center for Automotive Research (Stanford University)
City of Pittsburgh, Department of Mobility and Infrastructure
Governors Highway Safety Association
National Transportation Safety Board
SAE International
Transportation Technology Center, Inc.
Volpe National Transportation Systems Center
Women in Trucking

Source: GAO. | GAO-21-197

Appendix II: Comments from the Department of Transportation

U.S. Department of
Transportation

Office of the Secretary
of Transportation

Assistant Secretary
for Administration

1200 New Jersey Ave., SE
Washington, DC 20590

December 7, 2020

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

Dear Ms. Krause:

Ensuring that the Department of Transportation (DOT) has a workforce with the skills and competencies to meet the challenges of the future is a priority for DOT. The Department has recently undertaken a comprehensive competency assessment of its mission critical occupations. We will use the results of the assessment, along with our workforce planning efforts, to work with our Operating Administrations to address the recommendations in the GAO draft report.

Upon review of the GAO's draft report, we concur with recommendations 1, 2, and 4. We partially concur with recommendation 3, that "The Director of DOT's Department of Human Resources should regularly measure progress toward closing skill gaps, such as on an annual basis, and ensure modal administrations offer training to close those gaps." We do not concur with "such as on an annual basis." Due to the labor-intensive nature of effectively and accurately measuring skill gap closures, we believe our current program of conducting comprehensive assessments every 3 years is sufficient. The Department will provide a detailed response to each recommendation within 180 days of the issuance of GAO's 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

Agency Comment Letter

Text of Appendix II: Comments from the Department of Transportation

Page 1

December 7, 2020

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

Dear Ms. Krause:

Ensuring that the Department of Transportation (DOT) has a workforce with the skills and competencies to meet the challenges of the future is a priority for DOT. The Department has recently undertaken a comprehensive competency assessment of its mission critical occupations. We will use the results of the assessment, along with our workforce planning efforts, to work with our Operating Administrations to address the recommendations in the GAO draft report.

Upon review of the GAO's draft report, we concur with recommendations 1, 2, and 4. We partially concur with recommendation 3, that "The Director of DOT's Department of Human Resources should regularly measure progress toward closing skill gaps, such as on an annual basis, and ensure modal administrations offer training to close those gaps." We do not concur with "such as on an annual basis." Due to the labor-intensive nature of effectively and accurately measuring skill gap closures, we believe our current program of conducting comprehensive assessments every 3 years is sufficient. The Department will provide a detailed response to each recommendation within 180 days of the issuance of GAO's 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

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Heather Krause, (202) 512-2834, KrauseH@gao.gov

Staff Acknowledgements

In addition to the individual named above, Nancy Lueke (Assistant Director); Sarah Farkas (Analyst-in-Charge); Oluwaseun Ajayi; Devin Braun; Kendall Childers; Kristen Farole; Yvonne Jones; Terence Lam; Andrea Levine; Steven Lozano; Ned Malone; Josh Ormond; Pam Snedden; Janet Temko-Blinder; Laurel Voloder; Michelle Weathers; Rebecca Woiwode; Elizabeth Wood; and Teresa Yost made significant contributions to this report.

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