



U.S. Department of Transportation

AUTOMATED VEHICLES

Comprehensive Plan





Letter from

THE UNITED STATES SECRETARY OF TRANSPORTATION

AS our country faces new challenges, the U.S. Department of Transportation (U.S. DOT) is more committed than ever to improving the daily lives of the American public through leadership in transportation innovation. Recent events have highlighted the importance of developing and maintaining a resilient transportation system that keeps our supply chains safe, open, and operational, and helps Americans access jobs, healthcare, and education. Emerging technologies such as automated vehicles have the potential to contribute to this goal by improving safety, transforming mobility, and promoting economic growth.

Through years of ongoing and active engagement with the automotive industry and other transportation stakeholders, U.S. DOT has made significant progress in establishing a regulatory environment supportive of safety and new technologies, but there is still much work to be done. We will continue efforts to leverage technology as a tool for the public good, knowing that one day riding in an automated vehicle may be as routine as getting behind the wheel.

This comprehensive plan lays out U.S. DOT's multimodal strategy to promote collaboration and transparency, modernize the regulatory environment, and prepare the transportation system for the safe integration of automated vehicles. It illustrates how the Department's work extends beyond government to meet the challenges of a modern transportation system by providing real-world examples of how the Department's operating administrations collaborate to address the needs of emerging technology applications.

While no one can predict the future, it is important to prepare for it by establishing a flexible approach that prioritizes safety and encourages American ingenuity. We look forward to your feedback as we continue to work together and learn from each other.



ELAINE L. CHAO

United States Secretary of Transportation

Executive Summary

The Automated Vehicles Comprehensive Plan (Comprehensive Plan) advances the United States Department of Transportation's (U.S. DOT) work to prioritize safety while preparing for the future of transportation. Building upon the principles stated in *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 (AV 4.0)*, the plan defines three goals to achieve this vision for Automated Driving Systems (ADS):

1. **Promote Collaboration and Transparency** – U.S. DOT will promote access to clear and reliable information to its partners and stakeholders, including the public, regarding the capabilities and limitations of ADS.
2. **Modernize the Regulatory Environment** – U.S. DOT will modernize regulations to remove unintended and unnecessary barriers to innovative vehicle designs, features, and operational models, and will develop safety-focused frameworks and tools to assess the safe performance of ADS technologies.
3. **Prepare the Transportation System** – U.S. DOT will conduct, in partnership with stakeholders, the foundational research and demonstration activities needed to safely evaluate and integrate ADS, while working to improve the safety, efficiency, and accessibility of the transportation system.

Each goal includes a discussion of key objectives, as well as associated illustrative actions the Department is undertaking to address priorities while preparing for the future. These actions include an Advance Notice of Proposed Rulemaking on Framework for Automated Driving System Safety,¹ which will create a safety framework for defining, assessing, and providing for the safety of ADS, while allowing safety innovations and novel designs to be introduced into commerce more efficiently. The plan also includes a set of real-world examples that relate the U.S. DOT's framework for ADS integration to emerging technology applications. The Department will periodically review its activities and plans to reflect new technology and industry developments, eliminate unnecessary or redundant initiatives, and align investments with emerging focus areas.

The *Comprehensive Plan* was informed by extensive stakeholder engagement and the ongoing efforts of U.S. DOT's operating administrations and the Office of the Secretary of Transportation to understand and respond to the opportunities and challenges presented by ADS. It is intended to reflect the Department's fundamental focus on safety, transportation system efficiency, and mobility for people and goods.

The U.S. DOT developed the *Comprehensive Plan* document to help stakeholders understand ADS activities across the Department and in response to recommendations from the Government Accountability Office (GAO) and Congress.

For additional information on U.S. DOT's automation activities, please visit <http://www.Transportation.gov/AV>.

¹ <https://www.federalregister.gov/documents/2020/12/03/2020-25930/framework-for-automated-driving-system-safety>.

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Acronyms and Abbreviations

ACE	Automated Commercial Motor Vehicle Evaluation
ADS	Automated Driving Systems
AIM	Accelerating Innovative Mobility
ANPRM	Advance Notice of Proposed Rulemaking
AV	Automated Vehicle
AV TEST	Automated Vehicle Transparency and Engagement For Safe Testing
CAT	Cooperative Automated Transportation
CDA	Cooperative Driving Automation
CMV	Commercial Motor Vehicle
DDT	Dynamic Driving Task
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulations
FMVSS	Federal Motor Vehicle Safety Standards
FTA	Federal Transit Administration
GAO	Government Accountability Office
ITS JPO	Intelligent Transportation Systems Joint Program Office
LSV	Low-Speed Vehicle
MARAD	Maritime Administration
MUTCD	Manual on Uniform Traffic Control Devices
NHTSA	National Highway Traffic Safety Administration
NPA	Notice of Proposed Amendment
NPRM	Notice of Proposed Rulemaking
ODD	Operational Design Domain
OST	Office of the Secretary of Transportation
PARTS	Partnership for Analytics Research in Traffic Safety
PHMSA	Pipeline and Hazardous Materials Safety Administration
PoC	Proof of Concept
RFC	Request for Comments
RFI	Request for Information
TSMO	Transportation Systems Management and Operations
U.S. DOT	U.S. Department of Transportation
VOICES	Virtual Open Innovation Collaborative Environment for Safety
VSSA	Voluntary Safety Self-Assessment

Accomplishments



The publication of *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0* unified efforts in automated vehicles across 38 Federal departments, independent agencies, commissions, and Executive Offices of the President, providing high-level guidance to Federal agencies, innovators, and all stakeholders on the U.S. Government's posture toward automated vehicles. *AV 4.0* complements the guidance provided to private- and public-sector stakeholders in *A Vision for Safety: Automated Driving Systems 2.0* and *Preparing for the Future of Transportation: Automated Vehicles 3.0*.



Launch of NHTSA's Automated Vehicles Transparency and Engagement for Safety Testing (AV TEST) Initiative with 9 Automated Driving System developers and 10 States voluntarily submitting Automated Driving Systems information.



Initiated rulemaking activities to begin modernizing the regulatory environment for ADS.

Granted the first ADS-related temporary exemption from certain low-speed vehicle standard requirements.



FTA awarded nearly \$8 million in grants for automated transit research and demonstration projects, including a demonstration of the Nation's first automated bus rapid transit system.



\$60 million in grant funding awarded across 7 States with 8 innovative demonstrations, pilots, and deployments involving Automated Driving Systems.



WHAT IS THE COMPREHENSIVE PLAN?

What is the Comprehensive Plan?

The *Automated Vehicles Comprehensive Plan* (*Comprehensive Plan*) describes how the United States Department of Transportation (U.S. DOT) is supporting the safe integration of Automated Driving Systems (ADS)² into the surface transportation system. It explains Departmental goals related to ADS, identifies actions being taken to meet those goals, and provides real-world examples of how these Departmental actions relate to emerging ADS applications.

Development of ADS technology is occurring along multiple paths, and significant uncertainty still exists around what form ADS applications and vehicles will take in the future. Even with the progress the industry has made over the last decade, to date no vehicle equipped with an ADS is available for purchase in the United States. Technologies are still under development, and the timing of wide-scale ADS-equipped vehicle deployment remains uncertain.

The *Comprehensive Plan* addresses clear, near-term needs while laying the groundwork for longer-term changes. This plan does not attempt to predict the future forms of ADS-equipped vehicles or the services they may provide. The Department will periodically review its activities and plans to reflect new technology and industry developments, eliminate unnecessary or redundant initiatives, and align investments with emerging focus areas.

The U.S. DOT developed the *Comprehensive Plan* document to help stakeholders understand ADS activities across the Department and in response to recommendations from the Government Accountability Office (GAO) and Congress for a “comprehensive plan to better manage departmental initiatives related to automated vehicles.”^{3, 4, 5}

HOW WAS THE PLAN DEVELOPED?

This document builds upon years of work by U.S. DOT’s operating administrations and the Office of the Secretary of Transportation to understand existing conditions, identify needs, set goals, and implement outreach, research, and regulatory modernization activities.

New technologies raise issues important to U.S. DOT and its partners, including other Federal agencies, State and local governments, associations, industry, and safety advocates. Stakeholder input, informed by extensive outreach, was critical for creating the *Comprehensive Plan*. U.S. DOT conducts stakeholder engagement through several avenues, including in-person and virtual events, public listening sessions, and *Federal Register* notices requesting input. Input gathered through each of these mechanisms is actively considered when planning the Department’s research and policy activities.

The *Comprehensive Plan* builds on the U.S. Government’s core principles related to automated vehicles, outlined in *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 (AV 4.0)* and summarized on pages 3 and 4.

- 2 Automated Driving Systems (ADS) are defined as systems capable of performing the entire driving task on a *sustained* basis, regardless of whether it is limited to a specific *operational design domain* (ODD); this term is used specifically to describe SAE Levels 3, 4, or 5 *driving automation systems*. See SAE International, *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*, June 2018, retrieved from https://www.sae.org/standards/content/j3016_201806/.
- 3 United States Government Accountability Office, *Automated Vehicles: Comprehensive Plan Could Help DOT Address Challenges*, 2017, retrieved from <https://www.gao.gov/assets/690/688676.pdf>.
- 4 *Joint Explanatory Statement on the Consolidated Appropriations Act of 2018*, Congressional Record, 164(50), H2876, (Washington, DC: United States Congress, March 22, 2018), retrieved from <https://www.congress.gov/crc/2018/03/22/CRC-2018-03-22-bk3.pdf>.
- 5 In the 2018 Consolidated Appropriations Act, Congress provided \$500,000 to U.S. DOT to support the development of the *Comprehensive Plan*.

WHAT IS IN THE PLAN?

The *Comprehensive Plan* presents key actions the Department is pursuing related to enabling and overseeing the safety of the integration of ADS into the surface transportation system. Automation in aviation, maritime, or rail transportation is not addressed in this plan, except for their interface points with surface transportation (e.g., ports or grade crossings).

The following section discusses U.S. DOT's vision, goals, and objectives for ADS, with examples of how it is implementing each objective. The remainder of the document shows how the *Comprehensive Plan* addresses an illustrative set of ADS use cases currently being developed and tested within industry and describes how the Department works with stakeholders to implement the plan.

U.S. GOVERNMENT AUTOMATED VEHICLE TECHNOLOGY PRINCIPLES

I. Protect Users and Communities

Automated vehicles (AVs) have the potential to improve physical safety for vehicle operators and occupants, pedestrians, bicyclists, motorcyclists, and other travelers sharing the road. To realize these benefits, we must attend to the public's safety, security, and privacy.



1. Prioritize Safety

The U.S. Government will lead efforts to facilitate the safe integration of AV technologies, address potential safety risks, enhance the life-saving potential of AVs, and strengthen public confidence in these emerging technologies. The U.S. Government will also enforce existing laws to ensure entities do not make deceptive claims or mislead the public about the performance capabilities and limitations of AV technologies including, for example, deceptive claims relating to vehicle safety or performance.



2. Emphasize Security and Cybersecurity

The U.S. Government will support the design and implementation of secure AV technologies, the systems on which they rely, and the functions that they support to safeguard adequately against the threats to security and public safety posed by criminal or other malicious use of AVs and related services. The U.S. Government will work with developers, manufacturers, integrators, and service providers of AVs and AV services to ensure the successful prevention, mitigation, and investigation of crimes and security threats targeting or exploiting AVs, while safeguarding privacy, civil rights, and civil liberties. These efforts include the development and promotion of physical and cybersecurity standards and best practices across all data mediums and domains of the transportation system to deter, detect, protect, respond, and safely recover from known and evolving risks.



3. Ensure Privacy and Data Security

The U.S. Government will use a holistic, risk-based approach to protect the security of data and the public's privacy as AV technologies are designed and integrated. This will include protecting driver and passenger data as well as the data of passive third parties—such as pedestrians about whom AVs may collect data—from privacy risks such as unauthorized access, collection, use, or sharing.



4. Enhance Mobility and Accessibility

The U.S. Government embraces the freedom of the open road, which includes the freedom for Americans to drive their own vehicles. The U.S. Government envisions an environment in which AVs operate alongside conventional, manually driven vehicles and other road users; therefore, the U.S. Government will protect the ability of consumers to make the mobility choices that best suit their needs. The U.S. Government will support AV technologies that enhance freedom by providing additional options for consumers to access goods and services, allowing individuals to live and work in places that fit their families' needs and expanding access to safe, affordable, accessible, and independent mobility options to all people, including those with disabilities and older Americans.

II. Promote Efficient Markets

AVs offer a dynamic area for research and development. To promote rapid development of the technologies underlying AVs, the U.S. Government will promote market efforts for American investment and innovation.



5. Remain Technology Neutral

The U.S. Government will adopt—and promote the adoption on an international level of—flexible, technology-neutral policies that will allow the public, not the Federal Government or foreign governments, to choose the most economically efficient and effective transportation and mobility solutions.



6. Protect American Innovation and Creativity

The U.S. Government will continue to advance pro-growth policies to protect our economic prosperity and innovative competitiveness, promote new engines of growth, and to prioritize America's innovative and creative capacity in all sectors, including AVs. The U.S. Government will continue to promote sensitive emerging technologies through the protection and enforcement of intellectual property rights—patents, trademarks, copyrights, and trade secrets—technical data, and sensitive proprietary communications and will continue to work to prevent other nations from gaining unfair advantage at the expense of American innovators.



7. Modernize Regulations

The U.S. Government will modernize or eliminate outdated regulations that unnecessarily impede the development of AVs—or that do not address critical safety, mobility, and accessibility needs—to encourage a consistent regulatory and operational environment. In doing so, it will promote regulatory consistency among State, local, tribal and territorial, and international laws and regulations so that AVs can operate seamlessly nationwide and internationally. When regulation is needed, the U.S. Government will seek rules, both at home and abroad, which are as performance-based and nonprescriptive as possible and do not discriminate against American technologies, products, or services.

III. Facilitate Coordinated Efforts

AVs touch upon areas of concern to Federal, State, local, tribal, and territorial governments, while also directly affecting international cooperation. This complex governance environment offers opportunities for collaboration, facilitation, and information sharing.



8. Promote Consistent Standards and Policies

The U.S. Government will prioritize participation in and advocate abroad for voluntary consensus standards and evidence-based and data-driven regulations. The U.S. Government will engage State, local, tribal, and territorial authorities as well as industry to promote the development and implementation of voluntary consensus standards, advance policies supporting the integration of AVs throughout the transportation system, and seek harmonized technical standards and regulatory policies with international partners.



9. Ensure a Consistent Federal Approach

The U.S. Government will proactively facilitate coordination of AV research, regulations, and policies across the Federal Government to ensure maximum effectiveness and leverage inter-agency resources. The U.S. Government will ensure all Federal dollars used for automated and connected vehicle research, grants, and any other Federal funding opportunities will comply with Executive Order 13788 (Buy American and Hire American), Executive Order 13881 (Maximizing Use of American-Made Goods, Products, and Materials), and all current laws, regulations, and Executive Orders to ensure American growth and leadership in AV technology.



10. Improve Transportation System-Level Effects

The U.S. Government will focus on opportunities to improve transportation system-level performance, efficiency, and effectiveness while avoiding negative transportation system-level effects from AV technologies.

A stylized illustration of a man in a suit talking on a mobile phone, standing next to a yellow school bus. The background is a mix of yellow and green tones with some abstract shapes.

HOW WILL U.S. DOT ACHIEVE ITS VISION FOR ADS?

How Will U.S. DOT Achieve Its Vision for ADS?

The U.S. DOT vision for ADS is to **prioritize safety while preparing for the future of transportation.**

Safety is U.S. DOT's highest priority. If developed and deployed safely, ADS have the potential to prevent or mitigate a large number of crashes involving driver error, judgment, or other human-related causes.⁶ Safe integration begins with the proactive identification, assessment, and management of safety risks potentially associated with ADS, so that desired benefits can be realized.

Transportation system efficiency and mobility for people and goods are also central to U.S. DOT's mission. ADS could, if carefully integrated, positively impact mobility and operational efficiency for all users. For instance, deployment of mature ADS could reduce delays related to incidents or support independent travel by people with disabilities. In contrast, potential negative outcomes of ADS include increased traffic congestion due to induced demand and inequitable service. The Department is actively engaged in research to understand and mitigate these possible negative outcomes.

U.S. DOT has three broad goals to achieve its vision with respect to ADS:

1. **Promote Collaboration and Transparency** – U.S. DOT will promote access to clear and reliable information to its partners and stakeholders, including the public, regarding the capabilities and limitations of ADS.
2. **Modernize the Regulatory Environment** – U.S. DOT will modernize regulations to remove unintended and unnecessary barriers to innovative vehicle designs, features, and operational models, and will develop safety-focused frameworks and tools to assess the safe performance of ADS technologies.
3. **Prepare the Transportation System** – U.S. DOT will conduct, in partnership with stakeholders, the foundational research and demonstration activities needed to safely evaluate and integrate ADS, while working to improve the safety, efficiency, and accessibility of the transportation system.

The following sections describe how U.S. DOT translates these goals into action. Some actions are discrete and quick to implement; others are complex and have longer time horizons. The figure below summarizes the Department's plan, including goals, objectives, and illustrative actions, to achieve its vision for ADS.

⁶ See, e.g., S. Singh, *Critical reasons for crashes investigated in the National Motor Vehicle Crash Causation Survey*, Traffic Safety Facts Crash Stats, Report No. DOT HS 812 115, (Washington, DC: National Highway Traffic Safety Administration, February 2015), <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115>.



Vision					
Prioritize Safety While Preparing for the Future of Transportation					
Goals	Promote Collaboration and Transparency U.S. DOT will promote access to clear and reliable information to its partners and stakeholders, including the public, regarding the capabilities and limitations of ADS.		Modernize the Regulatory Environment U.S. DOT will modernize regulations to remove unintended and unnecessary barriers to innovative vehicle designs, features, and operational models, and will develop safety-focused frameworks and tools to assess the safe performance of ADS technologies.		Prepare the Transportation System U.S. DOT will conduct, in partnership with stakeholders, the foundational research and demonstration activities needed to safely evaluate and integrate ADS, while working to improve the safety, efficiency, and accessibility of the transportation system.
		Streamline Paths to Deployment	Update Existing Regulations to Remove Unnecessary Barriers	Conduct Appropriate Safety Oversight of ADS	
Objectives	Engage with stakeholders to monitor for emerging trends, issues, and needs	Issue exemptions and waivers consistent with applicable authorities	Conduct rulemaking and research to adapt existing FMVSS to remove unintended and unnecessary barriers to the introduction of novel vehicle designs and features enabled by ADS	Explore new approaches to safety assurance and investigate innovative models and tools to evaluate the safety of ADS technologies	Conduct targeted technical research
	Provide guidance to industry to encourage transparency and adoption of best practices	Streamline administrative processes for seeking exemptions and waivers	Adapt existing FMCSRs to remove unnecessary barriers to the operation of ADS-equipped commercial motor vehicles in interstate commerce		Provide funding for ADS-focused demonstrations, pilots, and deployments
	Facilitate information sharing				Update infrastructure standards to reflect ADS technologies
Actions					
U.S. DOT Actions: Stakeholder Engagement, Research, Guidance Documents, Rulemakings					

GOAL 1: PROMOTE COLLABORATION AND TRANSPARENCY

Access to clear and reliable information on the capabilities and limitations of ADS technologies supports their safe testing, development, and eventual deployment. Transparency supports the safe integration and adoption of new technology by ensuring that key information is accessible to all. U.S. DOT will use tools tailored to a variety of audiences, such as case studies, guidance, technical reports, online public-facing platforms, and in-person and virtual events, to ensure ongoing, transparent communications as it engages with stakeholders at all levels. The Department promotes transparency through regular engagement with stakeholders, voluntary guidance, and information sharing. Examples of these activities follow.

Objective: Engage with stakeholders to monitor for emerging trends, issues, and needs

► Cooperative Automated Transportation (CAT)

Coalition (FHWA): The CAT Coalition is a joint effort of the American Association of State Highway and Transportation Officials (AASHTO), ITS America, and Institute of Transportation Engineers (ITE), and serves as a collaborative focal point for Federal, State, and local government officials, academia, industry, and their related associations to address critical program and technical issues associated with the nationwide deployment of connected vehicles and automated vehicles on streets and highways.⁷

► National Dialogue on Highway Automation (FHWA):

FHWA hosted a series of meetings across the country to facilitate information sharing, identify key issues, and support the transportation community in safely and efficiently integrating automated vehicles into the road network. Input received during the National Dialogue has informed FHWA research, policies, and programs.⁸

► Transit Automation Community of Practice (FTA):

FTA's Transit Bus Automation Community of Practice regularly convenes transit agencies and others who

are using U.S. DOT funds to pilot or demonstrate transit bus automation technologies, including ADS. The community of practice is designed to foster a community of innovative, pioneering agencies to advance transit bus automation and its potential to enhance transit operations in the United States.

Objective: Provide guidance to industry to encourage transparency and adoption of best practices

► Automated Driving Systems 2.0:

A Vision for Safety (ADS 2.0)

(U.S.DOT/NHTSA): ADS 2.0

provides voluntary guidance to help ADS developers analyze,

identify, and resolve safety considerations prior to deployment using their own, industry, and other best practices. It outlines 12 safety elements, which the Department believes represent the consensus across the industry as the most salient design aspects to consider and address when developing, testing, and deploying ADS on public roadways.⁹

► Preparing for the Future of

Transportation: Automated

Vehicles 3.0 (AV 3.0) (U.S.

DOT): AV 3.0 builds upon ADS

2.0 and expands the scope to

provide a multimodal approach to the safe integration of automated vehicles into the Nation's broader surface transportation system.¹⁰

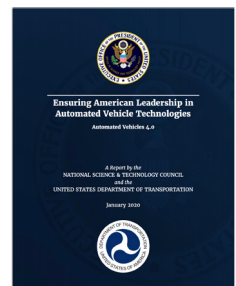
► Ensuring American Leadership in

Automated Vehicle Technologies:

Automated Vehicles 4.0 (AV 4.0)

(U.S.DOT): AV 4.0 presents the

U.S. Government's posture for surface transportation automated vehicles based on a future vision



⁷ Cooperative Automated Transportation (CAT) Coalition," National Operations Center of Excellence (NOCoe), <https://transportationops.org/CATCoalition>.

⁸ "National Dialogue on Highway Automation," FHWA Office of Operations, last modified August 7, 2020, <https://ops.fhwa.dot.gov/automationdialogue/>.

⁹ *Automated Driving Systems 2.0: A Vision for Safety*, Report No. DOT HS 812 442, (Washington, D.C.: NHTSA, September 2017), https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf.

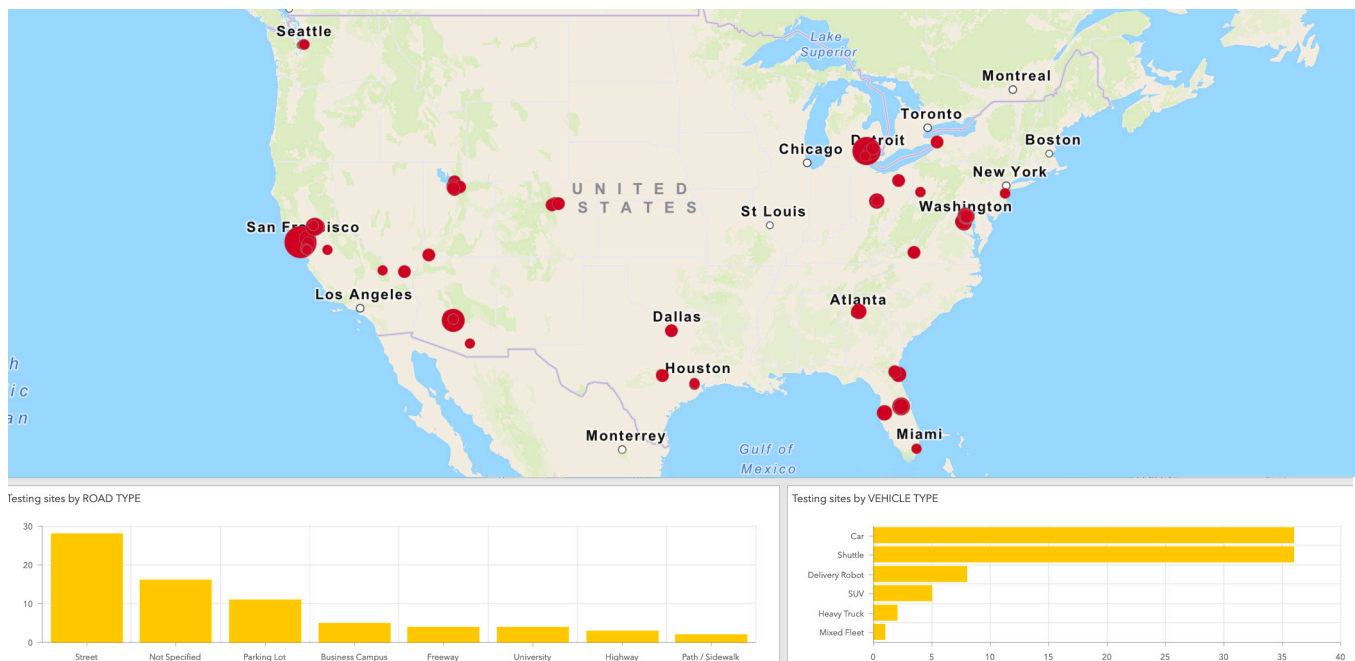
¹⁰ *Preparing for the Future of Transportation: Automated Vehicles 3.0*, (Washington, D.C.: U.S. DOT, October 2018), <https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf>.

in which American innovators are global leaders, implementing this technology in the United States and around the world in a safe and secure manner.¹¹

Objective: Facilitate information sharing

- ▶ **Voluntary Safety Self-Assessments (VSSA) (NHTSA):** A voluntary mechanism for entities that are developing and testing ADSs to communicate with the public how they are prioritizing safety.¹²
- ▶ **Automated Vehicle Transparency and Engagement for Safe Testing (AV TEST) Initiative (NHTSA):** The AV TEST Initiative provides a series of workshops for NHTSA, States, local governments, and stakeholders to discuss the safe testing of ADS on public roads.
- ▶ **Transit Bus Automation Market Assessment (FTA):** FTA developed and regularly updates this report to describe the current state of the industry, including the availability, capabilities, and limitations of automated transit bus technologies.¹³

AUTOMATED VEHICLE TRANSPARENCY AND ENGAGEMENT FOR SAFE TESTING (AV TEST) INITIATIVE



NHTSA launched the AV TEST Initiative in June 2020 with States, local governments, and companies throughout the driving automation community. The goal of the initiative is to provide the public with direct and easy access to information about the testing of ADS-equipped vehicles, including information from States regarding activity, legislation, regulations, local involvement in automation on our roadways, and information provided by companies developing and testing ADS. This information is expected to increase public awareness of on-road testing activities guiding the development and testing of ADS. In addition, NHTSA is improving public awareness through the AV TEST Initiative web pilot tool, as shown above.¹⁵ This initiative is another way that NHTSA is working with governmental and private stakeholders to facilitate the safe development, testing, integration, and education of driving automation technology in the United States.

11 *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0*, (Las Vegas, NV: U.S. DOT and the White House Office of Science and Technology Policy, January 2020), <https://www.transportation.gov/sites/dot.gov/files/2020-02/EnsuringAmericanLeadershipAVTech4.pdf>.

12 <https://www.nhtsa.gov/automated-driving-systems/voluntary-safety-self-assessment>.

13 *Transit Bus Automation Market Assessment*, Federal Transit Administration (FTA) Research, Report No. 0144, (Washington, D.C.: FTA and U.S. DOT, October 2019), <https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/134451/transit-bus-automation-market-assessment-fta-report-no0144.pdf>

- **Emerging Automated Urban Freight Delivery Concepts State of the Practice Scan (Intelligent Transportation Systems Joint Program Office [ITS JPO]):** This report characterizes the state of the industry in order to improve understanding of automated delivery vehicle concepts and industry activities, identify emerging issues, and present objective findings to stakeholders.¹⁴

GOAL 2: MODERNIZE THE REGULATORY ENVIRONMENT

U.S. DOT is responsible for overseeing the safety of motor vehicles and motor vehicle equipment and commercial vehicle operations. This safety mission remains the highest priority for the Department as it pursues an appropriate regulatory approach to overseeing the safety of ADS-equipped vehicles. U.S. DOT currently has several active and planned ADS-related rulemakings, some of which focus on removing unnecessary and unintended regulatory barriers, while others discuss when and how to regulate ADS performance. Many of these rulemakings address topics under NHTSA's authority, and one focuses on topics under the Federal Motor Carrier Safety Administration's (FMCSA) authority. These are discussed below.

GOAL 2A: STREAMLINE PATHS TO DEPLOYMENT

Exemptions and waivers are key near-term tools for safely enabling research, testing, and demonstration projects, as well as deployment, and U.S. DOT will continue to exercise these authorities where appropriate and consistent with all applicable legal requirements. NHTSA's authority to grant exemptions from the Federal Motor Vehicle Safety Standards (FMVSS) provides flexibility to allow for testing or demonstration of a wide

array of new technologies, including ADS,¹⁵ and allows for limited commercial deployment of vehicles that do not comply with FMVSS if an equivalent level of safety to a compliant vehicle is demonstrated.¹⁶ Exemptions also enable FMCSA to grant regulatory relief for motor carriers that cannot fully comply with the Federal Motor Carrier Safety Regulations (FMCSRs) through use of an ADS-equipped commercial motor vehicle (CMV), as long as they demonstrate that the exemption would likely achieve an equivalent level of safety.¹⁷

In general, exemptions from the FMVSS are limited in time, number of vehicles, and in some cases, location; they are not intended to allow indefinite noncompliance for large numbers of vehicles.¹⁸ As illustrated through the exemption petition that NHTSA granted in February 2020 (discussed below), exemptions can be a useful tool to safely permit testing and limited on-road deployment of some novel ADS-equipped vehicle concepts in the near-term. To help further these capabilities, U.S. DOT is working to streamline and modernize procedures for processing exemption petitions.

Objective: Issue exemptions and waivers consistent with applicable authorities

- **Grant of Temporary Exemption for a Low-Speed Vehicle with an Automated Driving System (NHTSA):** In February 2020, NHTSA granted a request from Nuro for a temporary exemption from certain requirements in FMVSS No. 500, "Low-speed vehicles" (Docket No. NHTSA-2019-0017).¹⁹ NHTSA set a number of terms and conditions on the grant of this exemption to facilitate proper oversight.

14 Cregger, J., Machek, E., Behan, M., Epstein, A., Lennertz, T., Shaw, J., and Dopart, K. (2020). "Emerging Automated Urban Freight Delivery Concepts: State of the Practice Scan." Intelligent Transportation Systems Joint Program Office (ITS JPO) Report 20-825. Performed for ITS JPO by the Volpe National Transportation Systems Center, U.S. Department of Transportation. November 20, 2020. Accessed at: <https://rosap.nhtl.bts.gov/>.

15 49 U.S.C. § 30114.

16 49 U.S.C. § 30113.

17 49 U.S.C. §§ 31315(b) and 31136(e), 49 CFR part 381, subpart C.

18 https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/understanding_nhtsas_current_regulatory_tools-tag.pdf.

19 <https://www.federalregister.gov/documents/2020/02/11/2020-02668/nuro-inc-grant-of-temporary-exemption-for-a-low-speed-vehicle-with-an-automated-driving-system>.

Objective: Streamline administrative processes for seeking exemptions and waivers

- ▶ **Notice of Proposed Rulemaking (NPRM): Expansion of Temporary Exemption Program to Domestic Manufacturers for Research, Demonstrations, and Other Purposes (NHTSA):** This NPRM proposes a new regulation allowing domestic entities to request exemptions to operate nonconforming vehicles on public roads for purposes of research, investigations, demonstrations, training, competitive racing events, show, or display, but not sale or lease.
- ▶ **Notice of Proposed Rulemaking: Updating the Process for Temporary Exemptions (NHTSA):** This action will seek comment on ways to facilitate the Department's consideration of petitions for exemption from existing Federal motor vehicle safety standards to allow for limited and risk-mitigated deployment of innovative safety technologies more efficiently, while ensuring appropriate levels of safety. NHTSA will seek to streamline the temporary exemption process and clarify agency expectations.

GOAL 2B: UPDATE EXISTING REGULATIONS TO REMOVE UNNECESSARY BARRIERS

Through its rulemaking activities, U.S. DOT has recognized that existing regulations may unintentionally and unnecessarily pose barriers to the introduction of novel vehicle designs expected to accompany some vehicles equipped with ADS and operating models that they enable. These barriers may impact ADS-dedicated vehicles that do not have the means for human driving (e.g., a steering wheel and brake and accelerator pedals), as well as ADS-equipped vehicles that may offer seating or other systems that have multiple modes, such as front seats that rotate. Novel commercial motor vehicle operating models enabled by ADS may be similarly affected by existing FMCSRs.

Objective: Conduct rulemaking and research to adapt existing FMVSS to remove unintended and unnecessary barriers to the introduction of novel vehicle designs and features enabled by ADS

In January 2018, NHTSA published a *Federal Register* notice requesting comment on existing regulatory barriers that may block the introduction and certification of ADS-equipped vehicles, particularly those without human controls in a manner that would not adversely affect safety. In response to comments, as well as the agency's own research, NHTSA commenced development of several rulemakings, including those discussed below.

- ▶ **Notice of Proposed Rulemaking: Occupant Protection for Automated Driving Systems (NHTSA):** Through this action, published in March 2020, NHTSA proposed to amend crashworthiness regulations that may be necessary to facilitate the certification of motor vehicles equipped without driver controls.²⁰
- ▶ **Advance Notice of Proposed Rulemaking (ANPRM) on Removing Regulatory Barriers for Automated Driving Systems (NHTSA):** Through this ANPRM, published in May 2019, NHTSA sought comments on existing motor vehicle regulatory barriers in the agency's crash avoidance FMVSS to the innovative vehicle designs that often accompany vehicles equipped with ADS.²¹
- ▶ **Advance Notice of Proposed Rulemaking: Considerations for Telltales, Indicators, and Warnings in ADS Vehicles (NHTSA):** Through this action, NHTSA will seek comments on amending the FMVSS to address the applicability and appropriateness of safety messaging (telltales, indicators, and warnings) in vehicles without conventional driver controls.
- ▶ **Advance Notice of Proposed Rulemaking: Passenger-less Delivery Vehicles Equipped with Automated Driving Systems (NHTSA):** Through this action, NHTSA will seek comments on amending regulations that may be

²⁰ <https://www.federalregister.gov/documents/2020/03/30/2020-05886/occupant-protection-for-automated-driving-systems>. <https://www.federalregister.gov/documents/2020/03/30/2020-05886/occupant-protection-for-automated-driving-systems>.

²¹ <https://www.federalregister.gov/documents/2019/05/28/2019-11032/removing-regulatory-barriers-for-vehicles-with-automated-driving-systems>.

necessary to facilitate the certification of motor vehicles without a passenger compartment.

- ▶ **Advance Notice of Proposed Rulemaking: Specialized Motor Vehicles with Automated Driving Systems (NHTSA):** NHTSA will seek comment on establishing regulatory requirements specific to classes of specialized motor vehicles equipped with ADS.
- ▶ **Notice of Interpretation (NHTSA):** In December 2020, NHTSA published a notice reestablishing NHTSA's position that the FMVSS test conditions and procedures establish the means by which the Agency will evaluate compliance with an applicable FMVSS, but that manufacturers are not required to test a vehicle's performance using the test conditions and procedures in an FMVSS to certify compliance with a standard, or ensure that their vehicles are designed to be capable of being tested according to all test conditions and procedures.²² The notice corrects statements made in a 2016 letter of interpretation to Google, Inc. implying that manufacturers could not validly certify FMVSS compliance unless the vehicle were designed such that NHTSA could verify compliance using all applicable FMVSS test procedures. That previous interpretation did not account for design-specific test procedures, such as requiring that fuel tanks be filled to certain percentages that would effectively render electric vehicles incapable of being certified compliant.

Objective: Adapt existing FMCSRs to remove unnecessary barriers to the operation of ADS-equipped commercial motor vehicles in interstate commerce

- ▶ **Notice of Proposed Rulemaking: Safe Integration of Automated Driving Systems-Equipped Commercial Motor Vehicles (FMCSA):** FMCSA is exploring amendments and revisions to certain FMCSRs to ensure the safe introduction of ADS-equipped commercial motor vehicles onto the Nation's roadways. The NPRM would propose changes to the commercial vehicle operations, inspection, repair, and maintenance

regulations that would prioritize safety and security, promote innovation, and foster a consistent regulatory approach to ADS-equipped CMVs, and would recognize the difference between human operators and ADS.

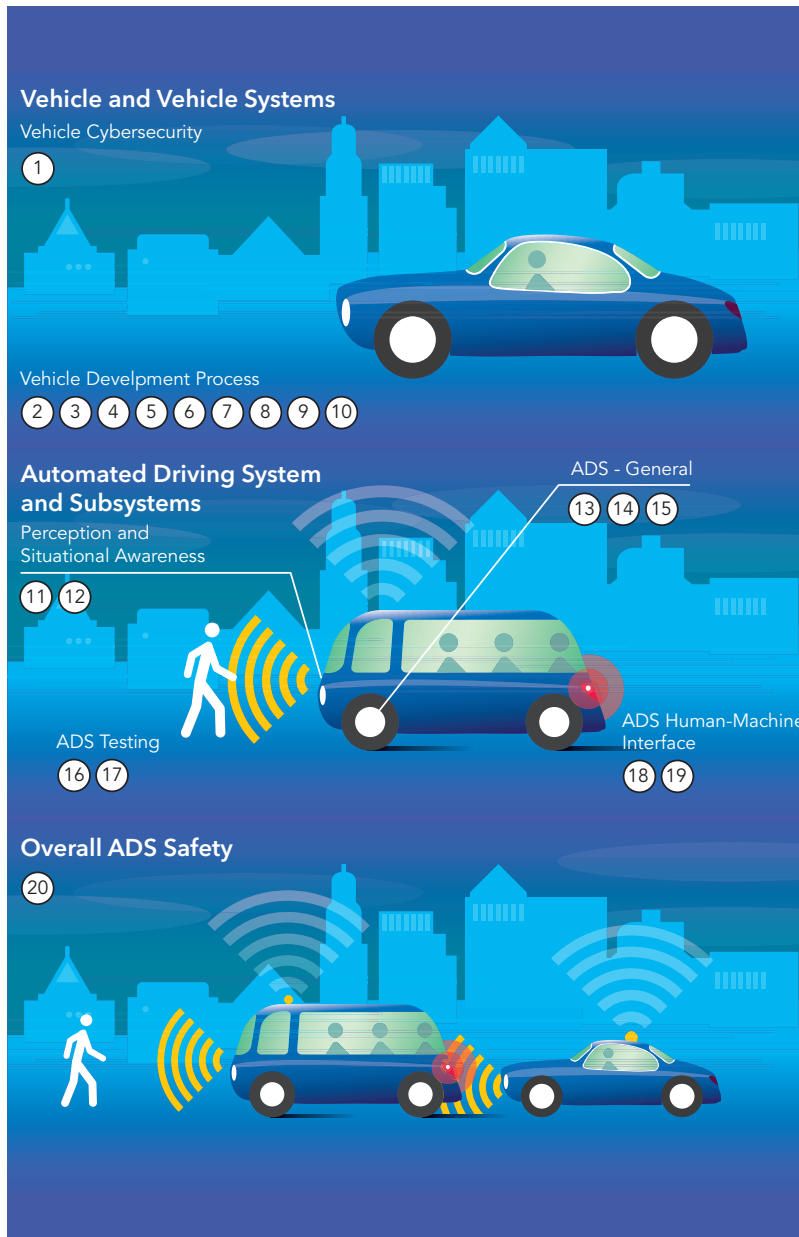
GOAL 2C: CONDUCT APPROPRIATE SAFETY OVERSIGHT OF ADS

Regulatory oversight of the deployment of ADS technologies may require using new approaches to assess safety performance and risk management. U.S. DOT is exploring new approaches to safety assurance and investigating innovative models and tools to evaluate the safety of ADS technologies.

Objective: Explore new approaches to safety assurance and investigate innovative models and tools to evaluate the safety of ADS technologies

- ▶ **Advance Notice of Proposed Rulemaking: Framework for Automated Driving System Safety (NHTSA):** Through this notice, published in November 2020, NHTSA requested comment on the potential creation of a safety framework that would provide a means for objectively defining, assessing, and managing the safety of ADS. The agency envisions that the framework would be coupled with one or more administrative mechanisms to implement engineering and process measures, and to facilitate appropriate agency safety oversight.
- ▶ **Voluntary Technical Standards:** The Department encourages and participates in the development of voluntary consensus standards. These standards are an existing mechanism for diverse industry partners to support technology development and interoperability (see figure below for an overview of voluntary consensus standards related to ADS).

²² <https://www.federalregister.gov/documents/2020/12/21/2020-28107/notice-regarding-the-applicability-of-nhtsa-fmvss-test-procedures-to-certifying-manufacturers>



VEHICLE CYBERSECURITY

1. ISO 21434 (forthcoming): Road Vehicles - Cybersecurity Engineering

VEHICLE DEVELOPMENT PROCESS

2. ISO 26262: Road Vehicles - Functional safety
3. ISO 15288: Systems and software engineering System lifecycle processes
4. ASPICE 3.0: Automotive Software Process Improvement and Capability Determination (ASPICE)
5. AUTOSAR: Automotive Open System Architecture (AUTOSAR)
6. IATF 16949/ISO 9001: International Standard for Automotive Quality Management Systems
7. MIL-STD-882E: Standard Practice for System Safety
8. SAE J2998: Model Description Documentation Recommended Practice for Ground Vehicle System and Subsystem Simulation
9. SAE J3049: Model Architecture and Interfaces Recommended Practice for Ground Vehicle System and Subsystem Dynamical Simulation
10. SAE AS5553A: Fraudulent/Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition*

PERCEPTION AND SITUATIONAL AWARENESS

11. ISO/PAS 21448 SOTIF: Road Vehicles -- Safety of the Intended Functionality
12. SAE J3088: Active Safety System Sensors

ADS - GENERAL

13. SAE J3016: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles
14. AVSC00002202004: AVSC Best Practice for Describing an Operational Design Domain: Conceptual Framework and Lexicon
15. SAE J3197: Automated Driving System Data Logger

ADS TESTING

16. SAE J3018: Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems
17. AVSC00001201911: AVSC Best Practice for safety operator selection, training, and oversight procedures for automated vehicles under test

ADS HUMAN-MACHINE INTERFACE

18. AVSC00003202006: AVSC Best Practice for Passenger-Initiated Emergency Trip Interruption
19. SAE J3114: Human Factors Definitions for Automated Driving and Related Research Topics

OVERALL ADS SAFETY

20. UL4600: Standard for Safety for the Evaluation of Autonomous Products

*Recently published NHTSA research explored the potential applicability of SAE AS5553A - originally developed for the aerospace industry - to the automotive sector (see Bielawski, R., Gaynier, R., Ma, D., Lauzon, S., & Weimerskirch, A. (2020, October). *Cybersecurity of Firmware Updates* (Report No. DOT HS 812 807). National Highway Traffic Safety Administration (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/cybersecurity_of_firmware_updates_oct2020.pdf)). Note that this standard has been updated to SAE AS5553C subsequent to the completion of the research and analysis conducted to inform this report.

GOAL 3: PREPARE THE TRANSPORTATION SYSTEM

The introduction of ADS-equipped vehicles may introduce new challenges to U.S. roadways. The Department is taking action so that the integration of ADS improves mobility and does not decrease operational efficiency of the Nation's surface transportation system. U.S. DOT is also seeking opportunities for ADS to expand access to safe, affordable, accessible, and independent mobility options for all people, including people with disabilities and older Americans.

U.S. DOT performs research and supports research by others by convening experts, supporting collaboration, and administering funding opportunities for demonstrations, pilots, and test deployments. These projects have focused on topics such as functional safety, safe CMV operations, human factors, cybersecurity, infrastructure, interoperability, and other topics. Future research will be subject to Congressional appropriations, technological development, and feedback from stakeholders.

Objective: Conduct targeted technical research

- ▶ **Automated Commercial Motor Vehicle Evaluation (ACE) Program (FMCSA):** The ACE program leverages a fleet of three tractor semi-trailers for testing and demonstration to enable research into specific ADS use cases, including roadside inspections and law enforcement scenarios; port drayage scenarios; emergency response and truck post-crash investigations; work zones; and international border crossings.
- ▶ **Automated Driving Systems (ADS) Operational Behavior and Traffic Regulation Information (FHWA):** This research assesses existing traffic laws and their applicability to ADS-equipped vehicles. It will identify needs regarding the development of a traffic regulations database.

- ▶ **Work Zone Data Exchange Demonstration Grants (ITS JPO):** The purpose of this research program is to increase the safety of the traveling public in both conventional and ADS-equipped vehicles through the production of consistent public work zone data feeds across jurisdictions.²³
- ▶ **Port Cooperative Driving Automation Drayage Truck Development and Testing (MARAD/FMCSA/ITS JPO):** The Port Cooperative Driving Automation Drayage Truck Development and Testing initiative is a demonstration of ADS in a port to demonstrate the benefit of automated truck movement in queues at ports and staging areas or warehouses. The project will demonstrate connected vehicles and automated vehicle technology applications with loading and unloading of chassis and containers, customs inspection point passage, gate passage, and short-haul drayage.

Objective: Provide funding for ADS-focused demonstrations, pilots, and deployments

- ▶ **Automated Driving System Demonstration Grants (Office of the Secretary [OST]):** On September 18, 2019, Secretary of Transportation Elaine L. Chao announced nearly \$60 million in Federal grant funding to eight projects in seven States across the country as part of the ADS Demonstration Grants Program. This program provides funding for a "highly automated vehicle research and development program" to support planning, direct research, and demonstration grants for ADS and other driving automation systems and technologies.²⁴
- ▶ **Integrated Mobility Innovation (IMI) Grants (FTA):** The IMI Demonstration program's primary purpose is to fund projects, including transit bus automation, mobility on demand, and mobility payment integration, which demonstrate innovative and effective approaches, practices, partnerships, and technologies to enhance

²³ <https://www.transportation.gov/av/data/wzdx#:~:text=WZDx%20Demonstration%20Grants&text=This%20is%20an%20one%2Dtime,on%20the%20WZDx%20Specification%20development>.

²⁴ United States Department of Transportation. (2019, September 18). U.S. Secretary of Transportation Announces Automated Driving System Demonstration Grant Winners. Washington, DC. Retrieved from <https://www.transportation.gov/briefing-room/us-secretary-transportation-announces-automated-driving-system-demonstration-grant>.

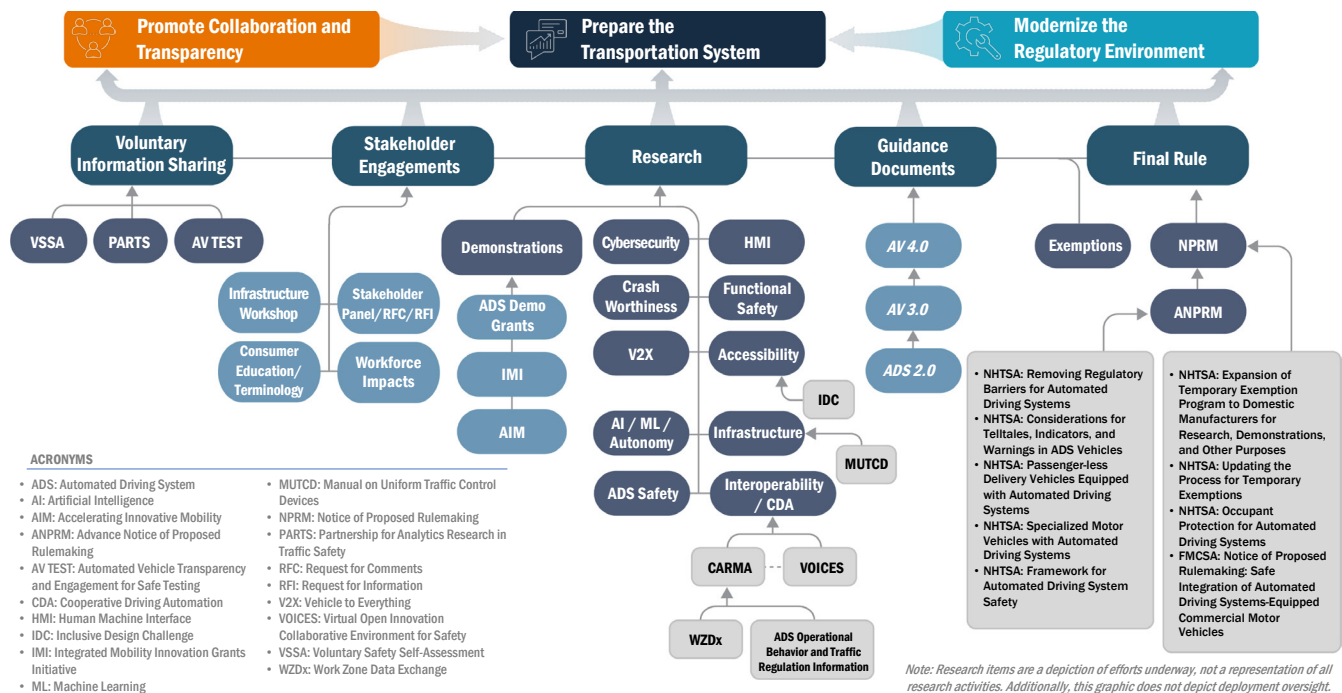
public transportation effectiveness, increase efficiency, expand quality, promote safety, and improve the traveler's experience.²⁵

- ▶ **Accelerating Innovative Mobility (AIM) Initiative (FTA):** The AIM initiative highlights FTA's continuing commitment to support and advance innovation in the transit industry. FTA provides AIM challenge grants to encourage transit agencies to experiment with forward-thinking service models and solutions, such as transit automation.²⁶
- ▶ **Inclusive Design Challenge (OST):** The challenge seeks innovative design solutions that can enable people with physical, sensory, and cognitive disabilities to use ADS-equipped vehicles through a two-stage competition with a prize of up to \$5 million.²⁷

Objective: Update infrastructure standards to reflect ADS technologies

- ▶ **Manual on Uniform Traffic Control Devices (MUTCD) Update (FHWA):** FHWA is assessing the MUTCD to identify how ADS-equipped vehicles and other transportation technologies should be considered in the MUTCD. This involves investigating whether greater standardization and consistency in traffic control devices, particularly lane markings and signage, could be beneficial to support safe interaction between ADS-equipped vehicles and the roadway infrastructure. In December 2020, FHWA released a Notice of Proposed Amendment (NPA) to gather input and address these issues.²⁸

The initiatives and activities the Department conducts are directly related to the goals outlined above. The figure below depicts how the Department's efforts inform these three goals. Note: the figure does not depict a comprehensive list.



25 <https://www.transit.dot.gov/IMI/>.

26 <https://www.transit.dot.gov/AIM/>.

27 United States Department of Transportation. (2020, May 6). Inclusive Design Challenge. Retrieved from <https://www.transportation.gov/accessibility/incluedesign>.

28 <https://www.federalregister.gov/documents/2020/12/14/2020-26789/national-standards-for-traffic-control-devices-the-manual-on-uniform-traffic-control-devices-for>



HOW DO U.S. DOT ACTIONS SUPPORT ADS DEVELOPMENT?

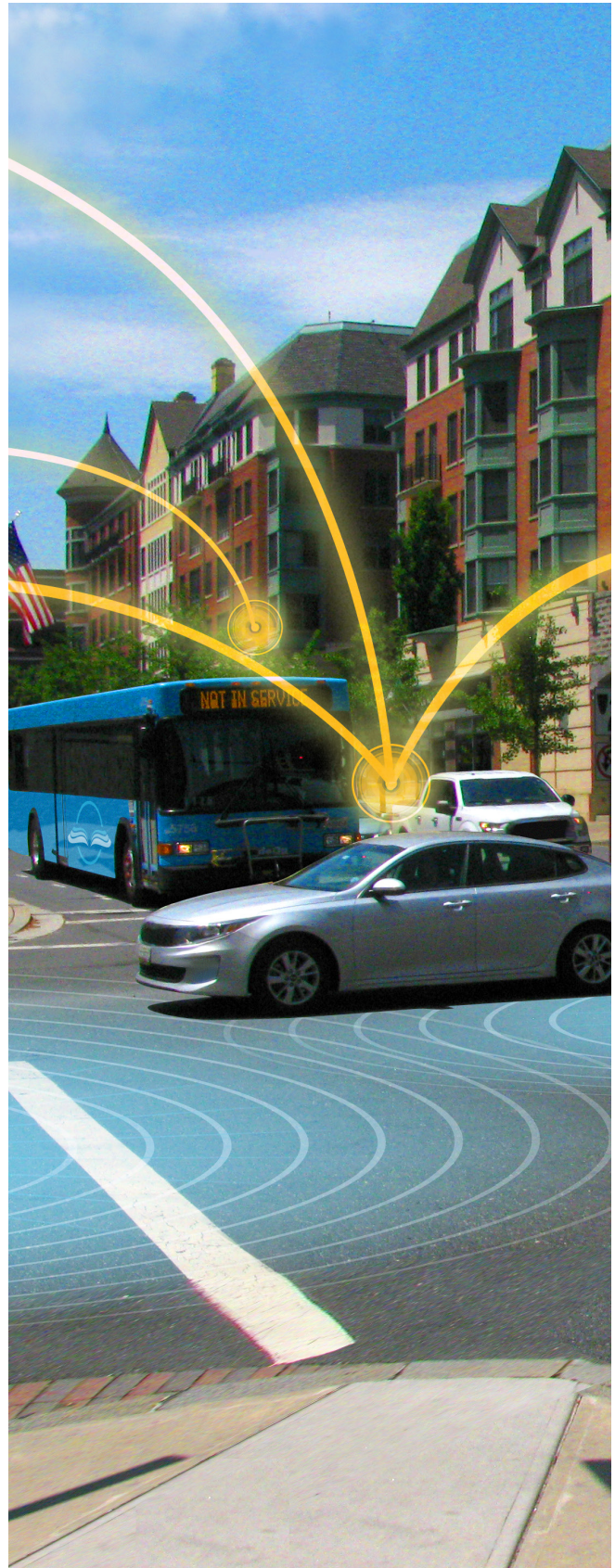


How Do U.S. DOT Actions Support ADS Development?

Many companies are actively developing and testing ADS technology throughout the United States. Although some ADS-equipped vehicles are being tested without an operator present in the vehicle in defined areas, most ADS testing on public roads currently involves the use of safety drivers to monitor vehicle operations. As noted previously, no vehicle equipped with an ADS is available for purchase in the United States today, and most of the vehicles being tested are still only prototypes.

Although ADS capabilities and applications still vary significantly in vehicle design and intended purpose, the *Comprehensive Plan* explores five use cases as a way to illustrate how U.S. DOT activities address different aspects of ADS technology, vehicles, and operational environments. The use cases provide a framework to understand how U.S. DOT activities relate to current ADS industry developments. Each use case is described in general terms based on public information about current ADS testing, and is not exhaustive. They are not intended to describe, nor represent, an endorsement by U.S. DOT of any specific company or system. Instead, they reflect a summary of common characteristics and capabilities. Moreover, these use cases do not represent a complete picture of all current or potential ADS-equipped vehicles or operating models, but rather an illustrative set of examples.

Following each use case summary, the plan lists examples of related U.S. DOT actions and activities. Most of the actions described apply to many potential use cases, as U.S. DOT generally addresses crosscutting issues rather than any particular ADS use case or technology. For example, the recently published Advance Notice of Proposed Rulemaking: Framework for Automated Driving System Safety pertains to ADS broadly. The examples in this section illustrate where selected U.S. DOT actions relate specifically to certain ADS, vehicle, or service characteristics.



OCCUPANT-LESS LOW-SPEED VEHICLES

Occupant-less Low-Speed Vehicles represent one emerging application of an ADS. Companies developing these vehicles may form partnerships—for example, with grocers or restaurants to provide delivery services to the partner company’s customers. Customers would be able to retrieve their purchases from the automated delivery vehicle. Unlike other vehicle categories that must meet a wide array of FMVSS, these vehicles are only required to meet the requirements of *FMVSS No. 500*, “Low Speed Vehicles (LSVs),” which poses far fewer regulatory barriers to deployment. Therefore, a manufacturer could implement this use case by either designing a compliant vehicle or seeking an exemption, similar to what NHTSA recently granted to Nuro (85 FR 7826, February 11, 2020).

Vehicles currently being developed and targeted for deployment for this application are equipped with a Level 4 ADS (per SAE J3016). To be considered an LSV, the vehicle must be limited to a maximum speed of 25 miles per hour and have a gross vehicle weight rating (GVWR) of less than 3,000 pounds. Thus, many of the vehicles in development generally have operational design domains (ODD) that are restricted to neighborhood roads with lower speed limits (i.e., not highways), and are often limited to fair weather conditions. It is foreseeable that the uses may expand over time; for example, by increasing the maximum speed capabilities of the vehicles, though changes to vehicle speed or weight would mean that the vehicle would likely no longer be a “low-speed vehicle,” and would need to comply with the full suite of FMVSS.

U.S. DOT activities addressing this use case

- ▶ Manufacturers that use vehicles which do not comply with the FMVSS, such as those without manual driving controls, must seek an exemption. For example, in February 2020, NHTSA granted a request from Nuro for a temporary exemption from certain FMVSS, with



Example Characteristics

- ▶ **Operational Environment:** Low-speed roads, urban and suburban
- ▶ **Speed:** Up to 25 mph
- ▶ **Automated Control (SAE Level):** 4 or 5
- ▶ **Application:** Freight delivery and transport of goods

terms and conditions in place to facilitate NHTSA’s oversight.²⁹

- ▶ In the longer term, changes to the regulations themselves could further support deployment. NHTSA plans to consider this issue in the rulemaking on Removing Barriers to Automated Driving Systems, as well as a future ANPRM on Passenger-less Delivery Vehicles Equipped with Automated Driving Systems.³⁰ These two rulemakings address the currently known unintended barriers at the Federal level to the commercialization of this use case.
- ▶ The ITS JPO is sponsoring exploratory research on emerging automated freight delivery applications and technologies, including low-speed occupant-less delivery, to document current industry activity such as pilots and early deployments.

²⁹ https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/nuro_grant_notice_final-unofficial.pdf.

³⁰ <https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202004&RIN=2127-AM18>.

PASSENGER VEHICLE CONDITIONAL DRIVING AUTOMATION

A passenger vehicle capable of conditional driving automation is a potential application of ADS in the existing ownership model (i.e., individual ownership rather than a fleet service). In this application, the ADS would be capable of performing the complete dynamic driving task (DDT) within a specific set of conditions, and the driver would be expected to be ready to take back control when the system requests it. Only a few companies have expressed continued interest in pursuing this use case, primarily in lower-risk driving environments such as during low-speed stop-and-go traffic environments.

Companies developing and testing the traffic jam pilot ADS state they are pursuing a solution to a commuter's need, where traffic may be at a relative standstill, and the ADS allows a driver to relinquish control and engage in other activities until the system reaches its design limits and hands back control of the DDT to the driver.³¹ If the driver cannot re-engage within a time period specified as reasonable by the companies, then companies suggest the vehicle would safely bring itself to a standstill.

This type of ADS application involves manual driving by a driver; hence, vehicles are designed to meet all applicable FMVSS. Under the current FMVSS, companies can deploy these types of vehicles by designing a compliant vehicle.

U.S. DOT activities addressing this use case

Researchers continue to investigate vehicle systems that could help human drivers maintain awareness and safely take over the driving task. NHTSA's human factors research portfolio is studying topics related to this use case, ranging from supporting drivers' understanding of ADS functionality to determining the best way to transition the driver to control of the vehicle. For example, in situations when ADS systems break down, and control needs to be handed over either to the driver or when the minimal risk condition must be automatically achieved. Current work



Example Characteristics

- ▶ **Operational Environments:** Variable, can operate in both urban and highway environments
- ▶ **Speed:** All normal vehicle operating speeds, both low and high
- ▶ **Automated Control (SAE Level):** 3
- ▶ **Application:** Conditional driving automation in passenger vehicles

is aimed at determining the kinds of information drivers may need to regain control successfully and quickly, as well as approaches to presenting this information. Part of the take-over process will involve a vehicle warning or notification. Another study is currently exploring the temporal components of the warning or notification to gain insights on how long it takes to build sufficient situational awareness to resume full manual driving safely, depending on different types and durations of disengagement.

31 E.g., see BMW Group Safety Assessment Report: Level 3 Automated Driving System (<https://www.bmwusa.com/content/dam/bmwusa/innovation-campaign/autonomous/BMW-Safety-Assessment-Report.pdf>) or Introducing DRIVE PILOT: An Automated Driving System for the Highway (<https://www.daimler.com/documents/innovation/other/2019-02-20-vssa-mercedes-benz-drive-pilot-a.pdf>)

PASSENGER VEHICLE AUTOMATED DRIVING SYSTEMS

A purpose-built, dedicated ADS vehicle with no manual driving controls is available for purchase by consumers, or as part of a dedicated fleet used to provide on-demand mobility services. The vehicle is to be used within a geo-fenced area, when weather and roadway conditions are suitable for safe operation. The vehicle is operated entirely by the Automated Driving System with no ability for the occupants to take control of the vehicle. The vehicle may communicate operating information over a telecommunications network to a remote location capable of operating the vehicle remotely.

U.S. DOT activities addressing this use case

- ▶ Manufacturers that use vehicles that do not comply with the FMVSS, such as those without manual driving controls, must seek an exemption. For example, in February 2020, NHTSA granted a request from Nuro for a temporary exemption from certain FMVSS, with terms and conditions in place to facilitate NHTSA's oversight.³²
- ▶ Changes to the regulations themselves could facilitate deployment without need of an exemption. NHTSA's rulemakings to remove barriers to Automated Driving Systems are intended to would eliminate unnecessary and unintended obstacles, while maintaining levels of safety provided in existing standards. Simultaneously, NHTSA is engaged in activities to establish a regulatory or subregulatory framework for ADS safety. This framework would objectively define, assess, and manage the safety of ADS performance while ensuring the needed flexibility to enable further innovation.



Example Characteristics

- ▶ **Operational Environment:** Variable, can operate in both urban and highway environments
- ▶ **Speed:** All normal vehicle operating speeds, both low and high
- ▶ **Automated Control (SAE Level):** 4
- ▶ **Application:** Driving automation in passenger vehicles

³² https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/nuro_grant_notice_final-unofficial.pdf.

AUTOMATED TRUCKING OPERATIONS

Several automated trucking companies are developing Level 4 ADSs that are specifically for use on CMVs and have an ODD of limited-access highways, either from exit-to-exit or on-ramp to off-ramp.³³ Several variations exist within this broad operational concept.

ADS-equipped CMVs may be capable of operating within their ODD with no human operator in the vehicle, and then, if necessary, may be operated by a human in other environments. Alternatively, some companies may explore a “hub-to-hub” operating model that extends the trip of Level 4 ADS-equipped CMVs from the shipping facility where the truck trailer is loaded to its destination at a receiving customer’s location.

In any of these variations, an ADS would be controlling the CMV at highway speeds over potentially long distances that could span multiple States. These vehicles may be configured to be both ADS- and human-driver operable and, therefore, may retain conventional manual driving controls and cabin configurations.

Many companies have publicly announced efforts to develop and test commercial motor vehicles with driving automation, including investment from traditional truck manufacturers and suppliers, as well as technology companies, startups, and venture capital firms.³⁴ Moreover,

several companies are already testing ADS-equipped CMVs and operational models in revenue service, including on routes in California, Arizona, Georgia, and Texas.^{35, 36, 37, 38, 39}

In the context of ADS-equipped CMVs, FMCSA will continue to exercise its existing statutory authority over the safety of motor carriers operating in interstate commerce, the qualifications and safety of CMV drivers, and the safe operation of commercial trucks and motor coaches.⁴⁰ FMCSA retains its authority to take enforcement action if an automated system inhibits safe operation.⁴¹ FMCSA previously stated that the agency’s 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. Currently, no regulations specifically address Levels 4 and 5, including in key areas such as equipment, repair, and maintenance.

U.S. DOT activities addressing this use case

- ▶ In AV 3.0, U.S. DOT clarified that 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.
- ▶ In July 2019, FMCSA released an ANPRM seeking comment on questions regarding several key regulatory

33 E.g., see voluntary safety self-assessments released by Ike, Kodiak, Starsky Robotics, TuSimple, and Waymo: <https://www.nhtsa.gov/automated-driving-systems/voluntary-safety-self-assessment>.

34 S. Clevenger, “TMC Takes Stock of Latest Developments in Automated Driving, Platooning,” *Transport Topics*, March 20, 2019, <https://www.ttnews.com/articles/tmc-takes-stock-latest-developments-automated-driving-https://www.ttnews.com/articles/tmc-takes-stock-latest-developments-automated-driving-platooning>; Aarian Marshall, “The DOT Says ‘Drivers’ Don’t Have to Be Human,” *Wired*, October 4, 2018, <https://www.wired.com/story/dot-says-drivers-dont-have-to-be-human/>.

35 “Embark, Frigidaire®, and Ryder Partner to Pilot Automated Driving Technology,” Press Release, *BusinessWire*, last modified November 13, 2017, <https://www.businesswire.com/news/home/2017112005077/en/Embark-Frigidaire%C2%AE-Ryder-Partner-Pilot-Automated-Driving>.

36 Waymo Team, “Same driver, different vehicle: Bringing Waymo self-driving technology to trucks,” *Medium*, last modified March 9, 2018, <https://medium.com/waymo/same-driver-different-vehicle-bringing-waymo-self-driving-technology-to-trucks-e55824b55b8f>.

37 TuSimple, Leading Fully-autonomous Truck Company, Announces Business Expansion with New Self-driving Routes, Customer Growth and Partners,” Press Release, *TuSimple*, last modified January 7, 2019, <https://www.prnewswire.com/news-releases/tusimple-leading-fully-autonomous-truck-company-announces-business-expansion-with-new-self-driving-routes-customer-growth-and-partners-300773546.html>.

38 S. O’Kane, “UPS has been quietly delivering cargo using self-driving trucks,” *The Verge*, August 15, 2019, <https://www.theverge.com/2019/8/15/20805994/ups-self-driving-trucks-autonomous-delivery-tusimple>.

39 “Self-Driving Truck Startup Kodiak Robotics Expands Into Texas and Begins First Freight Deliveries,” Press Release, *Kodiak Robotics*, August 6, 2019, <https://www.prnewswire.com/news-releases/self-driving-truck-startup-kodiak-robotics-expands-into-texas-and-begins-first-freight-deliveries-300897021.html>.

40 49 U.S.C. chaps. 311, 313, and § 31502.

41 49 CFR 396.7(a).

areas to understand better how changes to its rules can account for significant differences between human operators and ADS. These questions focus on topics such as: requirements of human drivers; Commercial Driver's License endorsements; hours of service rules; medical qualifications; distracted driving; safe driving, inspection, repair, and maintenance; roadside inspections; and cybersecurity. FMCSA is developing an NPRM that would propose rules to provide motor carriers with a uniform regulatory framework for deploying Levels 4 and 5 ADS-equipped CMVs in interstate commerce.

- ▶ FMCSA plans to host a series of collaborative sessions with ADS-equipped CMV developers, truck manufacturers, motor carriers, industry associations, and other interested stakeholders to facilitate development of industry-based consensus standards for the operation of ADS-equipped CMVs.
- ▶ U.S. DOT has awarded ADS Demonstration Grants to projects that include a significant focus on ADS-equipped CMVs.⁴²
- ▶ FMCSA has initiated its ACE Program to conduct ADS Performance Research.
- ▶ U.S. DOT is actively studying the potential impacts of ADS on the Nation's long-haul trucking workforce.



Example Characteristics

- ▶ **Operational Environment:** Limited-access highways
- ▶ **Speed:** Highway speeds
- ▶ **Automated Control (SAE Level):** 4
- ▶ **Application:** Long-distance freight transportation

⁴² <https://www.transportation.gov/av/grants>.

LOW-SPEED PASSENGER SHUTTLE

Low-speed passenger shuttles represent another emerging application of an ADS. Companies developing these vehicles may partner with other companies, State governments, local governments, universities, or other institutions to provide mobility options, especially for first- and last-mile transport options, to customers of a business, citizens of a State or city, students, or others in the community that they intend to serve, including for entertainment events and recreational activities. Unlike other vehicle categories that must meet a wide array of FMVSS, some of these vehicles are only required to meet the requirements of *FMVSS No. 500*, “Low Speed Vehicles (LSVs),” which poses far fewer regulatory barriers to deployment. Therefore, a manufacturer could deploy these by either designing a compliant vehicle or seeking an exemption.

Vehicles currently being developed and targeted for deployment for this application are equipped with a Level 4 ADS (per SAE J3016). To be considered an LSV, the vehicle must be limited to a maximum speed of 25 miles per hour and have a GVWR less than 3,000 pounds. Thus, many of these vehicles in development generally have ODDs that are restricted to neighborhood roads with lower speed limits (i.e., not highways) and are often limited to fair weather conditions. Some, but not all, of the low-speed shuttles fall within the definition of an LSV. It is foreseeable that their uses may also expand over time; for example, by increasing the maximum speed capabilities or weight of the vehicles, meaning they, along with those that currently do not meet the LSV definition, would need to comply with the full suite of FMVSS, as applicable.

U.S. DOT activities addressing this use case

- ▶ FTA is exploring automation in bus transit through funding for demonstration projects, such as the Integrated Mobility Innovation Demonstration and the Accelerating Innovative Mobility Programs; analysis of



Example Characteristics

- ▶ **Operational Environment:** Roadways with speed limits of no higher than 25 miles per hour
- ▶ **Speed:** Up to 25 miles per hour
- ▶ **Automated Control (SAE Level):** 4
- ▶ **Application:** Passenger transportation

the resulting data; and outreach to the transportation community to share what is being learned through ongoing knowledge transfer.⁴³ Research topics include policy, human factors, benefit-cost, and others.

- ▶ NHTSA's NPRMs on Updating the Process for Temporary Exemptions and the Expansion of Temporary Exemption Program to Domestic Manufacturers for Research, Demonstrations, and Other Purposes are expected to streamline the exemption process and allow domestic startup companies the ability to seek approval to test or demonstrate these vehicles on public roads, which would be subject to the same safety scrutiny as currently exists for imported vehicles.

⁴³ For more information and research results, see <https://www.transit.dot.gov/automation-research>.



HOW DOES U.S. DOT WORK WITH STAKEHOLDERS ON ADS?

How Does U.S. DOT Work with Stakeholders on ADS?

The implications of ADS integration cut across industries and agencies, and U.S. DOT is committed to ongoing engagement with stakeholders. Using tools such as requests for information and comment, listening sessions, roundtables, and workshops, and education and outreach, U.S. DOT obtains input from a diverse range of stakeholders and regularly incorporates feedback into the research and planning process. This section outlines key initiatives with governmental, industry, and international partners, and the figure below summarizes U.S. DOT's stakeholder outreach activities since the publication of *ADS 2.0* in 2017.

CROSS-GOVERNMENT PARTNERSHIPS

In 2019, U.S. DOT and the White House developed *AV 4.0* to coordinate automated vehicle activities across 38 Federal departments, independent agencies, commissions, and Executive Offices of the President. This milestone document clarifies the U.S. Government's approach toward realizing the benefits of automated vehicles and provides a framework for cross-governmental collaboration, with an emphasis on investments in the areas of safety, mobility, security and cybersecurity, infrastructure, and connectivity.

INTERNATIONAL COLLABORATION

U.S. DOT is leading the global development of principles and public policies for facilitating and guiding the testing and introduction of automated vehicles. The Department engages with partners worldwide in a variety of bilateral and multilateral forums, such as the United Nations Economic Commission for Europe Global Forum for Road Traffic Safety and World Forum for the Harmonization of Vehicle Regulations; the G7 Expert Group on Automated and Connected Driving; the International Technical Conference on the Enhanced Safety of Vehicles; the SAE

World Congress; the Consumer Electronics Show; and the ITS World Congress. U.S. DOT is also collaborating on research and testing to promote U.S. best practices regarding safety standard development and regulatory policies and procedures. These activities are expected to demonstrate that the U.S. science- and data-based system of regulation results in the most robust safety standards, which can increase economic competitiveness, improve foreign market access for U.S. industry, and reduce barriers to trade.

PUBLIC ENGAGEMENT

U.S. DOT shares information with the public regarding issues that affect the safety of, and interaction with, automated vehicles. This information is shared via a wide range of communications tools and formats including frequently asked questions, fact sheets, proceedings, and papers; webinars, panels, and conferences; technical assistance; and information and education campaigns.

Selected U.S. DOT Automation Public Input Activities

Events		Federal Register Requests
	2020	
SEP: AV TEST Initiative Test Tracking Tool Launch Event JUL: AV TEST Virtual Event: State and Local Governments JUN: AV TEST Initiative Launch Events JUN: Inclusive Design Challenge Informational Webinar MAY: <i>Increasing Worker and Driver Safety through Access to Work Zone</i> Virtual Event		DEC: FHWA MUTCD Notice of Proposed Amendment NOV: NHTSA ANPRM on Framework for Automated Driving System Safety APR: AV 4.0 RFC Docket closed JAN: Inclusive Design Challenge RFI closed
NOV: NHTSA Research Public Meeting OCT: Access and Mobility for All Summit MAR: AV Workforce Event	2019	DEC: AV 3.0 Docket closed DEC: NHTSA ANPRM: Pilot Program for Collaborative Research on Motor Vehicles With High or Full Driving Automation NOV: AV Workforce docket closed MAY: FMCSA RFC Concerning Federal Motor Carrier Safety Regulations (FMCSRs) Which May Be a Barrier to the Safe Testing and Deployment of Automated Driving Systems-Equipped Commercial Motor Vehicles on Public Roads
NOV: FHWA National Dialogue in Dallas OCT: FHWA National Dialogue in Phoenix SEP: FHWA National Dialogue in Chicago AUG: FHWA National Dialogue in Seattle JUL: FMCSA public meeting on Federal Motor Carrier Safety Regulations Which May Be Barrier to Safe Integration of Automated Driving Systems in Commercial Vehicle Operations JUN: FHWA National Dialogue in Detroit JUN: FHWA National Dialogue in Philadelphia JUN: FMCSA listening session on Federal Motor Carrier Safety Regulations (FMCSRs) Which May Be a Barrier to the Safe Integration of Automated Driving Systems (ADS) in Commercial Motor Vehicle (CMV) Operations MAR: AV 3.0: Public Listening Summit MAR: NHTSA Public Meeting on Removing Regulatory Barriers for Vehicles with Automated Driving Systems	2018	MAY: FRA RFI on Automation in the Railroad Industry MAY: PHMSA RFI on Regulatory Challenges to Safely Transporting Hazardous Materials by Surface Modes in an Automated Vehicle Environment MAR: NHTSA RFC on Removing Regulatory Barriers for Automated Driving Systems
DEC: Roundtable on Data for Automated Vehicle Safety NOV: Listening Session on Automated Driving Systems 2.0: A Vision for Safety OCT: Automated Driving Systems: Voluntary Safety Self-Assessment Public Workshop	2017	MAR: FHWA RFI on Integration of Automated Driving Systems (ADS) into the Highway Transportation System MAR: FTA RFC on Automated Transit Buses Research Program MAR: FTA RFC on Removing Barriers to Transit Bus Automation



PREPARING FOR THE FUTURE OF TRANSPORTATION: U.S. DOT RESEARCH HIGHLIGHTS



In addition to its ADS-focused activities, U.S. DOT is conducting research on enabling and complementary technologies that support the integration of ADS into the transportation systems. This research facilitates collaboration both within the government and with external stakeholders and will contribute to more seamless multimodal operations.

Photo Credit: Federal Highway Administration

CARMASM AND COOPERATIVE DRIVING AUTOMATION

CARMA is an FHWA-initiated open source platform for the research and development of cooperative driving automation (CDA). CDA enables communication between vehicles, infrastructure devices, and road users such as pedestrians and cyclists. FHWA's CDA research focuses on automated vehicles working together and with roadway infrastructure to increase safety and improve operational efficiency.

CARMA was designed using open source software and was created to work collaboratively with any vehicle, hardware, or control system. CARMA enables the research and development of CDA capabilities to support transportation system management and operations (TSMO). FHWA will also conduct testing on TSMO use cases using CARMA to show safety and mobility impacts, as well as enable rapid prototype, early standards development, and implementation. In partnership with FHWA, the FMCSA will

also be using CARMA on its test CMVs to conduct testing related to law enforcement interactions such as roadside inspections.

CARMA is a multimodal effort between FHWA, FMCSA, the Maritime Administration (MARAD), the Intelligent Transportation Systems Joint Program Office (ITS JPO), and the Volpe National Transportation Systems Center. Use of the platform is supported by the CARMA Collaborative, which consists of a growing community of platform users, prospective users, and other stakeholders, including government agencies, industry, and academia. The Collaborative aims to propel CDA research and development and encourage industry adoption of CDA concepts and capabilities.⁴⁴ The figure below identifies examples of voluntary consensus standards related to CDA.



Connected Vehicles and Cooperative Driving Automation

SAE J3216: Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles

SAE J2945: On-board System Requirements for Vehicle-to-Vehicle (V2V) Safety Communications

SAE J2266: Location Referencing Message Specification (LRMS)

SAE J1746: ISP-Vehicle Location Referencing Standard

⁴⁴ <https://highways.dot.gov/research/operations/CARMA-Collaborative>



Virtual Open Innovation Collaborative Environment for Safety (VOICES) Proof of Concept (PoC)

VOICES PoC will be a distributed virtual platform that will enable stakeholder virtual collaboration among participating entities (public sector including State and local governments, private sector, and academic institutions) in an intellectual property-protected virtual collaborative environment for research and interoperability testing of prototype CDA applications.⁴⁵ As the first use case, the VOICES PoC will focus on CDA, research, and interoperability-distributed testing of Cooperative Automated Driving Systems applications as defined by SAE J3216: *Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles*.



Partnership for Analytics Research in Traffic Safety (PARTS)

PARTS is a government/industry partnership in which partners voluntarily share and analyze safety-related data and information among each other, to facilitate early identification of safety-related issues in advanced automobile technologies and to develop efficient mitigations and improvements for those issues. As ADS vehicles are introduced into our transportation system, PARTS anticipates including safety analysis of ADS vehicles.



⁴⁵ <https://researchhub.bts.gov/results?id=57acbfd1-734e-41bf-af9b-5a8456972c03>



WHAT'S NEXT?

What's Next?

Automated Driving Systems have the potential to significantly improve safety and mobility for all travelers. The U.S. DOT will continue to explore the benefits of this innovative technology with an approach that prioritizes safety, is informed directly by input from stakeholders and research by the Department, and remains technology-neutral.

Automated Driving Systems and vehicle technologies will continue to evolve and progress in the future. Significant uncertainties remain around ADS and how they may impact travelers, public agencies, and the broader transportation system. This uncertainty poses challenges to the planning process, requiring a strategic and flexible approach. In addition to unknowns regarding technology advancements, the Department must consider potential changes in funding availability, future research outcomes, and broader societal needs and trends that may influence adoption.

U.S. DOT's *Comprehensive Plan* is iterative and flexible enough to adapt to new challenges and opportunities that may emerge from ADS. The Department will periodically review its approach, in consultation with stakeholders, and make adjustments to reflect the current state of technology and emerging industry developments. By creating robust frameworks for collaboration, research, and deployment, the Department has established the foundation to respond to uncertainty with a coordinated and multimodal approach.

Working together, we are confident that Automated Driving Systems will contribute to a transportation system that keeps the traveling public safe, provides mobility options for all, and enhances economic growth.



U.S. Department of Transportation

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