U.S. Department of Transportation

Automated Vehicles 3.0

PREPARING FOR THE FUTURE OF TRANSPORTATION

With the development of automated vehicles, American creativity and innovation hold the potential to once again transform mobility.

Preparing for the Future of Transportation

Automated Vehicles 3.0

U.S. Department of Transportation

LETTER FROM THE SECRETARY

Secretary Elaine L. Chao
U.S. Department of Transportation

America has always been a leader in transportation innovation. From the mass production of automobiles to global positioning system navigation, American ingenuity has transformed how we travel and connect with one another. With the development of automated vehicles, American creativity and innovation hold the potential to once again transform mobility.

Automation has the potential to improve our quality of life and enhance the mobility and independence of millions of Americans, especially older Americans and people with disabilities.

Moreover, the integration of automation across our transportation system has the potential to increase productivity and facilitate freight movement. But most importantly, automation has the potential to impact safety significantly—by reducing crashes caused by human error, including crashes involving impaired or distracted drivers, and saving lives.

Along with potential benefits, however, automation brings new challenges that need to be addressed. The public has legitimate concerns about the safety, security, and privacy of automated technology. So I have challenged Silicon Valley and other innovators to step up and help address these concerns and help inform the public about the benefits of automation. In addition, incorporating these technologies into our transportation systems may impact industries, creating new kinds of jobs. This technology evolution may also require workers in transportation fields to gain new skills and take on new roles. As a society, we must help prepare workers for this transition.

The U.S. Department of Transportation is taking active steps to prepare for the future by engaging with new technologies to ensure safety without hampering innovation. With the release of *Automated Driving Systems 2.0: A Vision for Safety* in September 2017, the Department provided voluntary guidance to industry, as well as technical assistance and best practices to States, offering a path forward for the safe testing and integration of automated driving systems. The Department also bolstered its engagement with the automotive industry, technology companies, and other key transportation stakeholders and innovators to continue to develop a policy framework that facilitates the safe integration of this technology into our transportation systems.

Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0) is another milestone in the Department's development of a flexible, responsible approach to a framework for multimodal automation. It introduces guiding principles and describes the Department's strategy to address existing barriers to safety innovation and progress. It also communicates the Department's agenda to the public and stakeholders on important policy issues, and identifies opportunities for cross-modal collaboration.

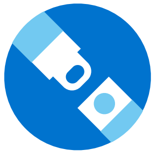
The Department is committed to engaging stakeholders to identify and solve policy issues. Since the publication of *Automated Driving Systems 2.0: A Vision for Safety,* the Department has sought input on automation issues from stakeholders and the general public through a wide range of forums including formal Requests for Information and Comments. In March 2018, I hosted the Automated Vehicle Summit to present the Department's six Automation Principles and discuss automation issues with public and private sector transportation stakeholders across every mode. The ideas and issues raised by stakeholders through these forums are reflected in this document. The goal of the Department is to keep pace with these rapidly evolving technologies so America remains a global leader in safe automation technology.

AV 3.0 is the beginning of a national discussion about the future of our surface transportation system. Your voice is essential to shaping this future.

Working together, we can help usher in a new era of transportation innovation and safety, and ensure that our country remains a global leader in automated technology.

U.S. DOT AUTOMATION PRINCIPLES

The United States Department of Transportation (U.S. DOT) has established a clear and consistent Federal approach to shaping policy for automated vehicles, based on the following six principles.



1. We will prioritize safety.

Automation offers the potential to improve safety for vehicle operators and occupants, pedestrians, bicyclists, motorcyclists, and other travelers sharing the road. However, these technologies may also introduce new safety risks. U.S. DOT will lead efforts to address potential safety risks and advance the life-saving potential of automation, which will strengthen public confidence in these emerging technologies.

2. We will remain technology neutral.

To respond to the dynamic and rapid development of automated vehicles, the Department will adopt flexible, technology-neutral policies that promote competition and innovation as a means to achieve safety, mobility, and economic goals. This approach will allow the public—not the Federal Government—to choose the most effective transportation and mobility solutions.

3. We will modernize regulations.

U.S. DOT will modernize or eliminate outdated regulations that unnecessarily impede the development of automated vehicles or that do not address critical safety needs. Whenever possible, the Department will support the development of voluntary, consensus-based technical standards and approaches that are flexible and adaptable over time. When regulation is needed, U.S. DOT will seek rules that are as nonprescriptive and performance-based as possible. *As a starting point and going forward, the Department 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 in fact include an automated system.*

4. We will encourage a consistent regulatory and operational environment.

Conflicting State and local laws and regulations surrounding automated vehicles create confusion, introduce barriers, and present compliance challenges. U.S. DOT will promote regulatory consistency so that automated vehicles can operate seamlessly across the Nation. The Department will build consensus among State and local transportation agencies and industry stakeholders on technical standards and advance policies to support the integration of automated vehicles throughout the transportation system.

5. We will prepare proactively for automation.

U.S. DOT will provide guidance, best practices, pilot programs, and other assistance to help our partners plan and make the investments needed for a dynamic and flexible automated future. The Department also will prepare for complementary technologies that enhance the benefits of automation, such as communications between vehicles and the surrounding environment, but will not assume universal implementation of any particular approach.

6. We will protect and enhance the freedoms enjoyed by Americans.

U.S. DOT embraces the freedom of the open road, which includes the freedom for Americans to drive their own vehicles. We envision an environment in which automated vehicles operate alongside conventional, manually-driven vehicles and other road users. We will protect the ability of consumers to make the mobility choices that best suit their needs. We will support automation technologies that enhance individual freedom by expanding access to safe and independent mobility to people with disabilities and older Americans.

SAE AUTOMATION LEVELS[1]

0 No Automation
The full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems.

1 Driver Assistance
The *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*.

2 Partial Automation
The *driving mode*-specific execution by one or more driver assistance systems of both steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*.

3 Conditional Automation
The *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*.

4 High Automation
The *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*.

5 Full Automation
The full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*.

1 SAE International, J3016_201806: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (Warrendale: SAE International, 15 June 2018), https://www.sae.org/standards/content/j3016_201806/.

“ ”

A Note on Terminology

Clear and consistent definition and use of terminology is critical to advancing the discussion around automation. To date, a variety of terms (e.g., self-driving, autonomous, driverless, highly automated) have been used by industry, government, and observers to describe various forms of automation in surface transportation. While no terminology is correct or incorrect, this document uses “automation” and “automated vehicles” as general terms to broadly describe the topic, with more specific language, such as “Automated Driving System” or “ADS” used when appropriate. A full glossary is in the Appendix.

CONTENTS

EXECUTIVE SUMMARY

Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0) advances U.S. DOT's commitment to supporting the safe, reliable, efficient, and cost-effective integration of automation into the broader multimodal surface transportation system. *AV 3.0* builds upon—but does not replace—voluntary guidance provided in *Automated Driving Systems 2.0: A Vision for Safety.*

Automation technologies are new and rapidly evolving. The right approach to achieving safety improvements begins with a focus on removing unnecessary barriers and issuing voluntary guidance, rather than regulations that could stifle innovation.

In *AV 3.0,* U.S. DOT's surface transportation operating administrations come together for the first time to publish a Departmental policy statement on automation. This document incorporates feedback from manufacturers and technology developers, infrastructure owners and operators, commercial motor carriers, the bus transit industry, and State and local governments.[2] This document considers automation broadly, addressing all levels of automation (SAE automation Levels 1 to 5), and recognizes multimodal interests in the full range of capabilities this technology can offer.[3]

AV 3.0 includes six principles that guide U.S. DOT programs and policies on automation and five implementation strategies for how the Department translates these principles into action *(see facing page).*

AV 3.0 Provides New Multimodal Safety Guidance

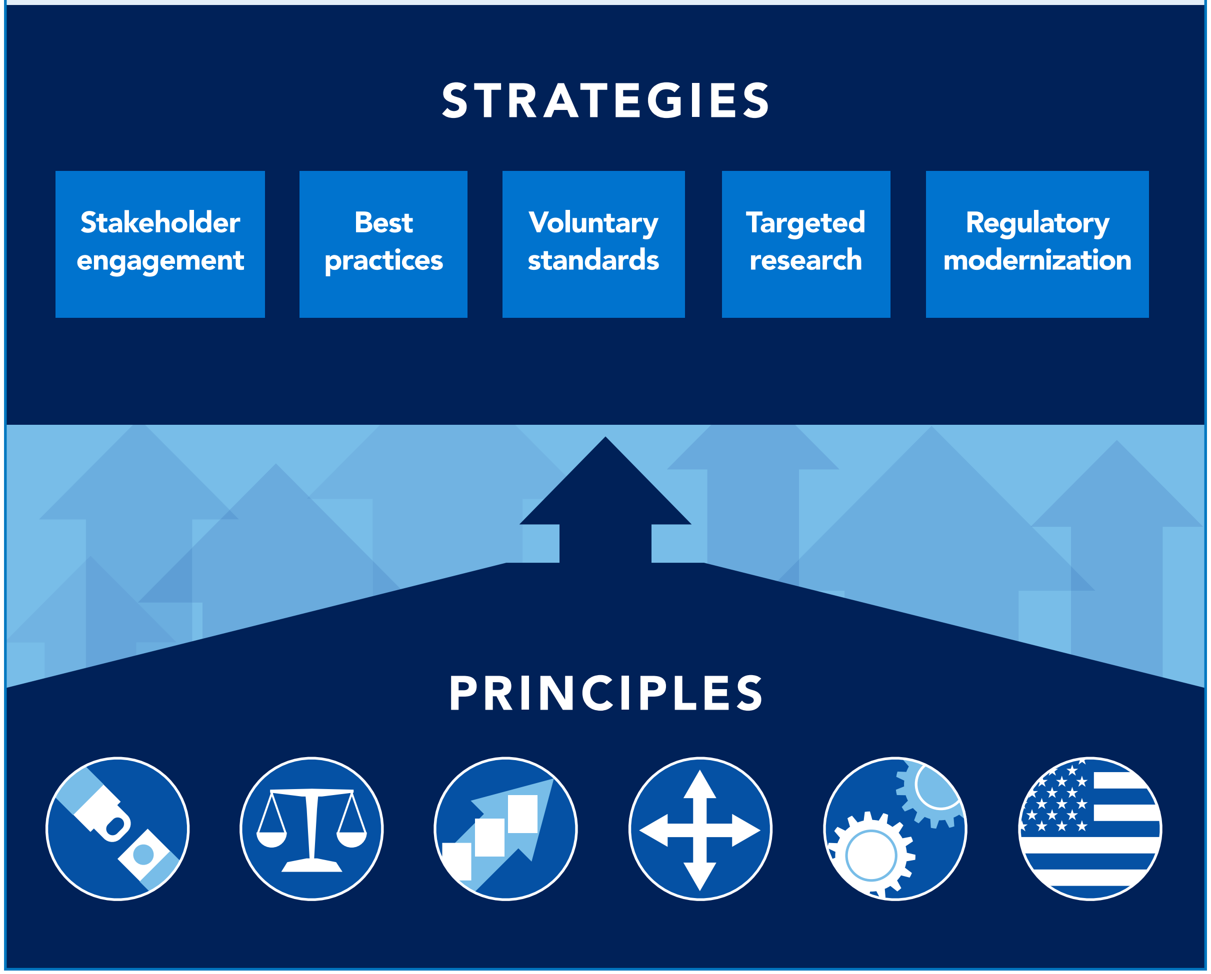
In accordance with the Department's first automation principle, *AV 3.0* outlines how automation will be safely integrated across passenger vehicles, commercial vehicles, on-road transit, and the roadways on which they operate. Specifically, *AV 3.0:*

- Affirms the approach outlined in *A Vision for Safety 2.0* and encourages automated driving system developers to make their Voluntary Safety Self-Assessments public to increase transparency and confidence in the technology.
- Provides considerations and best practices for State and local governments to support the safe and effective testing and operation of automation technologies.
- Supports the development of voluntary technical standards and approaches as an effective non-regulatory means to advance the integration of automation technologies into the transportation system.
- Describes an illustrative framework of safety risk management stages along the path to full commercial integration of automated vehicles. This framework promotes the benefits of safe deployment while managing risk and provides clarity to the public regarding the distinctions between various stages of testing and full deployment.
- Affirms the Department is continuing its work to preserve the ability for transportation safety applications to function in the 5.9 GHz spectrum.

2 See Appendix B for a summary of public input received.

3 SAE International, J3016_201806: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (Warrendale: SAE International, 15 June 2018), https://www.sae.org/standards/content/j3016_201806/.

Automation Principles and Implementation Strategies



AV 3.0 Clarifies Policy and Roles

AV 3.0 responds to issues raised by stakeholders and includes the following key policy and role clarifications:

- States that U.S. 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.
- Recognizes that given the rapid increase in automated vehicle testing activities in many locations, there is no need for U.S. DOT to favor particular locations or to pick winners and losers. Therefore, the Department no longer recognizes the designations of ten Automated Vehicle Proving Grounds announced on January 19, 2017.
- Urges States and localities to work to remove barriers—such as unnecessary and incompatible regulations—to automated vehicle technologies and to support interoperability.
- Affirms U.S. DOT's authority to establish motor vehicle safety standards that allow for innovative automated vehicle designs—such as vehicles without steering wheels, pedals, or mirrors—and notes that such an approach may require a more fundamental revamping of the National Highway Traffic Safety Administration's (NHTSA) approach to safety standards for application to automated vehicles.
- Reaffirms U.S. DOT's reliance on a self-certification approach, rather than type approval, as the way to balance and promote safety and innovation; U.S. DOT will continue to advance this approach with the international community.

- Clarifies that, rather than requiring a one-size-fits-all approach, the Federal Transit Administration will provide transit agencies with tailored technical assistance as they develop an appropriate safety management system approach to ensuring safe testing and deployment of automated transit bus systems.

AV 3.0 Outlines How to Work with U.S. DOT as Automation Technology Evolves

It identifies opportunities for partnership and collaboration among the private sector, State and local agencies, and U.S. DOT on issues ranging from accessibility to workforce development to cybersecurity. Specifically, *AV 3.0:*

- Announces a forthcoming notice of proposed rulemaking, which includes the possibility of setting exceptions to certain safety standards—*that are relevant only when human drivers are present*—for automated driving system (ADS)-equipped vehicles.
- Informs stakeholders that U.S. DOT will seek public comment on a proposal to streamline and modernize the procedures NHTSA will follow when processing and deciding exemption petitions.
- Defines a targeted Federal role in automation research.
- Informs stakeholders of the Federal Motor Carrier Safety Administration's (FMCSA) intent to initiate an Advance Notice of Proposed Rulemaking to better understand areas of responsibility between the State and Federal governments in the context of ADS-equipped commercial motor vehicles and commercial carriers.
- States that FMCSA will also consider changes to its motor carrier safety regulations to accommodate the integration of ADS-equipped commercial motor vehicles.
- Informs stakeholders that U.S. DOT plans to update the 2009 Manual on Uniform Traffic Control Devices, taking new technologies into consideration.
- Identifies automation-related voluntary standards being developed through standards development organizations and associations.
- Announces a study of the workforce impacts of automated vehicles, in collaboration among U.S. DOT, U.S. Department of Labor, U.S. Department of Commerce, and the U.S. Department of Health and Human Services.

U.S. DOT's Operating Administrations are United in Their Commitment to Safety

We act as "One DOT" in pursuing strategies to successfully integrate automation technologies into the transportation system. The operating administrations shown on the facing page contributed to *AV 3.0*.

Each of these U.S. DOT operating administrations actively encourages the integration of automation in ways guided by the U.S. DOT's automation principles and strategies noted above.[4] *AV 3.0* focuses on the automation of motor vehicles on roadways and the roles of NHTSA, FMCSA, FHWA, and FTA, with consideration of intermodal points (e.g., motor vehicles at ports and highway-rail grade crossings).

4 See https://www.transportation.gov/av for more information on automation efforts at U.S. DOT.

OPERATING ADMINISTRATIONS

For more information on how U.S. DOT agencies engage with automation, see www.transportation.gov/av

Federal Highway Administration

The Federal Highway Administration (FHWA) is responsible for providing stewardship over the construction, maintenance, and preservation of the Nation's highways, bridges, and tunnels. Through research and technical assistance, the FHWA supports its partners in Federal, State, and local agencies to accelerate innovation and improve safety and mobility.

Federal Motor Carrier Safety Administration

The Federal Motor Carrier Safety Administration's (FMCSA) mission is to reduce crashes, injuries, and fatalities involving large trucks and buses. FMCSA partners with industry, safety advocates, and State and local governments to keep the Nation's roads safe and improve commercial motor vehicle (CMV) safety through regulation, education, enforcement, research, and technology.

Federal Aviation Administration

The Federal Aviation Administration (FAA) provides the safest and most efficient aviation system in the world. Annually, FAA manages over 54 million flights, approaching a billion passengers.

Federal Railroad Administration

The Federal Railroad Administration's (FRA) mission is to enable the safe, reliable, and efficient movement of people and goods for a strong America. FRA is advancing the use of new technology in rail.

Federal Transit Administration

The Federal Transit Administration (FTA) provides financial and technical assistance to local public transit systems, including buses, subways, light rail, commuter rail, trolleys, and ferries. FTA also oversees safety measures and helps develop next-generation technology research.

Maritime Administration

The Maritime Administration (MARAD) promotes the use of waterborne transportation and its seamless integration with other segments of the transportation system, and the viability of the U.S. merchant marine.

National Highway Traffic Safety Administration

The National Highway Traffic Safety Administration's (NHTSA) mission is to save lives, prevent injuries, and reduce the economic costs of road traffic crashes through education, research, safety standards, and enforcement activity. NHTSA carries out highway safety programs by setting and enforcing safety performance standards for motor vehicles and equipment, identifying safety defects, and through the development and delivery of effective highway safety programs for State and local jurisdictions.

Pipeline and Hazardous Materials Safety Administration

The Pipeline and Hazardous Materials Safety Administration (PHMSA) protects people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives. To do this, PHMSA establishes national policy, sets and enforces standards, educates, and conducts research to prevent incidents.

Automated vehicles that accurately detect, recognize, anticipate, and respond to the movements of all transportation system users could lead to breakthrough gains in transportation safety.

INTRODUCTION: AUTOMATION AND SAFETY

The United States surface transportation system provides tremendous mobility benefits, including widespread access to jobs, goods, and services. It also connects many remote regions of the country to the larger economy. These benefits, however, come with significant safety challenges, as motor vehicle crashes remain a leading cause of death, with an estimated 37,133 lives lost on U.S. roads in 2017. Traditional safety programs and policies have made road travel significantly safer than in the past, but there is much room to improve traffic fatality and injury rates.

Automated vehicles that accurately detect, recognize, anticipate, and respond to the movements of all transportation system users could lead to breakthrough gains in transportation safety. Unlike human drivers, automation technologies are not prone to distraction, fatigue, or impaired driving, which contribute to a significant portion of surface transportation fatalities. Automated vehicle technologies that are carefully integrated into motor vehicles could help vehicle operators detect and avoid bicyclists, motorcyclists, pedestrians, and other vulnerable users on our roadways, and increase safety across the surface transportation system. Their potential to reduce deaths and injuries on the Nation's roadways cannot be overstated.

Automated vehicles rely on sensors and software that allow an expansive view of the environment across a range of lighting and weather conditions. They can quickly learn and adapt to new driving situations by learning from previous experience through software updates. Fully realizing the life-saving potential of automated vehicles, however, will require careful risk management as new technologies are introduced and adopted across the surface transportation system.

To support the deployment of safe automation technologies, the Department released *A Vision for Safety 2.0* in September 2017, which included 12 automated driving system (ADS) safety elements to help industry partners analyze, identify, and resolve safety considerations using best practices—all before deployment. The voluntary guidance outlined in *A Vision for Safety 2.0* on the design, testing, and safe deployment of ADS remains central to U.S. DOT's approach. ADS developers are encouraged to use these safety elements to publish safety self-assessments to describe to the public how they are identifying and addressing potential safety issues.

On-road testing and early deployments are important to improving automated vehicle performance and allowing them to reach their full performance potential. Careful real-world testing allows developers to identify and rapidly fix system shortcomings, not just on individual vehicles but across fleets. Reasonable risks must be addressed through the application of robust systems engineering processes, testing protocols, and functional safety best practices, such as those documented in *A Vision for Safety*

2.0.[5] However, delaying or unduly hampering automated vehicle testing until all specific risks have been identified and eliminated means delaying the realization of global reductions in risk.

AV 3.0 maintains U.S. DOT's primary focus on safety, while expanding the discussion to other aspects and modes of surface transportation. *AV 3.0* introduces a comprehensive, multimodal approach toward safely integrating automation.

AV 3.0 *introduces a comprehensive, multimodal approach toward safely integrating automation.*

5 As documented in *A Vision for Safety 2.0,* ADS developers should consider employing systems engineering guidance, best practices, design principles, and standards developed by established and accredited standards-developing organizations (as applicable) such as the International Standards Organization (ISO) and SAE International as well as standards and processes available from other industries, such as aviation, space, and the military and other applicable standards or internal company processes as they are relevant and applicable. They should also consider available and emerging approaches to risk mitigation, such as methodologies that focus on functional safety (e.g., ISO 26262) and safety of the intended functionality.

Safety by the Numbers

- An estimated **39,141** people lost their lives on all modes of our transportation system in 2017. The vast majority—37,133 deaths—were from motor vehicle crashes[A,B]

- *Driver Factors:* Of all serious motor vehicle crashes, **94 percent** involve driver-related factors, such as impaired driving, distraction, and speeding or illegal maneuvers.

  In 2017:

  - Nearly **11,000** fatalities involved drinking and driving.[B]
  - Speeding was a factor in nearly **10,000** highway fatalities.[B]
  - Nearly **3,500** fatal crashes* involved distracted drivers.[B]

- *Commercial Vehicles:* **13 percent** of annual roadway fatalities occur in crashes involving large trucks.[B]

- In 2017, **82 percent** of victims in fatal large truck crashes were road users who were not an occupant of the truck(s) involved.[B]

- *Professional Drivers:* Professional drivers are **ten times** more likely to be killed on the job, and nearly nine times more likely to be injured on the job compared to the average worker.[C]

- *Pedestrians:* **5,977** pedestrians were killed by motor vehicles in 2017, representing 16 percent of all motor vehicle fatalities.[B]

- *Highway-Rail Grade Crossings:* Over the past decade, highway rail grade crossing fatalities averaged **253** per year, representing about one-third of total railroad-related fatalities.[A]

Sources:

A U.S. Department of Transportation, Bureau of Transportation Statistics, special tabulation, September 8, 2018

B NHTSA 2017 Fatal Motor Vehicle Crashes: Overview (DOT HS 812 603)

C Beede, David, Regina Powers, and Cassandra Ingram, *The Employment Impact of Autonomous Vehicles,* U.S. Department of Commerce, Washington, DC: http://www.esa.doc.gov/sites/default/files/Employment%20Impact%20Autonomous%20Vehicles_0.pdf

* *This number is likely underreported.*

Only by working in partnership can the public and the private sector improve the safety, security, and accessibility of automation technologies and address the concerns of the general public.

ROLES IN AUTOMATION

The traditional roles of the Federal Government, State and local governments, and private industry are well suited for addressing automation. The Federal Government is responsible for regulating the safety performance of vehicles and vehicle equipment, as well as their commercial operation in interstate commerce, while States and local governments play the lead role in licensing drivers, establishing rules of the road, and formulating policy in tort liability and insurance. Private industry remains a primary source of transportation research investment and commercial technology development. Governments at all levels should not unnecessarily impede such innovation. The Department relies on partners to play their respective roles, while continuing to encourage open dialogue and frequent engagement.

The Department seeks to address policy uncertainty and provide clear mechanisms by which partners can participate and engage with the U.S. DOT.

The Federal Government and Automation

U.S. DOT's role in transportation automation is to ensure the safety and mobility of the traveling public while fostering economic growth. As a steward of the Nation's roadway transportation system, the Federal Government plays a significant role by ensuring that automated vehicles can be safely and effectively integrated into the existing transportation system, alongside conventional vehicles, pedestrians, bicyclists, motorcyclists, and other road users. U.S. DOT also has an interest in supporting innovations that improve safety, reduce congestion, improve mobility, and increase access to economic opportunity for all Americans. Finally, by partnering with industry in adopting market-driven, technology-neutral policies that encourage innovation in the transportation system, the Department seeks to fuel economic growth and support job creation and workforce development.

To accomplish these goals, the Department works closely with stakeholders in the private and public sectors to pursue the following activities:

- Establish performance-oriented, consensus-based, and voluntary standards and guidance for vehicle and infrastructure safety, mobility, and operations.
- Conduct targeted research to support the safe integration of automation.
- Identify and remove regulatory barriers to the safe integration of automated vehicles.
- Ensure national consistency for travel in interstate commerce.
- Educate the public on the capabilities and limitations of automated vehicles.

Integrating Safety into Surface Transportation Automation

Each operating administration has its respective area of authority over improving the safety of the Nation's transportation system. Assuring the safety of automated vehicles will not only rely on the validation of the technology, such as the hardware, software, and components, but it will also depend on appropriate operating rules, roadway conditions, and emergency response protocols. The following sections outline the primary authorities and policy issues for the National Highway Traffic Safety Administration (NHTSA), Federal Motor Carrier Safety Administration (FMCSA), Federal Highway Administration (FHWA), and Federal Transit Administration (FTA) to demonstrate how the U.S. DOT is incorporating safety throughout the surface transportation system as it relates to automated vehicles. These sections also discuss ADS-equipped vehicles (SAE automation Levels 3 to 5) and lower level technologies (SAE automation Levels 0 to 2), depending on the role of each operating administration and its current engagement with automation.

NHTSA Authorities and Key Policy Issues

Safety Authority Over ADS-Equipped Vehicles and Equipment

NHTSA has broad authority over the safety of ADS-equipped vehicles and other automated vehicle technologies equipped in motor vehicles. NHTSA has authority to establish Federal safety standards for new motor vehicles introduced into interstate commerce in the United States, and to address safety defects determined to exist in motor vehicles or motor vehicle equipment used in the United States.[6] The latter authority focuses on the obligations that Federal law imposes on the manufacturers of motor vehicles and motor vehicle equipment to notify NHTSA of safety defects in those vehicles or vehicle equipment and to remedy the defects, subject to NHTSA's oversight and enforcement authority.[7]

Under Federal law, no State or local government may enforce a law on the safety performance of a motor vehicle or motor vehicle equipment that differs in any way from the Federal standard.[8] The preemptive force of the Federal safety standard does not extend to State and local traffic laws, such as speed limits. Compliance with the Federal safety standard does not automatically exempt any person from liability at common law, including tort liability for harm caused by negligent conduct, except where preemption may apply.[9] The Federal standard would supersede if the effect of a State law tort claim would be to impose a performance standard on a motor vehicle or equipment manufacturer that is inconsistent with the Federal standard.[10]

NHTSA's application of Federal safety standards to the performance of ADS-equipped vehicles and equipment is likely to raise questions about preemption and the future complementary mix of Federal, State and local powers. The Department will carefully consider these jurisdictional questions as NHTSA develops its regulatory approach to ADS and other automated vehicle technologies so as to strike the appropriate balance between the Federal Government's use of its authorities to regulate the safe design and operational performance of an ADS-equipped vehicle and the State and local authorities' use of their traditional powers.

6 49 U.S.C. §§ 30111 and 30166.
7 49 U.S.C. § 30118(c).
8 49 U.S.C. § 30103(b).
9 49 U.S.C. § 30103(e).
10 See *Geier v. American Honda Motor Co.*, 529 U.S. 861 (2000).

Federal Safety Standards for ADS-Equipped Vehicles

Several NHTSA safety standards for motor vehicles assume a human occupant will be able to control the operation of the vehicle, and many standards incorporate performance requirements and test procedures geared toward ensuring safe operation by a human driver. Some standards focus on the safety of drivers and occupants in particular seating arrangements. Several standards impose specific requirements for the use of steering wheels, brakes, accelerator pedals, and other control features, as well as the visibility for a human driver of instrument displays, vehicle status indicators, mirrors, and other driving information.

NHTSA's current safety standards do not prevent the development, testing, sale, or

use of ADS built into vehicles that maintain the traditional cabin and control features of human-operated vehicles. However, some Level 4 and 5 automated vehicles may be designed to be controlled entirely by an ADS, and the interior of the vehicle may be configured without human controls. There may be no steering wheel, accelerator pedal, brakes, mirrors, or information displays for human use. For such ADS-equipped vehicles, NHTSA's current safety standards constitute an unintended regulatory barrier to innovation.

The Department, through NHTSA, intends to reconsider the necessity and appropriateness of its current safety standards as applied to ADS-equipped vehicles. **In an upcoming rulemaking, NHTSA plans to seek comment on proposed changes to particular safety standards to accommodate automated vehicle technologies and the possibility of setting exceptions to certain standards—*that are relevant only when human drivers are present*—for ADS-equipped vehicles.**

Going forward, NHTSA may also consider a more fundamental revamping of its approach to safety standards for application to automated vehicles. However, reliance on a self-certification approach, instead of type approval, more appropriately balances and promotes safety and innovation; U.S. DOT will continue to advance this approach with the international community. NHTSA's current statutory authority to establish motor vehicle safety standards is sufficiently flexible to accommodate the design and performance of different ADS concepts in new vehicle configurations.

NHTSA recognizes that the accelerating pace of technological change, especially in the development of software used in ADS-equipped vehicles, requires a new approach to the formulation of the Federal Motor Vehicle Safety Standards (FMVSS). The pace of innovation in automated vehicle technologies is incompatible with lengthy rulemaking proceedings and highly prescriptive and feature-specific or design-specific safety standards. Future motor vehicle safety standards will need to be more flexible and responsive, technology-neutral, and performance-oriented to accommodate rapid technological innovation. They may incorporate simpler and more general requirements designed to validate that an ADS can safely navigate the real-world roadway environment, including unpredictable hazards, obstacles, and interactions with other vehicles and pedestrians who may not always adhere to the traffic laws or follow expected patterns of behavior. Existing standards assume that a vehicle may be driven anywhere, but future standards will need to take into account that the operational design domain (ODD) for a particular ADS within a vehicle is likely to be limited in some ways that may be unique to that system. For example, not all Level 3 vehicles will have the same ODD.

Performance-based safety standards could require manufacturers to use test methods, such as sophisticated obstacle-course-based test regimes, sufficient to validate that their ADS-equipped vehicles can reliably handle the normal range of everyday driving scenarios as well as unusual and unpredictable scenarios. Standards could be designed to account for factors such as variations in weather, traffic, and roadway conditions within a given system's ODD, as well as sudden and unpredictable actions by other road users. Test procedures could also be developed to ensure that an ADS does not operate outside of the ODD established by the manufacturer. Standards could provide for a range of potential behaviors—e.g., speed, distance, angles, and size—for surrogate vehicles, pedestrians, and other obstacles that ADS-equipped vehicles would need to detect and avoid. Other approaches, such as computer simulation and requirements expressed in terms of mathematical functions could be considered, as Federal law does not require that NHTSA's safety standards rely on physical tests and measurements, only that they be objective, repeatable, and transparent.

Exemptions from FMVSS for ADS Purposes

NHTSA values a streamlined and modernized exemptions procedure, and removing unnecessary delays. **NHTSA intends to seek**

public comment on a proposal to streamline and modernize procedures the Agency will follow when processing and deciding exemption petitions. Among other things, the proposed changes will remove unnecessary delays in seeking public comment as part of the exemption process, and clarify and update the types of information needed to support such petitions. The statutory provision authorizing NHTSA to grant exemptions from FMVSS provides sufficient flexibility to accommodate a wide array of automated operations, particularly for manufacturers seeking to engage in research, testing, and demonstration projects.[11]

11 49 U.S.C. § 30114

FMCSA Authorities and Key Policy Issues

Safety Authority Over Commercial Motor Vehicle Operations, Drivers, and Maintenance

The Department, through FMCSA, regulates the safety of commercial motor carriers operating in interstate commerce, the qualifications and safety of commercial motor vehicle drivers, and the safe operation of commercial trucks and motor coaches.[12] The best way to accomplish FMCSA's core mission of reducing fatalities and crashes involving large trucks and buses is to avoid unnecessary barriers to the development of ADS in commercial vehicles.

As automation introduces new policy questions, FMCSA will work with (1) industry, State governments, and other partners to further the safe operation of ADS-equipped commercial vehicles, and (2) law enforcement, inspection officers, and first responders to create new techniques and protocols.

12 49 U.S.C. § 31502; 49 U.S.C. chapter 311, subchapter III; 49 U.S.C. chapter 313. Additional statutory authority includes the Hazardous Materials Transportation Uniform Safety Act of 1990 (Pub. L. 101-615, 104 Stat. 3244), codified at 49 U.S.C. Chapter 51; and the ICC Termination Act of 1995 (Pub. L. 104-88, 109 Stat. 803), codified at 49 U.S.C. Chapters 135-149. Note that FMCSA's statutory authority also authorizes the Agency's enforcement of the Hazardous Materials Regulations (HMRs) and the Federal Motor Carrier Commercial Regulations (FMCCRs),. 49 U.S.C. chapter 311, subchapters I and III; chapter 313; and section 31502

In order to develop experience with the technology, demonstrate its capabilities, and socialize the idea of automated vehicles on the road with traditional vehicles, FMCSA will continue to hold public demonstrations of the technology—such as the recent truck platooning demonstration on the I-66 Corridor co-hosted with FHWA—with key stakeholders such as law enforcement.

FMCSA consults with NHTSA on matters related to motor carrier safety.[13] NHTSA and FMCSA have different but complementary authorities over the safety of commercial motor vehicles (CMVs) and commercial vehicle equipment. NHTSA has exclusive authority to prescribe Federal safety standards for new motor vehicles, including trucks and motor coaches, and oversees actions that manufacturers take to remedy known safety defects in motor vehicles and motor vehicle equipment.[14] NHTSA and FMCSA collaborate and consult to develop and enforce safety requirements that apply to the operation and maintenance of vehicles by existing commercial motor carriers. They will continue to do so in the context of ADS-equipped commercial motor vehicles. FMCSA also works closely with States and private stakeholders to develop and enforce safety standards related to the inspection, maintenance, and repair of commercial motor vehicles.

13 49 U.S.C. § 113(i).
14 See 49 U.S.C. §§ 30111 and 30166

Operating ADS-Equipped CMVs under Existing Regulations

In the context of ADS-equipped CMVs, FMCSA will continue to exercise its existing statutory authority over the safe operation of the vehicle.[15] When driving decisions are made by an ADS rather than a human, FMCSA's authority over the safe and proper operating condition of the vehicle and its safety inspection authority may be even more important, particularly between when ADS operations begin and when a revised regulatory framework is established. In addition, **FMCSA retains its authority to take enforcement action if an automated system inhibits safe operation.**[16]

In exercising its oversight, FMCSA will first ask whether the ADS-equipped CMV placed into operation complies with the requirements for parts and accessories for which there are no FMVSS (e.g., fuel tanks and fuel lines, exhaust systems, and rear underride guards on single unit trucks). A motor carrier may not operate an ADS-equipped CMV—or any CMV—until it complies with the requirements and specifications of 49 CFR Part 393, Parts and Accessories Necessary for Safe Operation. If the ADS is installed aftermarket, any equipment that decreases the safety of operation could subject the motor carrier to a civil penalty.[17] In addition, ADS-equipped vehicles that create an "imminent hazard" may be placed out of service and the motor carrier that used the vehicle similarly fined. [18]

FMCSA will then consider whether the motor carrier has complied with the operational requirements of the current Federal Motor Carrier Safety Regulations (FMCSRs). These include, for example, compliance with rules on driving CMVs, including the laws, ordinances, and regulations of the jurisdiction in which the vehicle is operated. Notably, however, in the case of vehicles that do not require a human operator, none of the human-specific FMCSRs (i.e., drug testing, hours-of-service, commercial driver's licenses (CDL)s, and physical qualification requirements) apply.

If the motor carrier cannot fully comply with the FMCSRs through use of its ADS-equipped CMV, then the carrier may seek an exemption.[19] The carrier would need to demonstrate that the ADS-equipped CMV likely achieves an equivalent level of safety. Ultimately, a motor carrier would not be permitted to operate an ADS-equipped CMV on public highways until it complies with the operational requirements or until the carrier obtains regulatory relief.

In general, subject to the development and deployment of safe ADS technologies, the Department's policy is that going forward FMCSA regulations will no longer assume that the CMV driver is always a human or that a human is necessarily present onboard a commercial vehicle during its operation.

The Department and FMCSA are aware of the concerns that differing State regulations present for ADS technology development, testing, and deployment in interstate commerce. **If FMCSA determines that State or local legal requirements may interfere with the application of FMCSRs, the Department has preemptive authority.** The Department works with State partners to promote compatible safety oversight programs. U.S. DOT will carefully consider the appropriate lines of preemption in the context of ADS-equipped commercial motor vehicles and commercial carriers.

FMCSA also has authority, in coordination with the States, to set the Federal qualifications required for CDLs[20]. States have an essential role in training commercial drivers and issuing CDLs, but they must follow the FMCSA regulations that set minimum qualifications and limitations on CDLs in order to stay eligible for Federal grants[21]. The Department will carefully consider the appropriate division of authority between

15 49 U.S.C. §§ 31136(a)(1) and 31502(b)(1))
16 49 CFR 396.7(a).
17 49 CFR 393.3
18 49 U.S.C. § 5122(b); 49 CFR 386.72.
19 49 U.S.C. §§ 31315 and 31136(e).
20 49 U.S.C. § 31136(a)(3).
21 Section 4124 of Public Law 109-59, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, Public Law No.109–59, §§ 4101(c)(1), 4124, 119 Stat. 1144, 1715, 1736–37 (2005), as amended by Moving Ahead for Progress in the 21st Century, Pub. L. No.112–141, §§ 32603(c) and 32604 (c)(1) (2012), 49 U.S.C. §31313 (2006), as amended.

FMCSA and the States on how or whether CDL qualifications should apply to computerized driving systems.

Considering Changes to Existing Regulations

FMCSA is in the process of broadly considering whether and how to amend its existing regulations to accommodate the introduction of ADS in commercial motor vehicles. As noted above, some FMCSA regulatory requirements for commercial drivers have no application to ADS—such as drug and alcohol testing requirements—but many regulations, such as those involving inspection, repair, and maintenance requirements, can be readily applied in the context of ADS-equipped commercial trucks and motor coaches. Current FMCSRs would continue to apply, and motor carriers can seek regulatory relief if necessary. Carriers therefore may deploy ADS-equipped CMVs in interstate commerce, using existing administrative processes.

In adapting its regulations to accommodate automated vehicle technologies, FMCSA will seek to make targeted rule changes and interpretations, and will supplement its rules as needed to account for significant differences between human operators and computer operators. FMCSA is soliciting feedback through various mechanisms to understand which parts of the current FMCSRs present barriers to advancing ADS technology. FMCSA plans to update regulations to better accommodate ADS technology with stakeholder feedback and priorities in mind. FMCSA will also consider whether there is a reasonable basis to adapt its CDL regulations for an environment in which the qualified commercial driver may be an ADS.

Finally, FMCSA recognizes emerging concerns and uncertainty around potential impacts of ADS on the existing workforce. U.S. DOT is working with the Department of Labor to assess the impact of ADS on the workforce, including the ability of ADS to mitigate the current driver

Workforce and Labor

Automated vehicles could have implications for the millions of Americans who perform driving-related jobs or work in related industries. There is a high level of uncertainty regarding how these impacts will evolve across job categories with differing levels of driving and non-driving responsibilities. Past experience with transportation technologies suggests that there will be new and sometimes unanticipated business and employment opportunities from automation. For example, the advent of widespread automobile ownership after World War II led not only to direct employment in vehicle manufacturing and servicing, but also to new markets for vehicle financing and insurance, and ultimately to larger shifts in American lifestyles that created a wave of demand for tourism, roadside services, and suburban homebuilding. Automation will create jobs in programming, cybersecurity, and other areas that will likely create demand for new skills and associated education and training. At the same time, the Department is also aware of the need to develop a transition strategy for manual driving-based occupations. U.S. DOT is working with other cabinet agencies on a comprehensive analysis of the employment and workforce impacts of automated vehicles. Individual operating administrations within the Department have also begun reaching out to stakeholders and sponsoring research on workforce issues affecting their respective modes of transportation.

Entities involved in developing and deploying automation technologies may want to consider how to assess potential workforce effects, future needs for new skills and capabilities, and how the workforce will transition into new roles over time. Identifying these workforce effects and training needs now will help lead to an American workforce that has the appropriate skills to support new technologies.

shortage in the motor carrier industry. The study will also look at longer-term needs for future workforce skills and at the demand for a transportation system that relies on ADS technology.

FHWA's Authorities Over Traffic Control Devices

U.S. DOT recognizes that the quality and uniformity of road markings, signage, and other traffic control devices support safe and efficient driving by both human drivers and automated vehicles.

As part of its role to support State and local governments in the design, construction, and maintenance of the Nation's roads, FHWA administers the Manual on Uniform Traffic Control Devices (MUTCD).[22] The MUTCD is recognized as the national standard for all traffic control devices installed on any street, highway, bikeway, or private road open to public travel. Traffic control devices generally refer to signs, signals, markings, and other devices used to regulate or guide traffic on a street, highway, and other facilities. FHWA, in partnership with key stakeholder associations and the practitioner community, is conducting research and device experimentation for overall improvements to the manual, and to better understand the specific needs of the emerging automated vehicle technologies. Incorporating existing interim approved devices, experimentations, and other identified proposed changes into the updated MUTCD will help humans and emerging automated vehicles to interpret the roadway. FHWA will use current research to supplement knowledge regarding different sensor and machine vision system capabilities relative to interpreting traffic control devices. **As part of this effort, FHWA will pursue an update to the 2009 MUTCD that will take into consideration these new technologies and other needs.**

22 23 CFR 655.603

FTA's Safety Authority Over Public Transportation

Safety issues are the highest priority for all providers of public transportation. In recent years, Congress has granted FTA significant new safety authorities that have expanded the Agency's role as a safety oversight regulatory body.[23] Consequently, FTA developed and published a National Public Transportation Safety Plan (NSP).[24] The NSP functions as FTA's strategic plan and primary guidance document for improving transit safety performance; a policy document and communications tool; and a repository of standards, guidance, best practices, tools, technical assistance, and other resources.

23 49 U.S.C. § 5329
24 Federal Transit Administration, National Public Transportation Safety Plan (Washington: Federal Transit Administration, 2007), www.transit.dot.gov/regulations-and-guidance/safety/national-public-transportation-safety-plan.

A key foundational component of FTA's safety authority is the new Public Transportation Agency Safety Plan (PTASP) rule.[25] The PTASP rule, which FTA issued on July 18, 2018, and which becomes effective on July 19, 2019, is applicable to transit agencies that operate rail fixed-guideway and/or bus services. Transit agencies must develop, certify, and implement an agency safety plan by July 20, 2020. The PTASP rule requires transit agencies to incorporate Safety Management System (SMS) policies and procedures as they develop their individual safety plans. The PTASP rule sets scalable and flexible requirements for public transportation agencies by requiring them to establish appropriate safety objectives; to identify safety risks and hazards and to develop plans to mitigate those risks; to develop and implement a process to monitor and measure their safety performance; and to engage in safety promotion through training and communication. An overview of the PTASP is available here: https://www.transit.dot.gov/PTASP.

This new PTASP rule provides a flexible approach to evaluating the safety impacts of automated buses. **FTA recognizes that operating domains and vehicle types and capabilities differ significantly. That is why FTA is not proposing a one-size-fits-all approach**

25 49 C.F.R. Part 673

Disability, Accessibility, and Universal Design

Automation presents enormous potential for improving the mobility of travelers with disabilities. Through the Accessible Transportation Technologies Research Initiative (ATTRI), the Department is initiating efforts to partner with the U.S. Department of Labor (DOL), U.S. Department of Health and Human Services (HHS), and the broader disability community to focus research efforts and initiatives on areas where market incentives may otherwise lead to underinvestment.

ATTRI focuses on emerging research, prototyping, and integrated demonstrations with the goal of enabling people to travel independently and conveniently, regardless of their individual abilities. ATTRI research focuses on removing barriers to transportation for people with disabilities, veterans with disabilities, and older adults, with particular attention to those with mobility, cognitive, vision, and hearing disabilities. By leveraging principles of universal design and inclusive information and communication technology, these efforts are targeting solutions that could be transformative for independent mobility.

ATTRI applications in development include wayfinding and navigation, pre-trip concierge and virtualization, safe intersection crossing, and robotics and automation. Automated vehicles and robotics are expected to improve mobility for those unable or unwilling to drive and enhance independent and spontaneous travel capabilities for travelers with disabilities. One area of particular interest among public transit agencies is exploring the use of vehicle automation to solve first mile/last mile mobility issues, possibly providing connections for all travelers to existing public transportation or other transportation hubs.

In addition, machine vision, artificial intelligence (AI), assistive robots, and facial recognition software solving a variety of travel-related issues for persons with disabilities in vehicles, devices, and terminals, are also included to create virtual caregivers/concierge services and other such applications to guide travelers and assist in decision making.

or providing a paper checklist for safety certification. Rather, FTA will provide transit agencies with tailored technical assistance as they develop an appropriate SMS approach to ensuring safe testing and deployment of its automated transit bus system.

FTA recognizes the benefits that automated transit bus operations may introduce, but also new types of risks, ranging from technology limitations, hardware failures, and cybersecurity breaches, to subtler human factors issues, such as overreliance on technology and degradation of skills. FTA's transit bus automation research program is outlined in the five-year Strategic Transit Automation Research (STAR) Plan.[26] FTA aims to advance transit readiness for automation by conducting enabling research to achieve safe and effective transit automation deployments, demonstrating market-ready technologies in real-world settings, and transferring knowledge to the transit stakeholder community, among other objectives.

The Federal Role in Automation Research

U.S. DOT has a limited and specific role in conducting research related to the integration of automation into the Nation's surface transportation system. U.S. DOT's research focuses on three key areas:

Removing barriers to innovation. U.S. DOT identifies and develops strategies to remove unnecessary barriers to innovation, particularly barriers stemming from existing regulations. In order to identify and evaluate solutions, U.S. DOT employs research to establish safety baselines; supports cost-benefit analysis for rulemaking; develops and implements processes to make the government more agile (e.g., updates to exemption and waiver processes to support the testing and deployment of novel technologies); and supports the development of voluntary standards that can enable the safe integration of automation.

Evaluating impacts of technology, particularly with regard to safety. U.S. DOT develops and verifies estimates of the impacts of automation on safety, infrastructure conditions and performance, mobility, and the economic competitiveness of the United States. The Department employs a variety of methods including simulation, modeling, and field and on-road testing. The Department also develops innovative methodologies to support the broader transportation community in estimating and evaluating impacts.

Addressing market failures and other compelling public needs. Public investments in research are often warranted to support the development of potentially beneficial technologies that are not easily commercialized because the returns are either uncertain, distant, or difficult to capture. This can include research that responds to safety, congestion, cybersecurity, or asymmetric information (e.g., public disclosures), or where a lack of private sector investment may create distributional issues that disadvantage particular groups (e.g., access for individuals with disabilities).

Across the areas outlined above, U.S. DOT collaborates with partners in the public and private sectors and academia, shares information with the public on research insights and findings, and identifies gaps in public and private sector research.

U.S. DOT Role in Key Cross-Cutting Policy Issues

Cooperative Automation and Connectivity

Connectivity enables communication among vehicles, the infrastructure, and other road users. Communication both between vehicles (V2V) and with the surrounding environment (V2X) is an important complementary technology that is expected to enhance the benefits of automation at all levels, but should not be and realistically cannot be a precondition to the deployment of automated vehicles.

26 Federal Transit Administration, Strategic Transit Automation Research Plan, Report No. 0116 (Washington: Federal Transit Administration, 2018), www.transit.dot.gov/research-innovation/strategic-transit-automation-research-plan.

Automation to Support Intermodal Port Facility Operations

Automation has the potential to transform the Nation's freight transportation system, a vital asset that supports every sector of the economy. Intermodal port facilities could benefit from applications of automation, enabling more seamless transfers of goods and a less strenuous experience for operators. The Maritime Administration (MARAD) and FMCSA are jointly exploring how SAE Level 4 truck automation might improve operations at intermodal port facilities. Currently at many of the Nation's busiest ports, commercial vehicle drivers must wait in slow-moving queues for hours to pick up or deliver a load. MARAD and FMCSA are evaluating how automation might relieve the burden on a driver under these circumstances, and, in particular, the regulatory and economic feasibility of using automated truck queueing as a technology solution to truck staging, access, and parking issues at ports. The study will investigate whether full or partial automation of queuing within ports could lead to increased productivity by altering the responsibilities and physical presence of drivers, potentially allowing them to be off-duty during the loading and unloading process.

Throughout the Nation there are over 70 active deployments of V2X communications utilizing the 5.9 GHz band. U.S. DOT currently estimates that by the end of 2018, over 18,000 vehicles will be deployed with aftermarket V2X communications devices and over 1,000 infrastructure V2X devices will be installed at the roadside. Furthermore, all seven channels in the 5.9 GHz band are actively utilized in these deployments.

In addition to the Dedicated Short-Range Communication (DSRC)-based deployments, private sector companies are already researching and testing Cellular-V2X technology that would also utilize the 5.9 GHz spectrum.

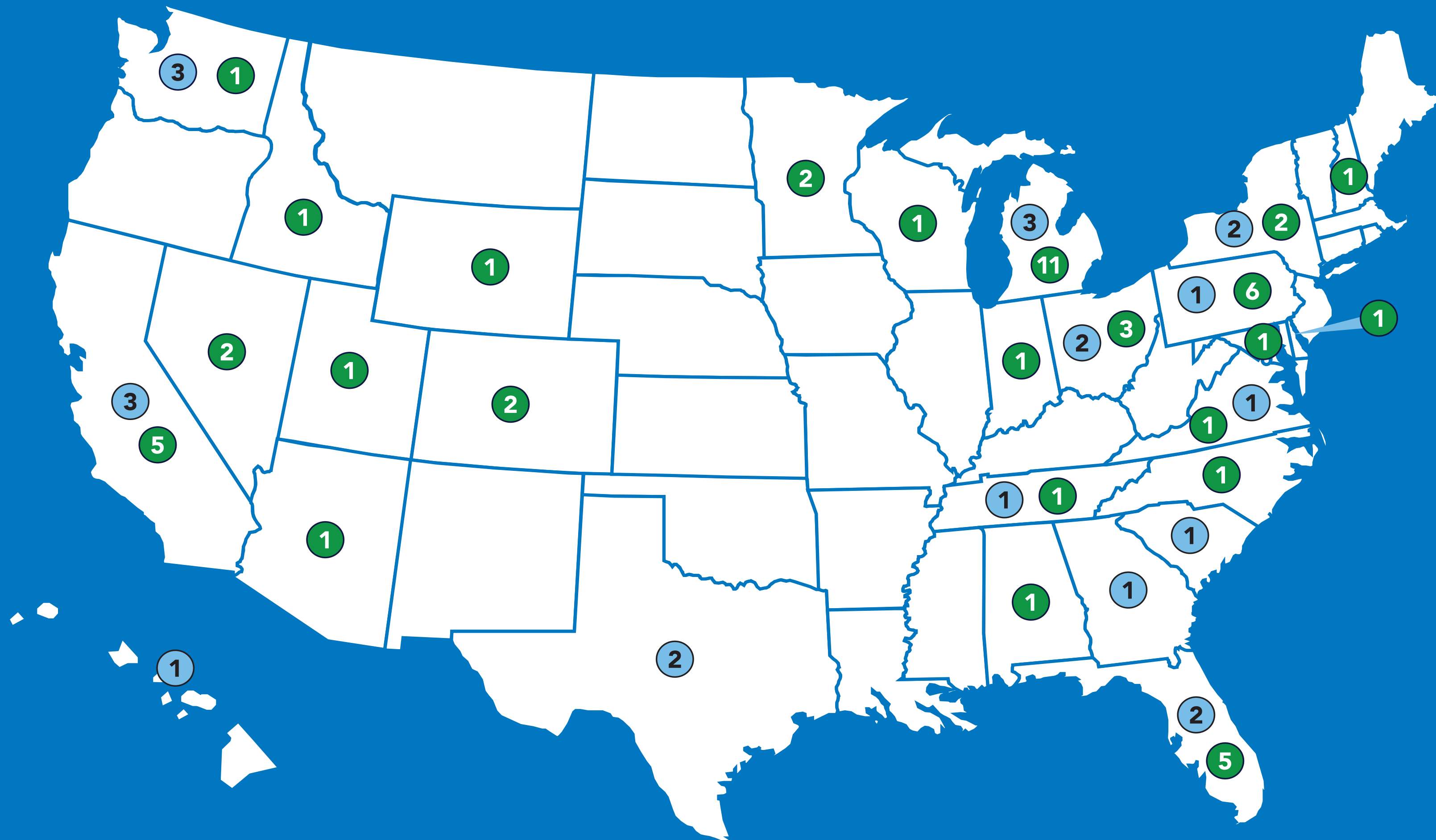
An effort led by State and local public-sector transportation infrastructure owner operators is the Signal Phase and Timing (SPaT) Challenge.[27] This initiative has plans to deploy a V2X communications infrastructure with SPaT broadcasts in at least one corridor in each of the 50 States by January 2020. Over 200 infrastructure communications devices are already deployed with over 2,100 planned by 2020 under this initiative in 26 States and 45 cities with a total investment of over $38 million. The SPaT message is designed to enhance both safety and efficiency of traffic movements at intersections.

Also underway are the U.S. DOT-funded deployment programs such as the Ann Arbor

27 https://transportationops.org/spatchallenge

Planned and Operational Connected Vehicle Deployments

Where Infrastructure and In-Vehicle Units are Planned or In Use



Planned Projects
Operational Projects
Source: USDOT September 2018

	Infrastructure Units	In-Vehicle Units
Operational (52 Projects)*	2,044	3,340
Planned (23 projects)*, **	242	0
Total	**2,286**	**3,340**

* Projects shown include those sponsored by U.S. DOT and others.
** Device numbers for many of the planned projects are currently unavailable.

Cooperative Automation

FHWA is conducting research to measure the efficiency and safety benefits of augmenting automated vehicle capabilities with connected vehicle technologies to enable cooperative automation. Cooperative automation allows automated vehicles to communicate with other vehicles and the infrastructure to coordinate movements and increase efficiency and safety. It uses a range of automation capabilities, including automation technologies at SAE Level 1 and Level 2. Examples of cooperative automation applications include:

- Vehicle platooning to enable safe close following between vehicles and improve highway capacity.
- Speed harmonization using wireless speed control to reduce bottleneck conditions.
- Cooperative lane change and merge functions to mitigate traffic disruptions at interchanges.
- Coordination of signalized intersection approach and departure, using Signal Phase and Timing (SPaT) data to enable automated vehicles to enter and exit signalized intersections safely and efficiently, to mitigate delays and reduce fuel consumption.

Current activities focus on technical assessments, traffic modeling, and proof-of-concept/prototype tests to understand how to improve safety, smooth traffic flow, and reduce fuel consumption. FHWA is partnering with automotive manufacturers to further develop these concepts and is conducting modeling and analysis of corridors in several States. FHWA may pursue further proof-of-concept testing on test tracks and on public roads in the future. Additionally, studies are underway to consider how early automation applications like lane keeping and adaptive cruise control are being used and accepted by everyday drivers.

Connected Vehicle Environment, Connected Vehicle Pilots Program, and the Advanced Transportation and Congestion Management Technologies Deployment Program, which have combined over $150 million in Federal and State funding to deploy V2X communications. Finally, states such as Colorado are combining Federal-aid highway program funding with State funding ($72 million) to deploy V2X communications throughout the State highways by 2021.[28]

Over the past 20 years, the U.S. DOT has invested over $700 million in research and development of V2X through partnerships with industry and state/local governments. As a result of these investments and partnerships, V2X technology is on the verge of wide-scale deployment across the Nation.

The Department encourages the automotive industry, wireless technology companies, IOOs, and other stakeholders to continue developing technologies that leverage the 5.9 GHz spectrum for transportation safety benefits. Yet, the Department does not promote any particular technology over another. The Department also encourages the development of connected infrastructure because such technologies offer the potential to improve safety and efficiency. As IOOs consider enabling V2X deployment in their region, the Department encourages IOOs to engage with the U.S. DOT for guidance and assistance.

As part of this approach, U.S. DOT is continuing its work to preserve the ability for transportation safety applications to function in the 5.9 GHz spectrum while exploring methods for sharing the spectrum with other users in a manner

28 https://www.codot.gov/about/transportation-commission/documents/2018-agendas-and-supporting-documents/june-2018/7-tech-committee.pdf

that maintains priority use for vehicle safety communications. A three-phase test plan was collaboratively developed with the Federal Communications Commission (FCC) and the U.S. Department of Commerce, and the FCC has completed[29] the first phase. Phases 2 and 3 of the spectrum sharing test plan will explore potential sharing solutions under these more real-world conditions.

Pilot Testing and Proving Grounds

U.S. DOT supports and encourages the testing and development of automation technologies throughout the country with as few barriers as needed for safety. ADS developers are already testing automated vehicle technologies at test tracks, on campuses, and on public roadways across the United States. Pilots on public roads provide an opportunity to assess roadway infrastructure, operational elements, user acceptance, travel patterns, and more.

The Department appreciates that there are significant automated vehicle research and testing activities occurring in many States and locations across the country, and there is considerable private investment in these efforts. The Department does not intend to pick winners and losers or to favor particular automated vehicle proving grounds over others. **Therefore, the Department no longer recognizes the designations of ten "Automated Vehicle Proving Grounds" as announced on January 19, 2017.** The Department has taken no actions to direct any Federal benefits or support to those ten locations on the basis of these designations, and these designations will have no effect—positive or negative—going forward on any decisions the Department may make regarding Federal support or recognition of research, pilot or demonstration projects, or other developmental activities related to automated vehicle technologies.

Instead, if and when the Department is called upon to provide support or recognition of any kind with regard to automated vehicle proving grounds, the Department intends to apply neutral, objective criteria and to consider all locations in all States where relevant research and testing activities are actually underway.

Cybersecurity

Transportation systems are increasingly complex, with a growing number of advanced, integrated functions. Transportation systems are also more reliant than ever on multiple paths of connectivity to communicate and exchange data, and they depend on commodity technologies to achieve functional, cost, and marketing objectives.

Surface transportation is a broad sector of the economy and requires coordination across all levels of government and the private sector in the event of a significant cyber incident to enable shared situational awareness and allow for a unified approach to sector engagement. U.S. DOT will work closely with the U.S. Department of Justice; the U.S. Department of Commerce and its National Institute of Standards and Technology (NIST); the Federal Trade Commission; the Federal Communications Commission; the U.S. Department of Homeland Security (DHS); industry subject matter experts; and other public agencies to address cyber vulnerabilities and manage cyber risks related to automation technology and data.

Transportation-related cyber vulnerabilities and exploits can be shared with Government partners anonymously through various Information Sharing and Analysis Centers (ISACs). **DHS's National Cybersecurity and Communications Integration Center (NCCIC) is a 24x7 cyber situational awareness, incident response, and management center that is a national nexus of cyber and communications integration for the Federal Government, intelligence community, and law enforcement.**

If a transportation sector entity deems Federal assistance may be warranted, they are encouraged to contact NCCIC[30] and the relevant

29 Letter to Congress proposing the test plan: https://apps.fcc.gov/edocs_public/attachmatch/DOC-337251A1.pdf
FCC Phase 1 test plan: https://transition.fcc.gov/oet/fcclab/DSRC-Test-Plan-10-05-2016.pdf

30 https://ics-cert.us-cert.gov/Report-Incident

ISACs (e.g., Auto-ISAC,[31] Aviation ISAC,[32] Maritime ISAC,[33] and Surface Transportation ISAC[34]).

Privacy

While advanced safety technologies have the potential to provide enormous safety, convenience, and other important benefits to consumers, stakeholders frequently raise data privacy concerns as a potential impediment to deployment. U.S. DOT takes consumer privacy seriously, diligently considers the privacy implications of our safety regulations and voluntary guidance, and works closely with the Federal Trade Commission (FTC)—the primary Federal agency charged with protecting consumers' privacy and personal information—to support the protection of consumer information and provide resources relating to consumer privacy. The Department suggests that any exchanges of data respect consumer privacy and proprietary and confidential business information. Additional information is available here: https://www.ftc.gov/news-events/media-resources/protecting-consumer-privacy.

31 https://www.automotiveisac.com/
32 https://www.a-isac.com/
33 http://www.maritimesecurity.org/
34 https://www.surfacetransportationisac.org/

State, Local, and Tribal Governments and Automation

State, local, and Tribal governments hold clearly defined roles in ensuring the safety and mobility of road users in their jurisdictions. They are responsible for licensing human drivers, registering motor vehicles, enacting and enforcing traffic laws, conducting safety inspections, and regulating motor vehicle insurance and liability. They are also responsible for planning, building, managing, and operating transit and the roadway infrastructure. Many of those roles may not change significantly with the deployment of automated vehicles.

There are many ways these governments can prepare for automated vehicles:

- Review laws and regulations that may create barriers to testing and deploying automated vehicles.
- Adapt policies and procedures, such as licensing and registration, to account for automated vehicles.
- Assess infrastructure elements, such as road markings and signage, so that they are conducive to the operation of automated vehicles.
- Provide guidance, information, and training to prepare the transportation workforce and the general public.

This section provides best practices and considerations for State, local and Tribal government officials as they engage with new transportation technologies.

Best Practices for State Legislatures and State Highway Safety Officials

A Vision for Safety 2.0 provided best practices for both State legislatures and State highway safety officials. In reviewing recent State legislation and executive orders, and in engaging with stakeholders, U.S. DOT identified new insights, commonalities, and elements that States should consider including when developing legislation. Additional best practices for State highway safety officials are also discussed in this section. The best practices provided here are not intended to replace recommendations made in *A Vision for Safety 2.0*, but rather are meant to supplement them. For more information, refer to www.transportation.gov/av.

Automated Vehicles at Rail Crossings

To explore the interaction between automated vehicles and highway-rail grade crossings and identify what information automated vehicles will need in order to negotiate highway-rail intersections, the Federal Railroad Administration (FRA) has conducted a literature review, engaged with stakeholders, and used scenarios to develop and demonstrate a concept of operations, including system requirements (technology and sensors).

A broad stakeholder set was identified to represent researchers, manufacturers, transit agencies, and infrastructure owner-operators, among others. Currently, FRA is expanding the research with U.S. DOT partners and the Association of American Railroads to develop a closed loop safety system to support the safe interaction of connected and automated vehicles with grade crossings.

Best Practices for State Legislatures

States are taking differing legislative approaches and have enacted varying laws related to testing and operating automated vehicles. U.S. DOT regularly monitors legislative activities in order to support the development of a consistent national framework for automated vehicle legislation.

A Vision for Safety 2.0 recommended that State legislators follow best practices, such as providing a technology-neutral environment, licensing and registration procedures, and reporting and communications methods for public safety officials. States should consider reviewing and potentially modifying traffic laws and regulations that may be barriers to automated vehicles. For example, several States have following distance laws that prohibit trucks from following too closely to each other, effectively prohibiting automated truck platooning applications.

In addition to the best practices identified in *A Vision for Safety 2.0*, the Department recommends that State officials consider the following safety-related best practices when crafting automated vehicle legislation:

Engage U.S. DOT on legislative technical assistance. State legislatures are encouraged to routinely engage U.S. DOT on legislative activities related to multimodal automation safety. State legislatures may want to first determine if there is a need for State legislation. Unnecessary or overly prescriptive **State requirements could create unintended barriers for the testing, deployment, and operations of advanced vehicle safety technologies.** U.S. DOT stands ready to provide technical assistance to States on request.

Adopt terminology defined through voluntary technical standards. Different use and interpretations of terminology regarding automated vehicles can be confusing for the public, State and local agencies, and industry. In the interest of supporting consistent terminology, State legislatures may want to use terminology already being developed through voluntary, consensus-based, technical standards. SAE terminology on automation represents one example and includes terms such as ADS, the Dynamic Driving Task (DDT), minimal risk conditions, and ODD.

Assess State roadway readiness. States may want to assess roadway readiness for automated vehicles, as such assessments could help infrastructure for automated vehicles, while improving safety for drivers today. Automated vehicle developers are designing their technologies with the assumption that these technologies will need to function with existing infrastructure. There is general agreement that greater uniformity and quality of road markings, signage, and pavement condition would be beneficial for both human drivers and automated vehicles.

Best Practices for State Highway Safety Officials

States are responsible for reducing traffic crashes and resulting deaths, injuries, and property damage for all road users in their jurisdictions. States use this authority to establish and maintain highway safety programs addressing driver education and testing, licensing, pedestrian safety, and vehicle registration and inspection. States also use this authority to address traffic control, highway design and maintenance, crash prevention, investigation and recordkeeping, and law enforcement and emergency service considerations.

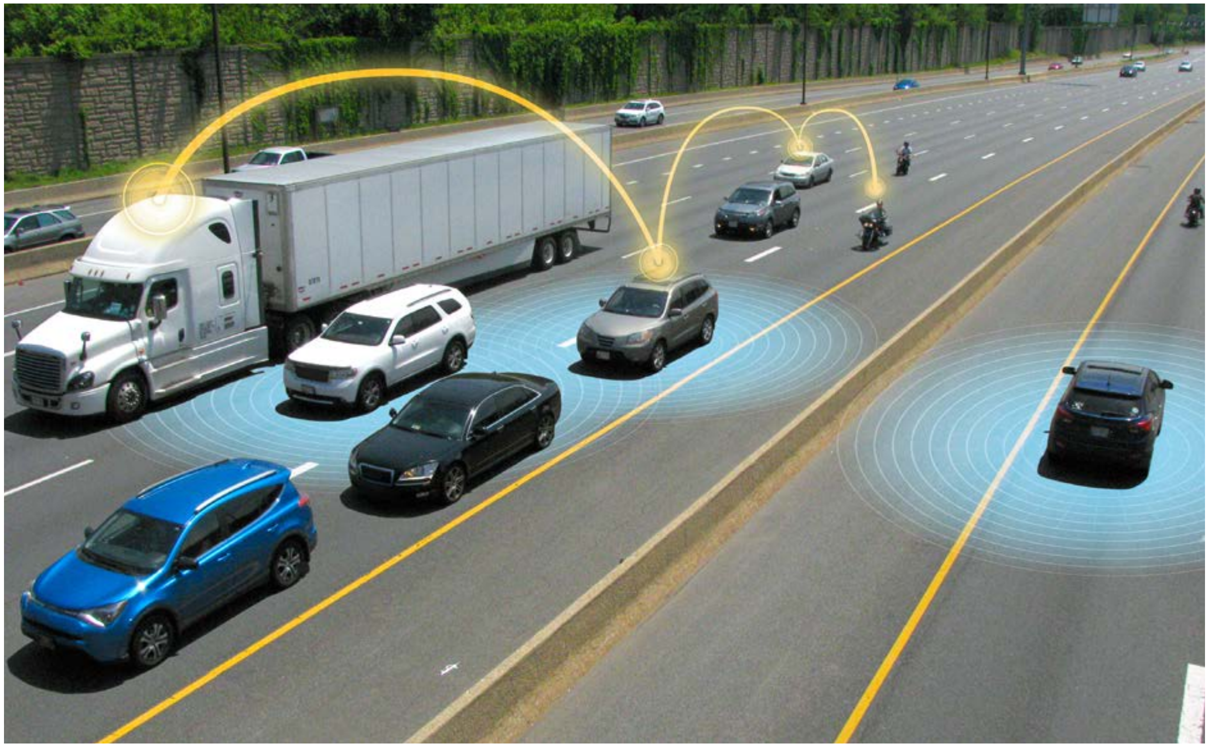
The following best practices build on those identified in *A Vision for Safety 2.0* and provide a framework for States looking for assistance in developing procedures and conditions for the operation of automated vehicles on public roadways. For additional best practices, see Section 2 of *A Vision for Safety 2.0*.

Consider test driver training and licensing procedures for test vehicles. States may consider minimum requirements for test drivers who operate test vehicles at different automation levels. States may want to coordinate and collaborate with a broad and diverse set of stakeholders when developing and defining jurisdictional guidelines for safe testing and deployment of automated vehicles.

Recognize issues unique to entities offering automated mobility as a service. Automated mobility providers are exploring models to move people and goods using automated vehicle technology. States may consider identifying and addressing issues that are unique to companies providing mobility as a service using automated vehicle technologies. These could include such issues as congestion or the transportation of minors, persons with disabilities, and older individuals.

Considerations for Infrastructure Owners and Operators

Infrastructure owners and operators are involved in the planning, design, construction, maintenance, and operation of the roadway infrastructure. Infrastructure owners and operators have expressed interest in more information and guidance on how to prepare for automated vehicle deployment and testing on public roadways. FHWA is conducting the National Dialogue on Highway Automation, a series of workshops with partners, stakeholders, and the public to obtain input regarding the safe



and efficient integration of automated vehicles into the roadway system.[35] U.S. DOT provides the following considerations for infrastructure owners and operators, including State DOTs, metropolitan planning organizations (MPOs), and local agencies. FHWA, in particular, will continue to update these considerations as informed by continued research efforts, stakeholder engagement, and testing. Suggested considerations include:

35 More information can be found at https://ops.fhwa.dot.gov/automationdialogue/

Support safe testing and operations of automated vehicles on public roadways. State DOTs and local agencies want to understand under what conditions automated vehicles can safely operate in automated mode and how they will affect the highway infrastructure and surrounding communities. Where testing is taking place, State and local agencies should consider ways to establish consistent cross-jurisdictional approaches and work with first responders to develop commonly understood traffic law enforcement practices and emergency response plans for automated vehicle testing and operation.

Learn from testing and pilots to support highway system readiness. State and local agencies may consider collaborating with automated vehicle developers and testers to identify potential infrastructure requirements that support readiness for automated vehicles and to understand their expectations for automated vehicle operations under varying roadway and operational conditions. This interaction could assist with identifying what balance of capabilities (for both vehicles and the roadway) promotes safe and efficient operations of automated vehicles. Testing, research, and pilot programs can help State and local agencies understand automation and identify opportunities to inform transportation planning, infrastructure design, and traffic operations management.

Build organizational capacity to prepare for automated vehicles in communities. State and local agencies may need to assess their workforce capacity and training needs to address new issues that emerge from having automated vehicles on public roads. State and local agencies will want to work with peers, industry, associations, the research community, and FHWA to build knowledge of automated vehicle technologies and identify technical assistance resources.

Identify data needs and opportunities to exchange data. The exchange of data and information in the roadway environment can help automated vehicles address static and dynamic elements that otherwise may be challenging for ADS (e.g., work zones, rail crossings, managed lanes, and varying traffic laws). State and local agencies and industry may work together to identify data elements that will help automated vehicles navigate challenging, unique roadway environments and alter operational behavior in relation to changing traffic laws.

Collaborate with stakeholders to review the existing Uniform Vehicle Code (UVC). Each State creates its own laws governing traffic codes, and many municipalities enact ordinances as allowed in the State. The UVC is a model set of traffic laws developed years ago by stakeholders that States can consult when considering legislation. **FHWA suggests working with automated vehicle developers, traffic engineers, and law enforcement stakeholders to revise the UVC to be consistent with automated vehicle operations.**

Support scenario development and transportation planning for automation. There is uncertainty around how automation will change travel behavior, land use, and public revenues across the transportation landscape in the long term. State and local policymakers must wrestle with the effects of automation when conducting long-term transportation planning. Scenario planning tools allow States and MPOs to review multiple scenarios for how automation technologies could be adopted and used, and analyze issues including infrastructure investment, congestion, operations, and other transportation needs.[36] To assist in this process, FHWA is supporting scenario development for State and local agencies to use for incorporating automation into transportation planning processes.

Considerations for State Commercial Vehicle Enforcement Agencies

U.S. DOT recommends that State agencies responsible for enforcing commercial vehicle operating rules and regulations consider the following as ADS-equipped commercial motor vehicles are tested and operated on public roads:

Compatibility between intrastate and interstate commercial motor vehicle regulations. State enforcement agencies should monitor prevailing regulatory activity, including regulatory guidance by FMCSA—including a forthcoming Advance Notice of Proposed Rulemaking (ANPRM)—and consider whether amendments of their intrastate motor carrier safety regulations are needed in order to be compatible with the Federal requirements concerning the operation of ADS-equipped commercial motor vehicles. **Ensuring compatibility between intrastate and interstate commercial vehicle regulations is important for maintaining eligibility for grant funding under the Motor Carrier Safety Assistance Program (MCSAP).**

36 For more information on scenario planning, see https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/

Continued application of roadside inspection procedures. State enforcement agencies should continue to apply existing inspection selection procedures to identify which CMVs should be examined during a roadside inspection. State enforcement agencies should refrain from selecting ADS-equipped CMVs solely because the vehicle is equipped with advanced technology. States can partner with FMCSA as it develops appropriate roadside inspection procedures and inspection criteria for use in examining ADS-equipped CMVs, so that the movement of such vehicles is not delayed unless there are problems that are likely to adversely impact safety.

Considerations for Public Sector Transit Industry and Stakeholders

U.S. DOT offers the following for consideration by public sector transit industry stakeholders (e.g., transit agencies) when developing, demonstrating, deploying, and evaluating transit bus automation:

Needs-based implementation. Transit agencies should consider automation as a means of addressing specific needs and solving particular problems. Implementation of new technologies and service models should not be based merely on novelty. Agencies should obtain input from stakeholders to determine unmet needs and identify potential solutions that might be addressed through automation. Ongoing dialogue with community residents, original equipment manufacturers (OEMs), technology developers, integrators, and industry associations will help identify the most appropriate transit bus automation technology solutions for their communities.

Realistic expectations. Public transportation operators should establish realistic expectations when implementing transit bus automation projects and demonstrations. As an example, transit agencies engaged in pilots to retrofit vehicles with advanced driver assistance capabilities, such as pedestrian avoidance and automatic emergency braking, might find that implementation may take longer than expected for a variety of reasons. Integration, test planning, contracting, and data management can present significant challenges that cause delay. Another example may be where transit providers are conducting pilots of low-speed automated vehicles or shared automated vehicles. Although these service approaches could potentially address first-mile/last-mile needs, agencies may find that the vehicles themselves currently have technological limitations such as lower speeds and passenger capacity constraints.

Workforce and labor. An important consideration for public transportation operators is to begin preparing for workforce changes that may accompany an automated bus fleet. The transit workforce will require new, high-tech skills for inspecting and maintaining automated transit buses at all levels of automation. The transit industry should begin thinking about retraining the current workforce to help transit operators transition into new roles and to adapt to a transforming surface transportation industry. **Transit agencies should recognize emerging workforce needs and requirements, identify new future career paths, and conduct succession planning in this new, high-technology environment.** Transit agencies can work with FTA, industry associations, and private sector consultants to identify core training needs; academic institutions may be able to assist in implementing training.

Complete Streets. Transit agencies should seek out and work with local partners to review complete streets policies and practices when planning and deploying transit automation. Early consideration of complete streets will help make automation-enhanced mobility safer, more convenient, and more reliable for all travelers, while reducing the overall cost of widespread deployment. Transit agencies, MPOs, and local governments may seek assistance from industry associations, private sector consultants, and automation technology developers to create and implement complete streets concepts.[37]

Accessibility. It is critical that all agencies considering automated transit vehicles in revenue service ensure accessibility for persons with disabilities. Although some users will likely continue to require the human assistance that existing paratransit service provides, automation has the potential to offer improved levels of service for persons with disabilities. Transit agencies must ensure that infrastructure, such as stations and stops, is accessible and Americans with Disabilities Act (ADA)-compliant. Transit agencies should continue to partner with local governments as appropriate to create and maintain an accessible environment for all travelers. Transit agencies may work with industry associations, private sector consultants, and technology developers for new accessibility tools and solutions such as those in the U.S. DOT's ATTRI. FTA can provide guidance and clarification regarding ADA requirements.

Engagement and education. To fully realize the benefits of automated transit vehicles, transit operators, riders, and other road users

37 Complete Streets are streets designed and operated to enable safe use and support mobility for all users. Those include people of all ages and abilities, regardless of whether they are traveling as drivers, pedestrians, bicyclists, or public transportation riders.

must understand and be wholly comfortable with the technology. Transit agencies seeking to test and pilot automated transit vehicles may wish to develop appropriate messaging as well as public engagement and education activities to promote awareness, understanding, and acceptance of automated transit buses. Public-facing technology demonstrations can create opportunities for members of the public to experience and learn about new technologies. Other knowledge transfer and stakeholder engagement activities can help align demonstrations and pilots with local needs and increase local stakeholder confidence and buy-in.

Considerations for Local Governments

Local governments control a substantial part of the Nation's roadway and parking infrastructure, and have considerable influence over land use, via zoning and permitting. Local governments are closest to citizens. Automation provides an opportunity to address local goals, including making more land available for housing and business, as well as improving transportation options for citizens who are not motorists. U.S. DOT suggests that local governments may wish to consider the following topics as they formulate local policies.

Facilitate safe testing and operation of automated vehicles on local streets. Local streets, with their variety of uses, offer a challenging environment for automated vehicles. As owner-operators of this infrastructure, local governments have an opportunity to partner with automated vehicle suppliers to test on their streets, learn from testing, and be prepared to enable safe deployment.

Understand the near-term opportunities that automation may provide. In the near term, automation provides increased driver assistance capabilities—such as automatic emergency braking and pedestrian detection—which may be useful for municipal fleets. Several low-speed passenger shuttle tests are also underway. Local governments should be aware of these efforts and the opportunities that they may provide, while being realistic about their limitations.

Consider how land use, including curb space, will be affected. A shared vehicle environment in which automated vehicles are used by a number of travelers over the course of a day could result in a significant reduction in private vehicle ownership, leading to less need for on- and off-street parking. At the same time, such an environment will require curb space for pick-up and drop-off activities. There may be an opportunity to reallocate curb space from long-term parking to other uses, including pick-up and drop-off. Furthermore, if vehicle ownership declines, minimum parking requirements in zoning may need to be revisited, freeing up land for other purposes. Finally, in such an environment, revenue from parking fees and fines may be reduced.

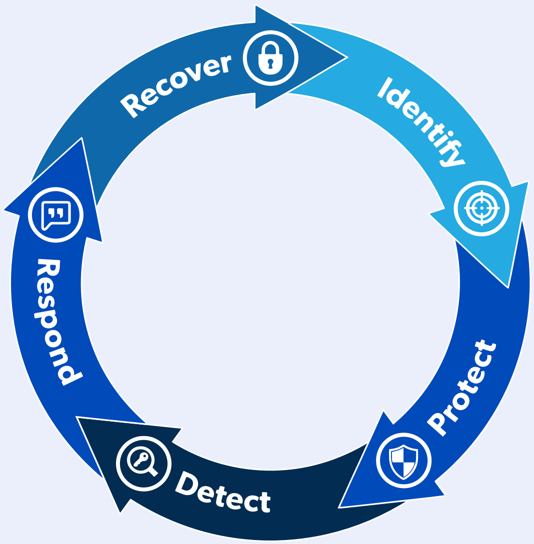
Consider the potential for increased congestion, and how it might be managed. If automation provides a convenient, low-cost option for single occupant vehicle trips, it may lead to more congestion. For example, some current transit users may shift to lower-occupancy automated vehicles. Automated vehicles may engage in zero-occupant vehicle trips, for vehicle repositioning. Automation will also provide new mobility options for people who do not travel much today. Local and State governments may need to consider appropriate policies to manage the potential for increased congestion.

Engage with citizens. Local governments are in an ideal position to engage with citizens, to address their concerns and to ensure that automation supports local needs. Such engagement may include public events associated with automated vehicle testing, educational forums, and consideration of automation in public planning and visioning meetings.

State, Local, and Tribal Roles in Transportation Sector Cybersecurity

State, local, and Tribal governments face unique cybersecurity threats that can endanger

NIST Cybersecurity Framework



See www.nist.gov/cyberframework

critical infrastructure. Transportation systems that depend on digital infrastructure are at risk when they do not prioritize maintaining security, modernizing systems to reduce vulnerabilities, and implementing enhancements to increase the resiliency of digital infrastructure. Significant service degradation has occurred when technology, people, and processes failed to prevent security failures; including data encrypting ransomware, other malware, and insider-threat activities. To mitigate potential threats, appropriate investments in the digital infrastructure that supports ADS should include strong security and functional testing of the technology, people, and processes. As threats evolve, key decision makers should have an effective and flexible security program in place to assess and manage risk, including evaluating technology, key facilities, engaged personnel, and security processes. Plans to respond to cyber-attacks should be exercised, and should be aligned with emergency management and recovery protocols shared across all industry sectors.

State, local, and Tribal governments play an important role in managing cyber risks by investing in improvements to cyber defenses and infrastructure. Those governments also identify, prioritize, and allocate resources to counteract cybersecurity threats, especially where a threat may affect transportation critical infrastructure. U.S. DOT encourages States, local, Tribal, and Territorial governments to fully utilize the resources provided by United States Computer Emergency Readiness Team (US-CERT).[38]

38 See: https://www.us-cert.gov/ccubedvp/sltt

Local governments are in an ideal position to engage with citizens, to address their concerns and to ensure that automation supports local needs.

The Private Sector and Automation

While the initial development of automated vehicle technologies received strong support from government-funded research projects, such as the Defense Advanced Research Projects Agency (DARPA),[39] over the past decade private sector innovators have taken the lead in developing and commercializing automation technologies. Today, private sector leadership is critical to advancing the development, testing, and commercialization of automated vehicles. U.S. DOT does not expect the private sector to be singularly responsible for addressing issues introduced alongside new technologies. The public sector—as planners, owners, and

39 See, for example: Defense Advanced Research Projects Agency, The DARPA Grand Challenge: Ten Years Later, (Arlington: Defense Advanced Research Projects Agency, 2014), https://www.darpa.mil/news-events/2014-03-13.

operators of transportation infrastructure, regulators and enforcers of transportation safety, and representatives of public concerns—must play a critical, complementary role in engaging automation technologies to improve safety and meet the public interest without hampering innovation.

In addition to developing and commercializing automation technology, the private sector also should play a critical role in promoting consumer acceptance in two distinct ways. First, companies developing and deploying automation technology need to be transparent about vehicle safety performance. Second, companies should engage with consumers through public education campaigns.

The exchange of information between the public and private sector is also critical for helping policymakers understand the capabilities and limitations of these new technologies, while ensuring that the private sector understands the priorities of policymakers and the issues they face. **Only by working in partnership can the public and the private sector improve the safety, security, and accessibility of automation technologies, address the concerns of the general public, and prepare the workforce of tomorrow.**

The sections below outline several critical areas where the private sector's role will be significant.

Demonstrate Safety through Voluntary Safety Self-Assessments

Demonstrating the safety of ADS is critical for facilitating public acceptance and adoption. Entities involved in the development and testing of automation technology have an important role in not only the safety assurance of ADS-equipped vehicles, but also in providing transparency about how safety is being achieved.

A Vision for Safety 2.0 provided voluntary guidance to stakeholders regarding the design, testing, and safe deployment of ADS. It identified 12 safety elements that ADS developers should consider when developing and testing their technologies. *A Vision for Safety 2.0* also introduced the Voluntary Safety Self-Assessment (VSSA), which is intended to demonstrate to the public that entities are: considering the safety aspects of an ADS; communicating and collaborating with the U.S. DOT; encouraging the self-establishment of industry safety norms; and building public trust, acceptance, and confidence through transparent testing and deployment of ADS. Entities are encouraged to demonstrate how they address the safety elements contained in *A Vision for Safety 2.0* by publishing a VSSA, as it is an important tool for companies to showcase their approach to safety, without needing to reveal proprietary intellectual property.

VSSAs allow the public to see that designers, developers, and innovators are taking safety seriously and that safety considerations are built into the design and manufacture of vehicles that are tested on our roadways. **Therefore, U.S. DOT encourages entities to make their VSSA available publicly as a way to promote transparency and strengthen public confidence in ADS technologies.** The Department currently provides a template for one of the elements in a VSSA, which entities can use to construct their own VSSA.[40] NHTSA also established a website where entities who have disclosed and made the Agency aware of their VSSAs can be listed in one central location.[41] Entities developing ADS technology may want to consider making available their VSSAs through this website.

Incorporate New Safety Approaches for Automation in Commercial Vehicle Operations

U.S. DOT recommends that motor carrier owners and operators consider the following as they explore the adoption of advanced driver assistance features and ADS in their vehicle fleets. As automation technology evolves,

40 Available at: https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/voluntary_safety_self- assessment_for_web_101117_v1.pdf

41 Available at: https://www.nhtsa.gov/automated-driving-systems/voluntary-safety-self-assessment

Hazardous Materials Documentation

The Pipeline and Hazardous Materials Safety Administration (PHMSA) is exploring alternatives to longstanding requirements for providing paper documentation to accompany hazmat shipments, while ensuring that the information is readily available to transport workers and emergency responders. **This capability may become increasingly important as transporters of hazardous materials explore the use of automation in their operations.** As motor carriers and railroads explore the use of automation to move hazardous materials, the ability to create electronic documentation also raises the potential to electronically transmit information to first responders before they arrive at an incident. PHMSA is also collaborating with the Environmental Protection Agency on the development of an e-manifest system that will digitize the exchange of information on hazardous material shipments.

FMCSA and PHMSA plan to solicit stakeholder input and provide more detailed guidance regarding the use of ADS in commercial vehicle operations.

System knowledge. If a motor carrier of passengers or property plans to begin operating a commercial motor vehicle equipped with driver-assist systems and/or ADS, the motor carrier's personnel should understand the capabilities and limitations of these systems, as well as ODD limitations (e.g., the types of roadway environments or environmental conditions under which they can operate). The motor carrier should also ask the equipment's manufacturer about the capabilities and limitations of these systems. Motor carriers may also wish to inquire about whether the manufacturer has completed a voluntary safety self-assessment, as described in *A Vision for Safety 2.0*.

System functionality. Motor carriers should ensure the driver assist system and/or ADS is functioning properly before activating these systems. This functionality should be able to be validated during a roadside inspection.

System training. Motor carriers should implement a training program to familiarize fleet managers, maintenance personnel, and drivers with the equipment and how it operates, including the procedures to follow in the event of an ADS malfunction.

Equipment maintenance. Motor carriers should be aware of maintenance requirements of driver-assist systems and/or ADS to enable safe and optimal operation. This includes understanding self-diagnostic capabilities of the system and the status or error messages the system may display.

Information exchange. Motor carriers should be aware that under certain situations such as a safety inspection or roadway crash, it may be necessary to exchange critical safety-oriented vehicle performance data with Federal and State officials. The motor carrier should maintain records of the systems it is using, the training provided, and the operation of those vehicles.

Safety inspections. Motor carriers should be prepared to interact and cooperate with roadside and other safety inspections of driver assist systems and ADS. This includes responding to law enforcement instructions, resolving any identified mechanical or software malfunction, implementing the equipment's safe shutdown procedures, and demonstrating system functionality.

Develop Safe and Accessible Transit Buses and Applications: Considerations for Private Sector Transit Industry

U.S. DOT offers the following considerations for private sector transit industry stakeholders when developing, demonstrating, deploying, and evaluating transit bus automation:

Accessibility. It is important to think about how to make automated vehicles and their technological capabilities accessible to persons with disabilities (including those with physical, sensory, and cognitive impairments) early in

the design process. This vital element is more easily integrated at the initial stages of vehicle research and development, rather than trying to incorporate it into the design through retrofits, which may be more difficult. Bus OEMs, technology developers, and integrators should work with transit agencies, industry associations, and the disability community to obtain input on functional and performance needs as well as the consequent human factors considerations. The Federal Government (e.g., FTA) can provide guidance and clarification with respect to the requirements of ADA.

Human factors. Consider human factors in the design of buses and vehicles for all levels of automation—for all participants in the system (transit operators, passengers, and other road users). The interaction between human and machine, ease of use, and comprehensibility of human-machine interfaces (HMI) should be explored thoroughly, particularly with respect to maintaining safety under all operating conditions. Where possible, technology companies should partner with transit agencies and passenger organizations to test various user-interface technologies and designs.

Testing. Open a dialogue and seek a collaborative relationship with FTA when developing and testing new bus technologies and products. FTA can provide guidance, feedback, and clarification on policies, requirements, and recommendations as they pertain to transit automation.

Provide Information to the Public

The understanding of automation technologies varies considerably across the general public, caused in part by a lack of consistency in terminology and confusion about the technology's limitations. The public needs accurate sources of information regarding automation to better understand the technology so that they can use it safely and make informed decisions about its integration. This can be done through direct communications with consumers and other users, demonstrations, public outreach in areas where vehicles are being tested, and a variety of other means.

Travel Patterns of American Adults with Disabilities

An estimated 25.5 million Americans have disabilities that make traveling outside the home difficult, according to the Bureau of Transportation Statistics report *Travel Patterns of American Adults with Disabilities.*[42] An estimated 3.6 million with disabilities do not leave their homes.

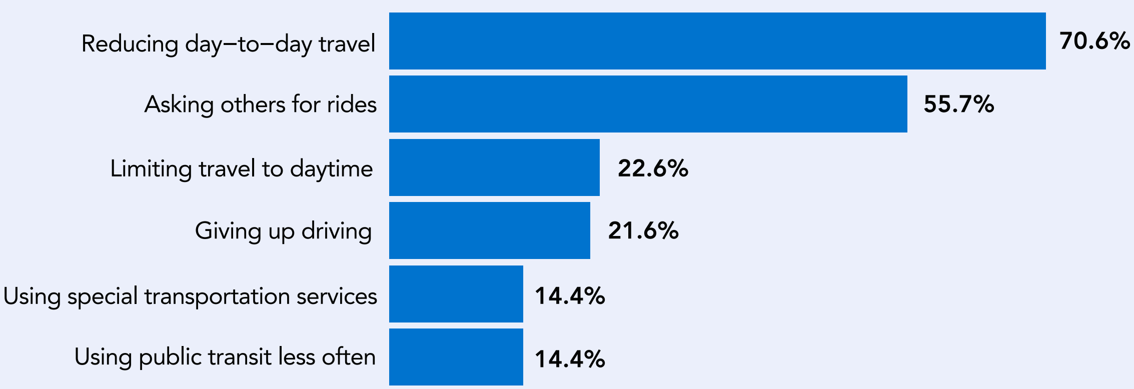
People with travel-limiting disabilities are less likely to own a vehicle or have vehicle access than people without disabilities.

When people with disabilities do use vehicles, they are often passengers. People with disabilities are less likely to have jobs, are more likely to live in very low-income households, and use smartphones and ride-hailing services less often than the general population. An estimated 71 percent reduce their day-to-day-travel, while an estimated 41 percent rely on others for rides.

Automated vehicles and other assistive technologies may provide substantial mobility benefits to people with disabilities who cannot drive.

42 Brumbaugh, Stephen. Travel Patterns of American Adults with Disabilities (Washington: Bureau of Transportation Statistics, 2018), https://www.bts.gov/travel-patterns-with-disabilities

Compensating Strategies for People with Travel-Limiting Disabilities (age 18–64)



Source: U.S. Department of Transportation, Federal Highway Administration, 2017 National Household Travel Survey.

With respect to currently available *Level 1 and Level 2* automation technologies and *Level 3* technologies under development, consumers and other users should understand what the technology is and is not capable of, when human monitoring of the system is needed, and where it should be operated (i.e., appropriate ODD). The private sector may need to consider new approaches for providing information so that consumers can use the technology safely and effectively. As part of their education and training programs and before consumer release, automated vehicle dealers and distributors may want to consider including an on-road or on-track experience demonstrating automated vehicle operations and how humans interact with vehicle controls. Other innovative approaches (e.g., virtual reality (VR) or onboard vehicle systems) may also be considered, tested, and employed.

Public education challenges are different for automated vehicle technologies at higher levels of automation or *Level 4 and Level 5* systems, where the consumer becomes a passenger rather than a driver. For these systems, the members of the public may require more general information and awareness of what the technology is and how they should interact with it, either as passengers or as others sharing the road with automated vehicles.

Developers of automated vehicle technologies are encouraged to develop, document, and maintain employee, dealer, distributor, and consumer education and training programs to address the anticipated differences in the use and operation of automated vehicles from those of the conventional vehicles that the public owns and operates today. Successful programs will provide target users with the necessary level of understanding to utilize these technologies properly, efficiently, and in the safest manner possible.

Consider All Possible Surface Transportation Conditions and Different Roadway Landscapes

Entities that are testing and operating on public roadways will want to consider the whole roadway environment, which could include different infrastructure conditions and operating rules. It will be important to account for all possible surface transportation conditions an ADS may encounter within its ODD. Such conditions, when appropriate, include maneuvering at-grade rail crossings, roundabouts, bicycle lanes, pedestrian walkways and special designated traffic lanes or crossing areas, entrances and driveways, and other potential hazards, especially in different roadway landscapes (e.g., urban versus rural). As part of their important role in the safety assurance of ADS-equipped vehicles, entities are also encouraged to consider such conditions in the design, testing, and validation of the designated fallback method. Entities are encouraged to engage with the U.S. DOT and infrastructure owners and operators to understand the full ODD for safe and efficient operations of automated vehicles.

Work with All Potential User Groups to Incorporate Universal Design Principles

The potential for automation to improve mobility for all Americans is immense, but if products and technologies are not designed with usability by a broad spectrum of travelers in mind, it may not be achieved.

U.S. DOT encourages developers and deployers to work proactively with the disability community to support efforts that focus on the array of accommodations needed for different types of disabilities, and ways to improve mobility as a whole—not just from curb to curb, but also from door to door.

Anticipate Human Factors and Driver Engagement Issues

Consider human factors design for surface transportation—at all levels of automation—for all road users. Safety risks, such as driver distraction and confusion, should influence early stages of design and vehicle development. User-interface usability and comprehension need to be explored, particularly during emergency situations, and in maintaining safety if vehicle functions are compromised.

In addition, it will be important to recognize human factors challenges related to driver awareness and engagement. Entities could consider methods that ensure driver awareness and engagement during ADS-equipped vehicle testing, to mitigate the potential for distraction, fatigue, and other possible risks.

Testing on public roadways is necessary for vehicle automation development and deployment. Public trust can be built during testing by using an in-vehicle driver engagement monitoring system, a second test driver, or other methods. It can be helpful for entities developing ADS technologies to share information with Federal agencies and appropriate organizations about the testing of user interface technologies and designs.

Identify Opportunities for Voluntary Data Exchanges

Voluntary data exchanges can help improve the safety and operations of ADS and lead to the development of industry best practices, voluntary standards, and other useful tools.

Work Zone Data Exchanges

The Work Zone Data Exchange project responds to priorities identified by public and private sector stakeholders. The goal is to develop a harmonized specification for work zone data that infrastructure owners and operators can make available as open feeds that automated vehicles and others can use.

Accurate and up-to-date information about dynamic conditions occurring on the roads—such as work zones—can help automated vehicles navigate safely and efficiently. Many infrastructure owners and operators maintain data on work zone activity, but a common specification for this type of data does not currently exist. This makes it difficult and costly for third parties—including vehicle manufacturers and makers of navigation applications—to access and use work zone data across various jurisdictions.

Several State DOT agencies and private companies are voluntarily participating in the project, with U.S. DOT acting as a technical facilitator. U.S. DOT has been working with these partners to help define the core data elements that should be included in an initial work zone specification and to determine what types of technical assistance the data producers will need to implement it, expand it over time, and address broader work zone data management challenges.

In U.S. DOT's Guiding Principles on Data for Automated Vehicle Safety, available at www.transportation.gov/av/data, the Department defines an approach that seeks to prioritize and enable voluntary data exchanges to address critical issues that could slow the safe integration of ADS technologies. These principles include:

- Promote proactive, data-driven safety, cybersecurity, and privacy-protection practices.
- Act as a facilitator to inspire and enable voluntary data exchanges.
- Start small to demonstrate value, and scale what works toward a larger vision.
- Coordinate across modes to reduce costs, reduce industry burden, and accelerate action.

The industry as a whole should consider working with Federal, State, and local agencies as well as relevant standards bodies (IEEE, SAE International, etc.) to identify opportunities to establish voluntary exchanges of data that can provide mutual benefit and help accelerate the safe integration of automation into the surface transportation system. This can include exchanges of data between the public and private sector regarding infrastructure conditions as well as exchanges among private sector entities to enable mutual learning and risk mitigation.

Any exchanges of data should respect consumer privacy[43] as well as proprietary and confidential business information.

Contribute to the Development of Voluntary, Consensus-Based, and Performance-Oriented Technical Standards

Voluntary standards offer flexibility and responsiveness to the rapid pace of innovation, can encourage investment and bring cost-effective innovation to the market more quickly, and may be validated by private sector conformity assessment and testing protocols. There are existing processes followed by Standards Development Organizations (SDOs), such as SAE International or IEEE, where industry participates in the development of voluntary standards. Industry and SDOs can continue to provide leadership in this area and collaborate with each other, as well as with U.S. DOT and other stakeholders, to address key issues. Areas where industry can support standards development include—but are not limited to—topics such as definitions, taxonomy, testing, interoperability, and performance characteristic definitions.

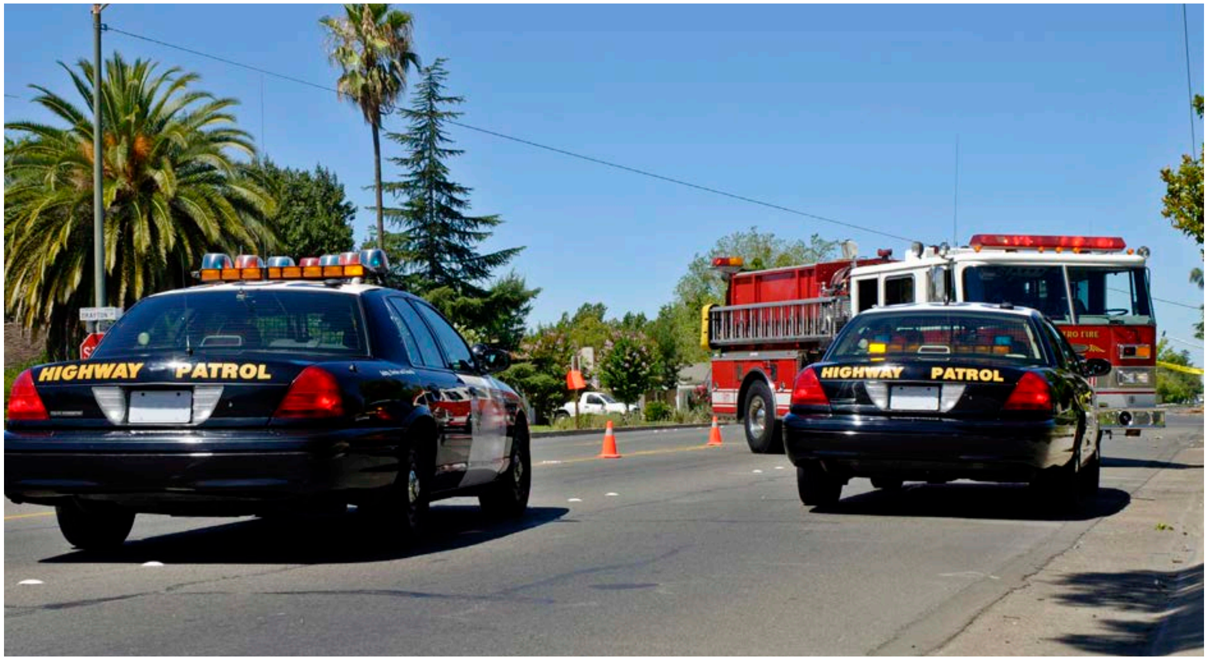
43 The Federal Trade Commission maintains oversight over, and provides resources related to, protecting consumer privacy. Additional information is available at https://www.ftc.gov/news-events/media-resources/protecting-consumer-privacy

The Department supports the development and continuing evolution of stakeholder-driven voluntary standards, which in many cases can be an effective non-regulatory means to support interoperable integration of technologies into the transportation system. The Department supports these efforts through multiple mechanisms, including cooperation and funding support to SDOs; cooperation with industry and governmental partners; making Federal, State, and local technical expertise available; and through international coordination.

Appendix C provides more information on key topic areas and work underway in standards development for automation.

Adopt Cybersecurity Best Practices

It is the responsibility of ADS developers, vehicle manufacturers, parts suppliers, and all stakeholders who support transportation to follow best practices, and industry standards, for managing cyber risks in the design, integration, testing, and deployment of ADS. As documented in *A Vision for Safety 2.0,* these entities are encouraged to consider and incorporate voluntary guidance, best practices, and design principles published by NIST, NHTSA, SAE International, the Alliance of Automobile Manufacturers, the Association of Global Automakers, the Auto ISAC, and



other relevant organizations, as appropriate. Stakeholders are also encouraged to report to the Auto ISAC—or another mode-specific ISAC[44]—all discovered incidents, exploits, threats, and vulnerabilities from internal testing, consumer reporting, or external security research as soon as possible, and provide voluntary reports of such information to the DHS NCCIC when and where Federal assistance may be warranted in response and recovery efforts.

Engage with First Responders and Public Safety Officials

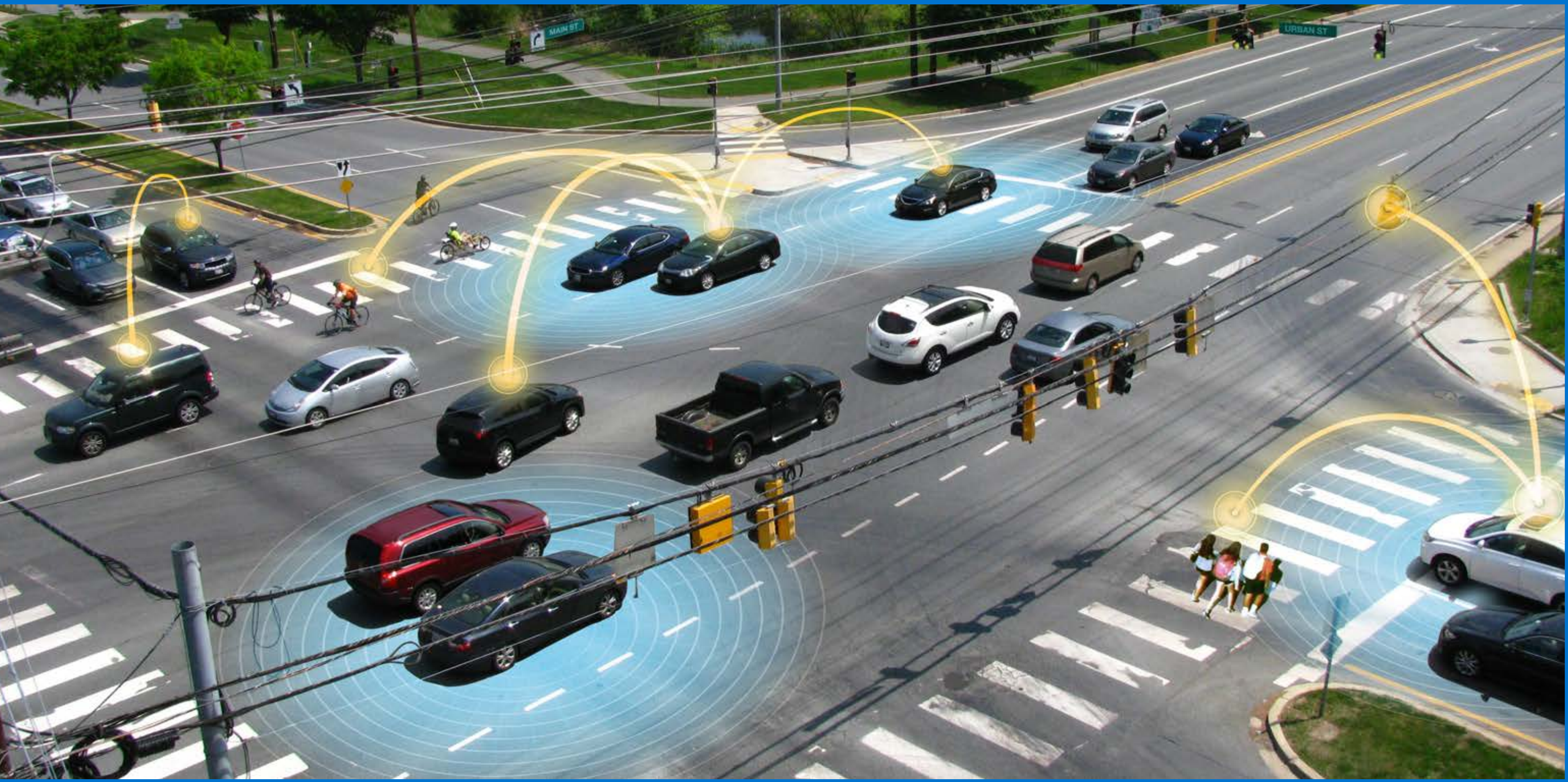
To ensure public safety, first responders and public safety officials need to have ways to interact with automated vehicles during emergencies. During traffic incidents, emergencies, and special events automated vehicles may need to operate in unconventional ways. Police officers responsible for traffic enforcement may need new procedures to signal an ADS-equipped vehicle to pull over and determine whether the occupant is violating the law or using the ADS appropriately. Responder personnel across many disciplines (including police, fire, emergency medical services, and towing) will need training to safely interact with partially or fully disabled ADS-equipped vehicles at the scene of a crash. Also, laws covering distracted driving, operating under the influence, and open alcohol containers may not be applicable or may be modified for operators or occupants of ADS-equipped vehicles.

Public safety officials also see the potential for automated vehicles to improve emergency response by improving data about traffic incidents and providing first responders with new tools to respond to traffic incidents quickly, effectively, and safely.

To educate, raise awareness, and develop emergency response protocols, automated vehicle developers should consider engaging with the first responder community when developing and testing automation technologies. Through such engagement, technology developers could potentially identify new applications of automation technologies that can enhance emergency response. The Federal Government may also act as a convener between public safety officials, technology companies, automobile manufacturers, and other stakeholders to build consensus around uniform voluntary data-sharing standards, protocols, and practices.

Private sector leadership is critical to advancing the development, testing, and commercialization of automated vehicles.

44 Including the Aviation ISAC (https://www.a-isac.com/), the Maritime Security ISAC (http://www.maritimesecurity.org/), and the Public Transit ISAC and Surface Transportation ISAC (https://www.surfacetransportationisac.org/)



U.S. DOT sees a bright future for automation technology and great potential for transforming our surface transportation system for the better, toward a future with enhanced safety, mobility, and economic competitiveness across all transportation modes.

THE ROAD AHEAD

This section discusses U.S. DOT's approach to moving forward on automation, informed by lessons from experience with the adoption of new technologies.

Automation Implementation Strategies

U.S. DOT is implementing five core strategies to accelerate the integration of automated vehicles and to understand their impact across all modes of the surface transportation system. The Department will put its six automation principles into action through these strategies. The strategies appear below in roughly sequential order, though some may occur in parallel. Stakeholders will be engaged throughout the process.

1. Engage stakeholders and the public as a convener and leader to address the issues automation raises. The Department will engage a broad range of stakeholders and provide them with opportunities to voice their concerns, expectations, and questions about the future of automation, to inform future research and policy development. U.S. DOT will also work to leverage knowledge and experience from across academia, industry, public sector agencies, and research organizations.

2. Provide best practices and policy considerations to support stakeholders as they work to better understand automation, how it may impact their roles and responsibilities, and how best to integrate automated vehicles into existing and future transportation networks. The Department is committed to providing best practices and updated policies as supported by research and will provide additional and more detailed information as the technology develops.

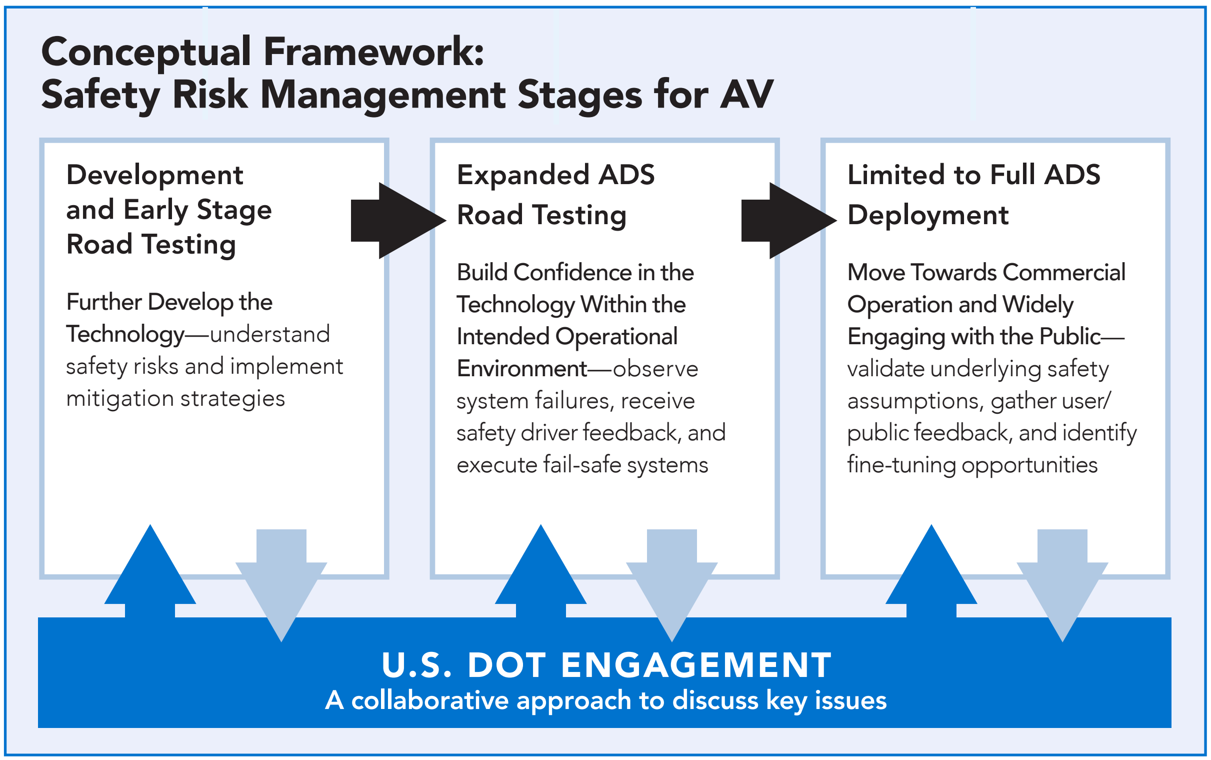
3. Support voluntary technical standards by working with stakeholders and SDOs to support technical standards and policies development. When in the public interest, the Department will support the integration of automation technologies throughout the Nation's transportation system. See Appendix C for more information.

4. Conduct targeted technical research to inform future policy decisions and agency actions. Research is critical for producing and analyzing data to inform policy decisions, moving beneficial applications and technologies toward deployment, and evaluating the safety of new technologies.

5. Modernize regulations as existing Federal regulations and standards may pose challenges to the widespread integration of automated vehicles. U.S. DOT developed many of its regulations over a period of decades, generally with the assumption that a human driver would always be present. U.S. DOT is in the process of identifying and modifying regulations that unnecessarily impede the testing, sale, operation, or use of automation across the surface transportation system.

Safety Risk Management Stages along the Path to Full Commercial Integration

In addition to meeting any regulatory or statutory requirements, U.S. DOT envisions that entities testing and eventually deploying ADS technologies will employ a mixture of industry best practices, consensus standards, and voluntary guidance to manage safety risks along the different stages of technology development.



Reflecting the breadth of industry activity and the variety of entities engaged in developing ADS technologies, it is useful to describe a general conceptual framework to help provide clarity to the public regarding the general distinctions between the stages of testing and full deployment.

This conceptual framework provides an opportunity for discussion around one potential vision for promoting safety, managing risk, and encouraging the benefits possible from the adoption of automated vehicle technologies. The following description is in no way intended to imply that there is only one path for ADS development. **Collaboration is needed among manufacturers, technology developers, infrastructure owners and operators, and relevant government agencies to establish protocols that will help to advance safe operations in these testing environments.** ADS developers may decide that this path does not make sense for them or that they will combine different phases in unique ways, all of which the Department fully supports, as long as safety risks are appropriately managed and all testing is conducted in accordance with applicable laws and regulations. Likewise, to the extent an ADS developer wishes to use this framework, it is not intended to provide benchmarks for when a developer may move from one phase to another, as that is best left to the ADS developer.

Development and Early Stage Road Testing

ADS development does not start with public road testing. Significant engineering and safety analysis are performed prior to on-road testing with a prototype ADS to understand safety risks and implement mitigation strategies. The primary purpose of this stage is to further develop the technology (software and hardware). There are many existing industry standards that guide general technology development. Conceptually, this stage can be characterized by these general characteristics:

- The system would generally be characterized as a prototype that already passed laboratory and/or closed-course testing.[45] The hardware and the vehicle platform may be comprised of development or rapid prototyping-level equipment.
- ADS use cases and associated ADS functions are identified and implemented, and requisite software validation and verification are performed in controlled environments prior to this stage. The primary purpose of this stage of road testing is to validate the completeness of use cases and to verify that implemented software can perform associated functions.
- Controlled environment (track, simulation, etc.) testing and software development are continuing alongside ADS prototype road testing. Known use cases are being tested in controlled environments and new use cases identified in road testing are being evaluated and stored.
- Development of use cases could include initial assessments of a broad range of roadway characteristics (e.g., lane markings, signage) and operational scenarios (e.g., work zones, road weather) to inform ADS performance in the roadway environment.
- In conjunction, additional software development is taking place in failure handling, crash imminent scenario handling, and edge case handling (non-nominal scenarios).[46]
- Safety drivers serve as the main risk mitigation mechanism at this stage. Safety-driver vigilance and skills are critical to ensuring safety of road testing and identifying new scenarios of interest.
- Some safety items (such as cybersecurity and human-machine interface) may be addressed in alternative ways when compared to production systems.
- Usually, in addition to a safety driver, an employee engaged in the ADS function/ software development track is also present in the vehicle. Software changes could happen frequently (both for safety-critical issues and other reasons) but are tracked and periodically harmonized.
- Members of the public are not in ADS prototype vehicles during early stage road testing.

45 For general guidance in safety of road testing associated with these types of systems, see: SAE International, SAE J3018_201503, Guidelines for On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems (Warrendale: SAE International, 2015), https://www.sae.org/standards/content/j3018_201503/

46 These scenarios are more suitable to develop, test, and validate in controlled environments for several reasons, including testing non-nominal scenarios in naturalistic real-world environments can involve high risk, probabilities of natural encounters are too low, and repeatability of tests is very difficult to establish.

Progressing through Testing Stages

The stage of testing and deployment of "an ADS in one ODD" does not adequately represent the maturity of all ADS development activities an entity may be pursuing. For example, an entity may be at a "limited-deployment stage" in one specific ODD giving limited rides to members of the public (e.g., daytime-only, less than 35 miles per hour, no precipitation, on a few streets in a metropolitan area). However, simultaneously that same entity may be developing its technologies to advance its ADS capabilities and expand the ODD elsewhere (e.g., to include nighttime, higher speeds, precipitation, or larger or different geographical areas).

Expanded ADS Road Testing

Once the development progresses and specifications and software components are validated to be generally complete, software handling of non-nominal cases is integrated into an ADS. The primary purpose of this stage of testing is to build statistical confidence in matured software and hardware within the intended operational environment and observe system failures, safety driver subjective feedback, and execution of fail-safe/fail-operational system behaviors. Conceptually, this stage can be characterized by these general attributes:

- The ADS has matured both in terms of hardware and software. Information necessary to establish a safety self-assessment should be available and reasonably stable.
- Targeted operational design domain is more clearly identified and near fully specified. This could include an understanding of how the ADS-equipped vehicle interprets the standard roadway environment, such as lane markings, signage, varying traffic laws, dynamic roadway conditions, and other users.
- The functional safety approach has been carried out; safety goals are identified and risk management controls implemented.
- ADS use cases are validated to be nearly complete. Implemented ADS functions are validated and verified to meet engineering requirements in both controlled and on-road environments.
- Most elements of the ADS—such as fallback (minimal risk condition) mechanisms—are identified and implemented. Safety drivers are still in the loop, but they are expected to serve as the secondary risk mitigation strategy.

The Role of On-Road Testing in Validation/Verification and Safety Assurance

Advancing an ADS function from prototyping stages to production release involves numerous development objectives. These include the ability for the ADS to perform nominal driving functions in known use cases, perform crash-avoidance maneuvers, revert to a safe state when there are identified system and sensor failures, and react reasonably safely in edge cases. **On-road testing cannot be expected to address all aspects of testing needs towards deployment.** For example, crash avoidance and failure response tests that put systems in imminent crash encounters cannot be safely performed in a naturalistic environment. On-road testing is an important part of the overall development process in identifying and validating the completeness of use cases, gaining statistical confidence in a system's ability to handle use cases, and identifying edge cases and otherwise interesting/difficult cases, as well as public perceptions and expectations. However, once a new scenario of interest is identified in road-testing, it is usually added to a library and retested many times in controlled environments (simulation, track, hardware-in-the-loop, software-in-the-loop, etc.) and integrated as part of each software update release readiness assessment.

- Depending on the vehicle platform, some safety items (such as cybersecurity and human-machine interface) may still be addressed in alternative ways.
- The safety driver may be the only person in the vehicle. Time between subsequent safety driver actions may be extending. Ensuring that safety drivers can maintain their vigilance in reduced workload is important.
- Members of the public are still not in ADS prototype vehicles during expanded road testing.

Limited to Full ADS Deployment

Limited ADS deployment is similar to what the public understands as demonstrations. Full deployment of automated vehicles represents an ADS that is able to, for example, operate commercially and widely engage with the public. The main purpose of this stage is to reach statistical confidence in the software for the intended operational environment, validate underlying safety assumptions, gather user and public feedback, and identify fine-tuning opportunities in user compatibility areas. Conceptually, this stage can be characterized by these general characteristics:

- Complete engineering requirements for ADS are specified by the entity developing the technology, and internally documented. Engineering design reviews are performed, and documented.
- The operational design domain is specified clearly and ADS operation only takes place within that ODD. Relevant ODD elements are monitored to ensure full coverage. Any ODD expansions go through requisite validation and verification processes, are documented, and are appropriately communicated when applied as a software update in deployed units.
- Near-full software, hardware, system failure validation, and verification processes have been carried out with near production hardware.
- Software is stable. Software changes are centrally managed at the fleet level. Any major change goes through new release readiness testing.
- Nearly all elements of ADS—such as fallback (minimal risk condition) mechanisms—are identified and implemented. Safety drivers (including remote safety drivers) may still be used, but their roles are limited and may eventually be eliminated. Risk-based assessments are performed to assure safety of these approaches.
- Safety and key performance indicators are set and monitored.
- All safety items (including cybersecurity and human-machine interface) are addressed in a production manner.
- Members of the public are allowed in ADS-equipped vehicles on public roads, initially on a limited basis.
- Systems move toward full operation by being offered for sale, lease, or rent (to include free ridesharing) or otherwise engaged in commerce in the form of the transport of goods or passengers.
- In specified deployment areas, law enforcement, first responders, and relevant State and local agencies know of operational protocols and administrative procedures following a crash or other roadway event related to an ADS-equipped vehicle in the ODD.

Engaging with U.S. DOT along the Way

As ADS developers move along their respective paths from development to full commercial integration, it is useful to identify opportunities to further engage with U.S. DOT and the broader stakeholder community. The path discussed in the previous section illustrates example phases of testing and deployment, with sample general characteristics defining each stage. This framework can help lay out points at which the U.S. DOT, ADS developers, and stakeholders can engage with each other throughout the technology development process and align to prioritize safety and manage risks. Rather than waiting to interact at the very end of the technology development cycle, the U.S. DOT prefers a collaborative approach for working with industry to address and solve major challenges together, where possible.

In the near-term, the U.S. DOT and its modal agencies will continue to pursue its safety oversight role within its existing authorities (as discussed in Section 2). NHTSA, for example, has authority over the safety of ADS-equipped vehicles, including establishing Federal safety standards for new motor vehicles and addressing known safety defects in motor vehicles and motor vehicle equipment.
FMCSA's oversight begins once the vehicles are placed into commercial operation in interstate commerce, whether for hire or as a private motor carrier, on public roadways. At that point, certain regulations designed to ensure safe operation apply.

During the first several years of ADS integration, light vehicles, transit vehicles, and the motor carrier industry will consist of a mixed fleet. For example, motor carriers that employ Level 4 or Level 5 driverless CMVs, those carriers with Level 3 or lower ADS-equipped CMVs that still have a human driver present, and carriers using only traditional non-ADS-equipped vehicles will at times be sharing the roadways. Some carriers will be operating mixed fleets and the ADS-equipped vehicles in deployment will represent an even broader array of operational design domains. As a result, the U.S. DOT and its State and local partners will need to adapt enforcement practices and other processes to new and rapidly developing ADS technology, while also continuing to ensure safe operation of conventional human driven vehicles. This will be an important area for stakeholders to work with the U.S. DOT going forward.

Moving Forward

In the long term, the U.S. DOT will pursue strategies to address regulatory gaps or unnecessary challenges that inhibit a safe and reasonable path to full commercial integration. The operating agencies within the U.S. DOT will be working together and with stakeholders to support a flexible and transparent policy environment to accommodate the safe development and integration of ADS technology.

Looking ahead, the U.S. DOT encourages stakeholder engagement in several areas as it pursues its long-term vision of modernizing regulations and supporting the path to full ADS commercialization:

- **NHTSA** will seek comment on existing motor vehicle regulatory barriers and other unnecessary barriers to the introduction and industry self-certification of ADS. NHTSA is developing an ANPRM to determine methods to maintain existing levels of safety while enabling innovative vehicle designs. The ANPRM also explores removing or modifying requirements that would no longer be appropriate if a human driver is not operating the vehicle. NHTSA previously published a Federal Register notice requesting public comment on January 18, 2018. NHTSA is issuing an ANPRM requesting public comments on designing a national pilot program that will enable it to facilitate, monitor, and learn from the testing and development of emerging advanced driving technologies and to assure the safety of those activities.
- **FMCSA** is finalizing an ANPRM to address ADS, particularly to identify regulatory gaps, including in the areas of inspection, repair, and maintenance for ADS. FMCSA anticipates considerable public interest and participation in this rulemaking effort, which will include an opportunity for formal written public comments as well as multiple public listening sessions.

  FMCSA is in the process of developing policy recommendations to address ADS technology. Through public listening sessions, the Agency hopes to solicit information on issues relating to the design, development, testing, and integration of ADS-equipped commercial motor vehicles. FMCSA is excited to share its progress to date and learn more about the perspective of the trucking and bus industries firsthand as it considers future guidance.
- **FTA** is investing significant research resources to support the commercialization of innovative solutions in transit automation. As part of this research, FTA will assess areas of potential regulatory and other unnecessary barriers. Examples include FTA funding eligibility and technology procurement requirements, as well as ADA compliance. Currently, FTA is preparing guidance to provide stakeholders with clarity on existing FTA rules relevant to developing, testing, and deploying automated transit buses.
- **FHWA** will continue to work with stakeholders through its National Dialogue and other efforts to address the readiness of the roadway infrastructure to support ADS-equipped vehicles. It is reviewing existing standards to address uniformity and consistency of traffic control devices, such as signage, and plans to update the existing MUTCD.

Stakeholders are encouraged to engage directly with the Department where and when possible to support collaboration. It will be important to gather information and feedback from the stakeholder community, including ADS developers, commercial motor vehicle carriers, transit agencies, infrastructure owners and operators, the public, and other groups to jointly address key challenges and promote safe technology development and deployment.

Conclusion

Over the past century, motor vehicles have provided tremendous mobility benefits, including widespread access to jobs, goods, and services. They have also helped connect many of the most remote and isolated regions of the country to the larger economy. Along with these benefits, however, have come significant safety risks and other challenges. Motor vehicle crashes remain a leading cause of death in the United States, with an estimated 37,133 lives lost on U.S. roads in 2017. Automation has the potential to improve the safety of our transportation system, improve our quality of life, and enhance mobility for Americans, including those who do not drive today.

Many Americans remain skeptical about the notion that their car could one day be driving itself, rather than being driven by humans. We certainly cannot predict the exact way consumers will choose to interact with these technologies. Therefore, the U.S. DOT will not rush to regulate a nascent and rapidly evolving technology. Instead, **the Department supports an environment where innovation can thrive and the American public can be excited and confident about the future of transportation.** Doing this requires a flexible policy architecture.

With *AV 3.0,* U.S. DOT acknowledges the need to modernize existing regulations and think about new ways to deliver on our mission. The Department will work with partners and stakeholders in government, industry, and the public to provide direction, while also remaining open to learning from their experiences and needs. Wherever possible, U.S. DOT will partner with industry to develop voluntary consensus-based standards and will reserve non-prescriptive, performance-based regulations for when they are necessary. The Department will work to assess and minimize the possible harms and spread the benefits of automation technology across the Nation.

Regarding the integration of automation into professional driving tasks, lessons learned through the aviation industry's experience with the introduction of automated systems may be instructive and inform the development of thoughtful, balanced approaches. These are not perfect comparisons, but are still worth considering (See Learning from the History of

Automation in Aviation). The aviation industry discovered that automation required careful consideration of human factors, but led to improved safety ultimately. This transition also did not result in the elimination of pilot jobs, as some had feared.

Despite the great promise of automation technology, important questions remain. For example, as driving becomes more automated, how can safety be improved? How will people interact with these technologies? What happens when a human vehicle operator switches to or from an automated driving mode? As automated driving technologies develop, how will the Nation's 3.8 million professional drivers be affected? Which regulatory obstacles need to be removed? What opportunities and challenges does automation present for long-range regional planning? Will automation lead to increased urban congestion?

U.S. DOT sees a bright future for automation technology and great potential for transforming our surface transportation system for the better, toward a future with enhanced safety, mobility, and economic competitiveness across all transportation modes.

Learning from the History of Automation in the Aviation Workforce

The aviation industry developed technological solutions to help airline pilots manage factors such as high workload, distractions, and abnormal situations. Innovation at that time eventually led to the introduction of autopilot, autothrottle, flight director, sophisticated alerting systems, and more. In part because of these innovations, the safety record for aviation improved significantly.[47] Early automation technology in aviation performed very simple functions; for example, maintaining a set altitude or heading—comparable to conventional cruise control systems offered on most passenger cars today. Pilots readily accepted these systems because they reduced their workload and were easy to understand.

As computer technology became more capable, automation in the flight deck became more complex. For example, it enabled sophisticated navigation using precise flight paths that contributed to more efficient operations. This increased automation came at a cost. It became harder for pilots to understand what the automated systems were doing, yet they remained responsible for taking over when the automated systems reached the limits of their operating domains or malfunctioned. Pilots were also encouraged to use automation to the exclusion of manual flight controls, potentially degrading manual flight skills.

Systems that alert pilots to hazardous conditions (e.g., proximity to the ground or to other aircraft—lane departure alerts are an analogous example offered in many passenger cars) have also contributed significantly to aviation safety despite initial challenges. Early alert systems sometimes had a high number of false alarms, so pilots did not trust them. Many improvements were made, such as better algorithms, better sensors, and improved and standardized display of alerts (and associated information) on the flight deck. These improvements have led to more reliable alerts and pilots are more willing to heed them.

Automation has undeniably made flying safer by supporting pilots. The characteristics that have improved trust in and effectiveness of these systems include:

- Reliable, robust systems that minimize false or missed alarms/reports.

47 Federal Aviation Administration, Operational use of flight path management systems, Final Report, Performance-based operations Aviation Rulemaking Committee/Commercial Aviation Safety Team, Flight Deck Automation Working Group (Washington: Federal Aviation Administration, 2013), https://www.faa.gov/aircraft/air_cert/design_approvals/human_factors/media/OUFPMS_Report.pdf.

- Pilot interfaces that are easy to understand and enhance awareness.
- Training to understand how the systems work (and how to operate them).
- Avoidance of skill degradation by encouraging pilots to practice manual flight and basic skills.

In the early days of aviation automation, many pilots worried that autopilot functions would completely replace them. Yet today, pilots are still paid well, highly regarded, and very much in demand. Although aviation is still undergoing technological changes, including increased automation of many services, its first four decades of experience shows that the transition from a mode of transportation of primarily human operation to one where humans and automated systems share in the vehicle's operation can occur in ways that dramatically increase safety while minimizing social disruption.

U.S. DOT supports an environment where innovation can thrive and the American public can be excited and confident about the future of transportation.

APPENDIX **A**

KEY TERMS AND ACRONYMS

Adaptive Cruise Control: A driver assistance system that automatically adjusts a vehicle's speed to maintain a set following distance from the vehicle in front. (NHTSA)

ADS-Dedicated Vehicle: A vehicle designed to be operated exclusively by a Level 4 or Level 5 ADS for all trips. (SAE J3016)

Advanced Driver-Assistance Systems (ADAS): Systems designed to help drivers with certain driving tasks (e.g., staying in the lane, parking, avoiding collisions, reducing blind spots, and maintaining a safe headway). ADAS are generally designed to improve safety or reduce the workload on the driver. With respect to automation, some ADAS features could be considered SAE Level 1 or Level 2, but many are Level 0 and may provide alerts to the driver with little or no automation.

Automation: Use of electronic or mechanical devices to operate one or more functions of a vehicle without direct human input. Generally applies to all modes.

Automated Driving System (ADS): The hardware and software that are collectively capable of performing the entire Dynamic Driving Task on a sustained basis, regardless of whether it is limited to a specific operational design domain. This term is used specifically to describe a Level 3, 4, or 5 driving automation system. (SAE J3016)

Automated Vehicle: Any vehicle equipped with driving automation technologies (as defined in SAE J3016). This term can refer to a vehicle fitted with any form of driving automation. (SAE Level 1–5)

Commercial Motor Vehicle: Any self-propelled or towed motor vehicle used on a highway in interstate commerce to transport passengers or property when the vehicle:

(1) Has a gross vehicle weight rating or gross combination weight rating, or gross vehicle weight or gross combination weight, of 4,536 kg (10,001 pounds) or more, whichever is greater; or

(2) Is designed or used to transport more than 8 passengers (including the driver) for compensation; or

(3) Is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation; or

(4) Is used in transporting material found by the Secretary of Transportation to be hazardous under 49 U.S.C. 5103 and transported in a quantity requiring placarding under regulations prescribed by the Secretary under 49 CFR, subtitle B, chapter I, subchapter C. (FMCSA, defined in 49 CFR 390.5)

Cooperative Automation: Ability for automated vehicles to communicate with each other and with infrastructure to coordinate their movements.

Cooperative Lane Change and Merge: A dynamic driving task for automated vehicles that uses communications to enable negotiations between vehicles to provide safe gaps for manual or automated lane change or merge maneuver on a roadway. (FHWA)

Driver Assistance Technologies: Cameras and sensors in vehicles that help drivers see more than they can with the naked eye and warn of a possible collision. Driver assistance technologies can help drivers with backing up and parking, maintaining safe distance from other vehicles, preventing forward collisions, and navigating lanes safely. (NHTSA)

Driving Automation System or Technology: The hardware and software that are collectively capable of performing part or all of the Dynamic Driving Task on a sustained basis; this term is used generically to describe any system capable of Level 1–5 driving automation. (SAE J3016)

Dynamic Driving Task (DDT): All of the real-time operational and tactical functions required to operate a vehicle in on-road traffic, excluding the strategic functions such as trip scheduling and selection of destinations and waypoints. (SAE J3016)

DDT Fallback: The response by the user or by an ADS to either perform the DDT or achieve a minimal risk condition after occurrence of a DDT performance-relevant system failure(s) or upon Operational Design Domain (ODD) exit. (SAE J3016)

GlidePath: A prototype application of signalized approach and departure that has been demonstrated to stakeholders. (FHWA)

Hazardous Material: The Secretary shall designate material (including explosive, radioactive material, infectious substance, flammable or combustible liquid, solid, or gas, toxic, oxidizing, or corrosive material, and compressed gas) or a group or class of material as hazardous when the Secretary determines that transporting the material in commerce in a particular amount and form may pose an unreasonable risk to health and safety or property. (PHMSA, defined 49 U.S.C. § 5103)

Human-in-the-loop: Intermittent remote operation or intervention by a human of an automated or autonomous vehicle for emergency or special handling reasons. (FRA)

Minimal Risk Condition: A condition to which a user or an ADS may bring a vehicle after performing the DDT fallback in order to reduce the risk of a crash when a given trip cannot or should not be completed. (SAE J3016)

Object Event Detection and Response (OEDR): The subtasks of the DDT that include monitoring the driving environment (detecting, recognizing, and classifying objects and events and preparing to respond as needed) and executing an appropriate response to such objects and events (i.e., as needed to complete the DDT and/or DDT fallback). (SAE J3016)

Operational Design Domain (ODD): The specific conditions under which a given driving automation system or feature thereof is designed to function, including, but not limited to, driving modes. This can incorporate a variety of limitations, such as those from geography, traffic, speed, and roadways. (SAE J3016)

Remote Driver/Remote Operation: A driver who is not seated in a position to manually exercise in-vehicle braking, accelerating, steering, and transmission gear selection input devices (if any) but is able to operate the vehicle. (SAE J3016)

Signalized Intersection Approach and Departure: An automated vehicle that communicates with infrastructure using Signal Phase and Timing (SPaT) and Map Data Message (MAP) messages to automate the movement of single or multiple automated vehicles through intersections to increase traffic flow and safety. (FHWA)

Speed Harmonization: A strategy to increase traffic flow enabled by communications between an automated vehicle and infrastructure to change traffic speed on roads that approach areas of traffic congestion, bottlenecks, incidents, special events, and other conditions that affect flow. (FHWA)

Vehicle Platooning: A group of automated vehicles that use communications to enable negotiations between vehicles to support organized behavior and safe close following. (FHWA)

ADA	Americans with Disabilities Act
ADS	Automated Driving Systems
AI	Artificial Intelligence
ANPRM	Advance Notice of Proposed Rulemaking
ATTRI	Accessible Transportation Technologies Research Initiative
CDL	Commercial Driver's License
CMV	Commercial Motor Vehicle
DARPA	Defense Advanced Research Projects Agency
DDT	Dynamic Driving Task
DHS	Department of Homeland Security
DOL	Department of Labor
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulations
FMVSS	Federal Motor Vehicle Safety Standards
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FTC	Federal Trade Commission
HHS	Health and Human Services
HMI	human-machine interface
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronics Engineers
ISAC	Information Sharing and Analysis Center
ISO	International Standards Organization
MARAD	Maritime Administration
MCSAP	Motor Carrier Safety Assistance Program
MPO	Metropolitan Planning Organization
MRC	Minimal Risk Condition
MUTCD	Manual on Uniform Traffic Control Devices
NCCIC	National Cybersecurity and Communications Integration Center
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NSP	National Public Transportation Safety Plan
ODD	operational design domain
OEDR	Object and Event Detection and Response
OHMS	Office of Hazardous Materials Safety
PHMSA	Pipeline and Hazardous Materials Safety Administration
PTASP	Public Transportation Agency Safety Plan
PTC	Positive Train Control
SAE	Society of Automotive Engineers
SDO	Standards Development Organization
SMS	Safety Management System
SPaT	Signal Phase and Timing
STAR	Strategic Transit Automation Research
U.S. DOT	U.S. Department of Transportation
US-CERT	United States Computer Emergency Readiness Team
UVC	Uniform Vehicle Code
VRU	Vulnerable Road User
VSSA	Voluntary Safety Self-Assessment

APPENDIX **B**

STAKEHOLDER ENGAGEMENT

Since the publication of *A Vision for Safety 2.0,* the U.S. DOT has sought input from the public through public meetings, demonstration projects, expert roundtables and workshops, Requests for Information, and Requests for Comment. In March 2018, U.S. DOT hosted an Automated Vehicle Summit to discuss the cross-modal issues most critical to the successful integration of automated vehicles and provide input to this document. For more information, see transportation.gov/AV.

The most common themes and concerns stakeholders shared with the U.S. DOT include:

- **Consumer and public education:** Stakeholders agreed on the need for improved public and consumer education regarding the capabilities of vehicles with different levels of automation. Responses emphasized the need to engage a diverse range of stakeholders.
- **Data and digital infrastructure:** Respondents identified a need for standardized frameworks and enhanced digital infrastructure for collecting, managing, and exchanging data related to automated vehicle operation.
- **Connectivity:** Many respondents suggested continued investment in research into V2V and V2I communications and their potential to complement automated vehicle technologies. Responses noted the need for standardized and interoperable communications.
- **Mobility and accessibility:** Many stakeholders see great promise in the potential for automated vehicles to support the independence of people with disabilities by improving the accessibility of mobility options. To achieve this potential, stakeholders stressed that innovators and policymakers need to engage in an open dialogue with the disability community.
- **Public safety and emergency response:** Some respondents emphasized the need for establishing protocols for emergency responders, including emergency overrides to transfer control to a human in case of an emergency or equipment malfunction.
- **Roadway readiness:** Stakeholders recognize that improved roadway maintenance, enhanced digital infrastructure, and increased uniformity have the potential to enhance automated vehicle operations. However, many are concerned about making long-term infrastructure investments given the uncertainty about automation capabilities and requirements.
- **Insurance and liability:** Respondents raised concerns regarding insurance requirements and methods for determining liability.
- **Cybersecurity:** Stakeholder responses stressed the need for setting cybersecurity standards and establishing models and partnerships to mitigate the risk of hacking or intrusions.
- **Workforce impacts:** Stakeholders expressed concerns about the potential impact of automation on employment, particularly in the motor carrier, transit, and rail industries, and encouraged additional research into opportunities for re-training and workforce development.

APPENDIX **C**

VOLUNTARY TECHNICAL STANDARDS FOR AUTOMATION

Standardization-related needs associated with surface vehicle automation are in various stages of identification, development, definition, and adoption. Standardization-related documents can include voluntary technical standards published by standards developing organizations (SDOs) as well as specifications, best practices descriptions and other types of documents. There are standards that apply to almost all levels of vehicle automation. These include ISO 26262 Road Vehicles Functional Safety and SAE's J3016_201806 Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems. There are many existing standards, but they may not fully address automated vehicle needs. Some standards specific to automated vehicles and many standards in other automation-relevant domains have been developed, but gaps remain where activity is underway or anticipated.

In addition to those standards that support interoperable integration, many standards development efforts are focused on describing common terminology, required performance capabilities, and interfaces between subsystems inside automated systems. These efforts include both automation-specific standards and domain-specific standards—for example, Information and Communications Technology (ICT) standards—applicable to subsystems and technologies that are then integrated into the overall automation system or surface transportation system. There are also sets of published best practices and frameworks that complement and are used in conjunction with voluntary technical standards. For example, the NIST cybersecurity framework describes a holistic approach to mitigating cyber threats across complex systems.

The Department will continue our cooperative, coordinated approach to supporting development of stakeholder-driven voluntary technical standards and similar documents across internal modal partners. The Department will follow a similar process to the approach for modernizing regulation, including:

1. **Gather information** through research, internal analysis, and stakeholder engagement on voluntary technical standardization needs.
2. **Explore and execute new approaches** to meet technical challenges in a way acceptable to the broad, diverse stakeholder community.
3. **Work to ease implementation** of automated vehicle products by supporting development of voluntary technical standards, system architecture options and user services for the interface between vehicles and infrastructure, along with companion software toolsets and implementation support programs.

   Means include cooperation and funding support to SDOs, cooperation with industry and governmental partners, making Federal technical expertise available, and international coordination.
4. **Cooperate with stakeholders** to maximize interoperability throughout North America as well as to take advantage of common international interests and global expertise by leveraging work across multiple regions and markets.

Vehicle automation systems represent one element of a larger system-of-systems architecture within surface transportation. Vehicle manufacturers control what goes into the vehicle, while infrastructure owners and operators control the physical environment where the vehicle operates. That infrastructure covers more than the roadway and can include communications networks, electric vehicle charging stations, and other components. Surface vehicle automation systems have technological crossovers and interdependencies. These include considerations about software reliability as the degree of software dependency increases. Interdependencies are not directly mapped from traditional standards, and those factors expand the scope of consensus agreement on systems architectures and voluntary technical standards.

To gain a general understanding of what standards might be beneficial for vehicle automation, the interests, goals, and perspectives of innovators and stakeholders can be used as a basis to categorize the different types of existing and prospective standards. Figure 1 offers one way of logically dividing the voluntary technical standards landscape into three complementary category areas to encompass multiple perspectives.

As innovators and stakeholders advance the state of the art in automation, it is useful to identify those standards that already are available. Table 1 organizes existing standards by three functional areas: technology, functional standards, and safety, and identifies the associated organization. In some cases, these standards are applicable globally or multi-regionally; in other cases, differing standards have evolved in specific regions. This is reflected in Table 1, which describes work by a wide spectrum of organizations whose standardization-related documents are applicable domestically and across global markets. There may be ongoing work that is not captured below.

Technology Areas	Functional Standards Areas	Safety Areas
Software	Definitions and Architecture	System Safety
System Engineering	Data	Operational Design Domain (ODD)
Communications	Design	Object and Event Detection and Response (OEDR)
Position, Navigation and Timing (PNT)	Maintenance and Inspection	Fallback (Minimal Risk Condition - MRC)
Mapping	Functional / Performance	Validation Methods
Sensing	Protocol (Communications)	HMI
Infrastructure	Security	Vehicle Cybersecurity
Human-Machine Interface (HMI)	Testing / Test Targets	Crashworthiness
	Training	Post-Crash ADS Behavior
		Data Recording
		Consumer Education and Training
		Federal, State, and Local Laws
		Commercial Vehicle Inspection

Table 1. Relevant Standardization-Related Document by Functional Area

(as of August 2018)

Functional Area	Standardization-Related Documents
Definitions and Architecture	**Definitions** • SAE J2944_201506 — *Operational Definitions of Driving Performance Measures and Statistics* • SAE J3016_201806 — *Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems* • SAE J3018_201503 — *Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems* • SAE J3063_201511 — *Active Safety Systems Terms and Definitions* • SAE J3077_201512 — *Definitions and Data Sources for the Driver Vehicle Interface (DVI)* • SAE J3087_201710 — *Automatic Emergency Braking (AEB) System Performance Testing* • SAE AS-4 *Joint Architecture for Unmanned Systems (JAUS)* • SAE AIR5372A:2014 *Information on Brake-By-Wire (BBW) Brake Control Systems [pertains to aircraft, but may be of use to surface transportation]* • National Institute of Standards and Technology (NIST) Special Publication (SP) 1011 I-2.0 *Autonomy Levels for Unmanned Systems (ALFUS) Framework* • NIST NISTIR 6910 — 4D/RCS Version 2.0: *A Reference Model Architecture for Unmanned Vehicle Systems* • ASTM Committee F45 on Driverless Automatic Guided Industrial Vehicles Architecture • ISO/IEC/IEEE 12207:2017(E) — *Systems and software engineering — Software life cycle processes* • U.S. Army Robotic Systems Joint Project Office Interoperability Profiles • Automotive Open System Architecture (AUTOSAR) Testing • European Committee for Standardization (CEN) European Standard (EN) 1525: *Safety of Industrial Trucks — Driverless Trucks and Their Systems* • CEN — CEN/Technical Committee (TC) 278 WG 12: *Intelligent Transport Systems Automatic Vehicles and Equipment Identification.*

(Continued) Table 1. Relevant Standardization-Related Document by Functional Area (as of August 2018)

Functional Area	Standardization-Related Documents	
Data	• Navigation Data Standard (NDS) — a standardized format for automotive-grade navigation databases, jointly developed by automobile manufacturers and suppliers. • North American Datum 1983 (NAD83) • World Geodetic System 1984 (WGS84) • European Terrestrial Reference System 1989 (ETRS89) • Chinese encrypted datum 2002 (CSJ-02) • ADASIS Forum vehicle to cloud messaging standards • Coordinated Universal Time (UTC) • International Atomic Time (TAI) • ISO 11270:2014 — *Intelligent Transport Systems — Lane Keeping Assistance Systems (LKAS) — Performance requirements and test procedures* • ISO 14296:2016 — *Intelligent Transport Systems — Extension of map database specifications for applications of cooperative Intelligent Transportation Systems* • ISO 14825:2011 — *Intelligent Transport Systems — Geographic Data Files (GDF) — GDF5.0*	• ISO 15622:2010 — *Intelligent Transport Systems — Adaptive Cruise Control Systems — Performance requirements and test procedures* • ISO 19237:2017 — *Intelligent Transport Systems — Pedestrian detection and collision mitigation systems (PDCMS) — Performance requirements and test procedures* • ISO 22178:2009 — *Intelligent Transport Systems — Low speed following (LSF) systems — Performance requirements and test procedures* • ISO 22179:2009 — *Intelligent Transport Systems — Full Speed Range Adaptive (FSRA) systems — Performance requirements and test procedures* • ISO 22839:2013 — *Intelligent Transport Systems — Forward vehicle collision mitigation systems — Operation, performance, and verification requirements* • ISO/DIS 20035 — *Intelligent Transport Systems — Cooperative adaptive cruise control (CACC) — Operation, performance, and verification requirements* • SAE J1698 — *Event Data Recorder (EDR)*

Functional Area	Standardization-Related Documents
Design	• Federal Highway Administration *Manual on Uniform Traffic Control Devices (MUTCD)* • American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets* (Green Book) • *AASHTO Roadside Design Guide* • Joint SAE-AASHTO *Committee on Road Markings* • ISO 2575:2010 — *Road vehicles — Symbols for controls, indicators, and tell-tales* • SAE J2945_201712 — *DSRC Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts*
Maintenance and Inspections	• Commercial Vehicle Safety Alliance (CVSA) North American Standard Inspection Program (roadside inspection process for inspecting commercial motor vehicles and drivers throughout North America)
Functional / Performance	• SAE J2958:2011 — *Report on Unmanned Ground Vehicle Reliability* • SAE J2980_201804 — *Considerations for ISO 26262 Automotive Safety Integrity Levels (ASIL) Hazard Classification* • SAE J3088 — *Active Safety System Sensors* • SAE J3116_201706 — *Active Safety Pedestrian Test Mannequin Recommendation* • U.S. Department of Defense (DOD) Military Standards (MIL-STD) — *882E Standard Practice for System Safety* • Radio Technical Commission for Aeronautics (RTCA) *DO-178C Software Considerations in Airborne Systems and Equipment Certification* • National Aeronautics and Space Administration (NASA) — *GB-8719.13 Software Safety Guidebook* • Automated Driving and Platooning Task Force of the American Trucking Associations Technology and Maintenance Council • ISO 13482:2014 — *Robots and robotic devices — Safety requirements for personal care robots* • ISO 15622:2010 — *Intelligent Transport Systems — Adaptive Cruise Control systems — Performance requirements and test procedures* • ISO 17386:2010 — *Transport information and control systems — Maneuvering Aids for Low Speed Operation (MALSO) — Performance requirements and test procedures* • ISO 22840:2010 — *Intelligent Transport Systems — Devices to aid reverse maneuvers — Extended-range backing aid (ERBA) systems* • ISO 26262 — *Road vehicles — Functional safety*

(Continued) Table 1. Relevant Standardization-Related Document by Functional Area (as of August 2018)

Functional Area	Standardization-Related Documents	
Protocols (Communications)	• IEEE 802.11X • IEEE 1609.0: 2013 — *IEEE Draft Guide for Wireless Access in Vehicular Environments (WAVE) — Architecture* • IEEE 1609.2: 2016 — *WAVE - Security Services for Applications and Management Messages* • IEEE 1609.2a: 2017 — *WAVE — Security Services and Message Sets — Amendment 1* • IEEE 1609.3: 2016 — *WAVE — Networking Services* • IEEE 1609.4: 2016 — *WAVE — Multi-channel Operations* • IEEE 1609.12: 2016 — *WAVE — Identifier Allocation* • IEEE 8802-3-2014 — *Standard for Ethernet* • IEEE 8802-3-2017 — *Standard for Ethernet — Amendments* • SAE J1939 Core Standards — *Serial Control and Communications Heavy Duty Vehicle Network* • SAE J2735_201603 — *Vehicle-to-Vehicle Message Sets*	• SAE J2945/1_201603 — *On-Board System Requirements for Vehicle-to-Vehicle (V2V) Safety Communications* • SAE J2945/9_201703 — *Vulnerable Road User Safety Message Minimum Performance Requirements* • SAE J3067_201408 — *Candidate Improvements to Dedicated Short Range Communications Message Set Dictionary [SAE J2735] Using Systems Engineering Methods* • SAE AS6802 — *Time-Triggered Ethernet* • Time-Sensitive Networking Task Group (IEEE 802.1X Ethernet) • Association of Radio Industries and Businesses (ARIB) Standard (STD) — *T109 700 MHz Band ITS (V2V communications)* • ARIB STD-T110 — *Dedicated Short Range Communications (Japan) Basic Application Interface* • ARIB STD-T88 *Dedicated Short Range Communications (Japan) Application Sublayer*
Security	• SAE J3061_201601 — *Cybersecurity Guidebook for Cyber-Physical Vehicle Systems* • NIST Cybersecurity Framework (CSF) • National Highway Traffic Safety Administration Cybersecurity Framework • International Electrotechnical Commission (IEC) — *62443 Industrial communication networks — Network and system security*	• ISO/IEC 15408 — *Information technology — Security techniques — Evaluation criteria for information technology (IT) Security* • ISO/IEC TR 15446:2017 — *Information Technology — Security Techniques — Guidance for the production of protection profiles and security targets* • ISO/IEC 18045:2008 — *Information technology — Security techniques — Methodology for IT security evaluation*

Functional Area	Standardization-Related Documents
Testing/Test Target	• SAE J2396_201705 — *Definitions and Experimental Measures Related to the Specification of Driver Visual Behavior Using Video Based Techniques* • SAE J3018_201503 — *Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems* • SAE J3048_201602 — *Driver-Vehicle Interface Considerations for Lane Keeping Assistance Systems* • SAE J3077_201512 — *Definitions and Data Sources for the DVI* • SAE J3114_201612 — *Human Factors Definitions for Automated Driving and Related Research Topics* • IEC-61508 — *Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems* • ISO/DIS 11270:2014 — *Intelligent Transport Systems — Lane keeping assistance systems (LKAS) — Performance requirements and test procedures* • ISO 15622:2010 — *Intelligent Transport Systems — Adaptive Cruise Control Systems — Performance requirements and test procedures* • ISO 19237:2017 — *Intelligent Transport Systems — Pedestrian detection and collision mitigation systems (PDCMS) — Performance requirements and test procedures* • ISO 22178:2009 — *Intelligent Transport Systems — Low speed following (LSF) systems — Performance requirements and test procedures* • ISO 22179:2009 — *Intelligent Transport Systems Full Speed Range Adaptive Cruise Control (FSRA) systems — Performance requirements and test procedures* • ISO 22839:2013 — *Intelligent Transport Systems — Forward vehicle collision mitigation systems — Operation, performance, and verification requirements* • ISO/DIS 20035 — *Intelligent Transport Systems — Cooperative adaptive cruise control systems (CACC) — Performance requirements and test procedures*

(Continued) Table 1. Relevant Standardization-Related Document by Functional Area (as of August 2018)

Functional Area	Standardization-Related Documents
Testing/Test Target	**Architecture/Software** ISO/IEC/IEEE 29119 — *Software and systems engineering — Software testing*

As automation technologies advance, additional needs may become evident that are not covered by currently available standards. Those needs may be met by a combination of automation-specific standards and domain-specific standards. The table below presents an inventory of known standards development activities underway to support known and anticipated automation needs.

Table 2: Known Current Standards Development Activities Relevant to Automated Surface Vehicles *(as of August 2018)*

Topic Area	Functional Needs	Standardization-Related Activities
Cooperative Situational Awareness	• Need to utilize perception systems from other surface vehicles and infrastructure systems to overcome sensor occlusion and range.	• SENSORIS, ADASIS Forum • SAE J2945/6 — *Performance Requirements for Cooperative Adaptive Cruise Control and Platooning* • SAE J3161 — *On-Board System Requirements for LTE V2X V2V Safety Communications*
Cybersecurity Framework	• Describe best practices • Cover aspects of identify, respond, recover, protect, and detect for vehicles and infrastructure	• Auto-ISAC Best Practices • NHTSA — Cyber Resiliency Framework project (RFP released winter 2017) • National Cooperative Highway Research Program (NCHRP) 03-127 Cybersecurity of Traffic Management Systems research project • ITS Joint Program Office Data Program ADS Data Roundtable • American Trucking Association Technology and Maintenance Council • Association of Global Automakers — Framework for Automotive Cybersecurity Best Practices
Data sharing: Scenarios	• Provide common set of parameters and interface definitions to enable sharing of scenarios	• Pegasus Open-Simulation Interface • ITS JPO Data Program ADS Data Roundtable • International work on standards harmonization

(Continued) **Table 2: Known Current Standards Development Activities Relevant to Automated Surface Vehicles (as of August 2018)**

Topic Area	Functional Needs	Standardization-Related Activities
Communications Performance	• Assure required reliability and availability of wireless communications links	• SAE J2945/2 — *DSRC Requirements for V2V Safety Awareness* • SAE J2945/3 — *Requirements for Vehicle-to-Infrastructure (V2I) Weather Applications* • SAE J2945/4 — *DSRC Messages for Traveler Information and Basic Information Delivery* • SAE J2945/6 — *Performance Requirements for CACC and Platooning*
DVI Guidelines	• Design for all user types including those with disabilities • Identify different driver states • Helps define minimal risk condition • Need to define approaches for testing and certification	• SAE J3171 — *ADS-DV User Issues for Persons with Disabilities* • SAE DVI Task Force (TF) 5 — *Automated Vehicles and DVI Challenges Committee*
Emergency Vehicle Interaction	• V2V/V2I or other communication/sensing techniques for ensuring safe and efficient passage of emergency vehicles	• SAE J2945/2 — DSRC Requirements for V2V Safety Awareness
Encrypted Communications	• Some communications can be signed and some will need to be encrypted	• IEEE 1609.2 — *Standard for Wireless Access in Vehicular Environments — Security Services for Applications and Management Messages* • ISO TC204 WG16 and WG18 activity
Event Data Recorder	• Data elements for crash reconstruction and determining if ADS defect may exist	• SAE Event Data Recorder Committee

Topic Area	Functional Needs	Standardization-Related Activities
Functional Architecture	• Encourage interoperability and enable system-level innovation and more complex applications to emerge	• SAE On-Road Automated Driving (ORAD) • SAE J3131 — *Automated Driving Reference Architecture* • IEEE WG2040 — *Standard for Connected, Automated and Intelligent Vehicles: Overview and Architecture* • IEEE WG2040.1 — *Standard for Connected, Automated and Intelligent Vehicles: Taxonomy and Definitions* • IEEE WG2040.2 — *Standard for Connected, Automated and Intelligent Vehicles: Testing and Verification* • Other domains: Robot Operating System (ROS), JAUS, VICTORY, AUTOSAR
Functional Safety	• Using verification and validation (V&V) from current standards to ensure a safe vehicle design	• ISO 26262 — *Road Vehicles — Functional Safety* • IEC 62508 — *Dynamic Test Procedures for Verification and Validation of Automated Driving Systems* • SAE J3092 — *Dynamic Test Procedures for Verification and Validation of Automated Driving Systems ISO/WD PAS 21448 — Road vehicles — Safety of the intended functionality*
General Atmospheric Conditions/Road Weather	• Classify various weather conditions and data formats • Identify ODD boundaries • Identify minimal risk condition and transition of control • Define approaches for testing and certification	• Reference model architecture efforts within ISO TC204 WG 1 include provision for road weather (connected vehicle focus) • NHTSA Testable Cases Project • SAE J3164 — *Taxonomy and Definitions for Terms Related to Automated Driving System Behaviors and Maneuvers for On-Road Motor Vehicles*

(Continued) Table 2: Known Current Standards Development Activities Relevant to Automated Surface Vehicles (as of August 2018)

Topic Area	Functional Needs	Standardization-Related Activities
Global Positioning System (GPS) Spoofing	• Describe risk mitigations • Define test apparatus, infrastructure, procedures	• SAE J3061_201601 — *Cybersecurity Guidebook for Cyber-Physical Vehicle Systems* • ISO 26262 — *Road vehicles — Functional safety*
Infrastructure signage and traffic control device design	• Describe how tests address functional requirements • Facilitate discussion between parties • Define test apparatus, infrastructure, and procedures • Define ODD-specific Object and Event Detection and Response (OEDR) tests	• Current joint SAE/AASHTO Task Force • SAE J2945/X — *Dedicated Short Range Communication (DSRC) Systems* • NCHRP 20-102(15) — Impacts of Connected and Automated Vehicle Technologies on the Highway Infrastructure
Interactions with Vulnerable Road Users (VRU)	• Identify minimal risk condition and transition of control • Define approaches for testing and certification	• Ongoing activity in SAE lighting committee • SAE J3122 — *Test Target Correlation*
Maintenance and inspection of sensors, software	• Automation benefits from routine maintenance of systems for optimal performance and operations	• ISO 3888 — Diagnostic, maintenance and test equipment may provide a guideline for this
Minimal Risk Condition	• Minimal Risk Condition (MRC) definition provides common understanding to enable discussion; it exists, but may need to be updated • MRC performance requirements set expectations between OEMs, regulators, and public • MRC data elements in EDR enable crash reconstruction	• SAE J3131 — *Automated Driving Reference Architecture* • SAE Event Data Recorder Task Force

Topic Area	Functional Needs	Standardization-Related Activities
ODD Definition	• Specify the boundaries of the ODD including: road type, lighting, weather, traffic volume, incidents, etc. • Boundaries may be set by vehicle capabilities and/or jurisdictional requirement or other factors.	• American Association of Motor Vehicle Administrators (AAMVA) *Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles* [46] • No known work with standards organizations; however, States are believed to have initiatives underway (Caltrans, Florida DOT) • SAE J3016 — *Definitions of ODD*
Over-the-Air (OTA) Software Updates	• Assess security threats, risks and vulnerabilities • Provision common methods to update vehicle software by a secure procedure • Security controls and protocol definition	• ITU-T X.1373 (03/2017) — International Telecommunication Standardization Sector (ITU-T) — *Recommendation Secure Software Update Capability for Intelligent Transportation System Communication Devices*
Sharing of static and dynamic road segment and traffic control device data	• Automation benefits from dynamic data on work zones, road closures, SPAT, etc., and static data like bus stop locations and crosswalk geometry, and laws that originate from roadway owner-operators and may be relayed via digital maps	• U.S. DOT is convening States that publish work zone data and want to harmonize feeds (e.g., Iowa DOT, Colorado DOT), standards activity may follow • NCHRP 20-102(15) — *Impacts of Connected and Automated Vehicle Technologies on the Highway Infrastructure* • SAE J2945/10 — *Recommended Practices for MAP/SPaT Message Development*

[46] American Association of Motor Vehicle Administrators, *Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles* (Arlington: American Association of Motor Vehicle Administrators, 2018), https://www.aamva.org/GuidelinesTestingDeploymentHAVs-May2018/.

(Continued) Table 2: Known Current Standards Development Activities Relevant to Automated Surface Vehicles (as of August 2018)

Topic Area	Functional Needs	Standardization-Related Activities
Testing Approaches	• Describe how tests address functional requirements • Facilitate discussion between parties • Define test apparatus, infrastructure, procedures • Define ODD-specific OEDR tests • Define role of simulation, track testing and on-road testing	• SAE *ORAD Verification and Validation Committee* • SAE J3018 — *Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems* • Pegasus/AdaptIVe project • TNO Streetwise methodology • U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) guidelines • Department of Defense Unmanned Systems Safety Guide being updated [47] • FHWA Test and Evaluation for Vehicle Platooning [48] • AAMVA — *Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles* • FHWA and SAE Cooperative Automation Research Modeling and Analysis (CARMA) program • US DOT V2I research program DSRC Roadside Unit (RSU) Specifications development
Transition of DDT Control	• Research to define time to alert, alert format, time to react if no takeover and driver states • Helps define minimal risk condition • Need to define approaches for testing and certification	• SAE ORAD Levels of Automation • SAE DVI Committee

[47] U.S. Department of Defense, *Unmanned Systems Safety Guide for DOD Acquisition* (Arlington: U.S. Department of Defense, 2007), http://www.denix.osd.mil/shf/programs/ssa/references/unmanned-systems-safety-guide-for-dod-acquisition/.

[48] Tiernan, Tim A., et al., *Test and Evaluation of Vehicle Platooning Proof-of-Concept Based on Cooperative Adaptive Cruise Control* Final Report (Washington: U.S. Department of Transportation, 2017), https://rosap.ntl.bts.gov/view/dot/1038.

Topic Area	Functional Needs	Standardization-Related Activities
ADS-DV Issues for Persons with Disabilities	• L4 and L5 ADS-Dedicated Vehicles (ADS-DVs) will eventually enable persons to travel at will who are otherwise unable to obtain a driver's license for a conventional vehicle • This work will document user issues specific to this population.	• SAE J3171 — ADS-DV User Issues for Persons with Disabilities

AV 3.0 is the beginning of a national discussion about the future of our surface transportation system. Your voice is essential to shaping this future.

Preparing for

THE FUTURE OF TRANSPORTATION

Automated Vehicles 3.0

October 2018

https://www.transportation.gov/av

U.S. Department of Transportation