

Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0

AV 4.0 presents a unifying posture to inform collaborative efforts in automated vehicles for all stakeholders and outlines past and current Federal Government efforts to address these areas of concern. AV 4.0 establishes U.S. Government principles that consist of three core interests, each of which is comprised of several sub-areas. [Documented as goals and objectives in this StratML rendition.] While AV 4.0 cannot practically address all areas related to AVs, our intent is to facilitate and guide future efforts in a safe and consistent way in order to embolden AV innovators and entrepreneurs and enable the public.

The United States Government is committed to fostering surface transportation innovations to ensure the United States leads the world in automated vehicle (AV) technology development and integration while prioritizing safety, security, and privacy and safeguarding the freedoms enjoyed by Americans. The U.S. Government recognizes the value of industry leadership in the research, development, and integration of AV innovations. Such innovation requires appropriate oversight by the Government to ensure safety, open markets, allocation of scarce public resources, and protection of the public interest. Realizing the full potential of AVs will require collaboration and information sharing among stakeholders from industry, State, local, tribal, and territorial governments, academia, not-for-profit organizations, standards development organizations (SDO), and the Federal Government.

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DEMONSTRATION ONLY



National Science & Technology Council (NSTC)

Stakeholder(s):

Michael Kratsios :
United States Chief Technology Officer

OSTP :

The White House OSTP encourages a future in which the United States is a global leader in AV technology. The U.S. Government offers AV innovators and entrepreneurs an ideal environment to develop and integrate AV technology while prioritizing safety, security, and privacy for users and communities; promoting efficient markets; and facilitating coordinated research efforts nationwide. In preparation for emerging and innovative AV technology, the U.S. Government will provide policies, guidance, and best practices; conduct appropriate research and pilot programs; and offer necessary assistance to help plan for and invest in a dynamic and flexible future for all Americans.

Automated Vehicle Fast Track Action Committee

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U.S. Department of Transportation (DOT)

Stakeholder(s):

Elaine L. Chao :
United States Secretary of Transportation

Vision

AV innovators and entrepreneurs are emboldened and the public is enabled

Mission

To facilitate and guide future efforts AV in a safe and consistent way

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I. Protection

Protect Users and Communities

Stakeholder(s)

AV Users

Communities

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. Safety

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... Safety is a key component for the development of a transportation system that efficiently and effectively incorporates AVs. The U.S. Government prioritizes safety for vehicle operators—including low-speed vehicles, motorcycles, passenger vehicles, medium-duty vehicles, and heavy-duty commercial motor vehicles (CMVs), such as large trucks and buses—and vehicle occupants, pedestrians, bicyclists, and all other road users.

Stakeholder(s):

Department of Transportation :

USDOT's mission is to ensure our Nation has the safest, most efficient, and modern transportation system in the world, which improves the quality of life for all American people and communities, from rural to urban, and increases the productivity and competitiveness of American workers and businesses. As a steward of the Nation's roadway transportation system, the Federal Government plays a significant role in facilitating the safe and effective integration of AVs into the existing transportation system, alongside conventional vehicles, pedestrians, bicyclists, motorcyclists, and other road users. Furthermore, USDOT is provided with significant research, regulatory, and enforcement authority to protect the safety of the American public pertaining to various aspects of AVs, to include establishing manufacturing, performance, and operational standards and supporting research that explores societal implications and interactions as AVs development and testing matures and eventually integration becomes increasingly common. Key modal agencies that are most relevant to surface transportation AVs are NHTSA, Federal Motor Carrier Safety Administration (FMCSA), Federal Transit Administration (FTA), and Federal Highway Administration (FHWA):

NHTSA :

NHTSA's 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 sets and enforces safety performance standards for motor vehicles and motor vehicle equipment, identifying safety defects, and

through the development and delivery of effective highway safety programs for State and local jurisdictions

FMCSA :

FMCSA's 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 CMV safety through regulation, education, enforcement, research, and technology.

FTA :

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.

FHWA :

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.

National Transportation Safety Board :

The National Transportation Safety Board (NTSB) was established to determine the cause of certain crashes and to apply the lessons discovered in each investigation through recommendations to prevent future crashes. The NTSB selects and prioritizes highway safety investigations by the likelihood of

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Stakeholders (continued)

gaining new knowledge. It has been focusing considerable resources on crashes involving AV control systems. The NTSB investigates crashes of vehicles under automated control and applies systemic lessons from other modes of transportation where human control has been replaced with automation in human-centric environments. For the foreseeable future, motorists are expected to have many options for transportation, including shared AVs and AVs for personal use. The NTSB's work to investigate and prevent crashes could enhance public confidence by

providing an accurate public perception that failures are taken seriously and corrected. This confidence, in turn, will help support more accurate public understanding of AV technology. The NTSB will also continue to advocate favorable action on recommendations germane to AVs and their building blocks, such as promoting the use of collision avoidance systems that confer a proven safety benefit and high potential to improve safety.

2. Security & Cybersecurity

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 adequately safeguard 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... Security and cybersecurity are critical for the development of a transportation system that safely and effectively incorporates AVs. High degrees of connectivity and automation increase the need to protect vehicle control systems and secure sensitive information. In addition, most AV manufacturers have indicated that their vehicles will use electric motors and therefore will need to be plugged into the grid and connected through charging equipment. In consideration of potential increases to the critical technologies for both vehicles and the wider critical infrastructure, the U.S. Government is dedicated to providing a secure AV environment.

Stakeholder(s):

Department of Energy :

DOE has deep cybersecurity expertise through its national laboratories. Vehicle-related cybersecurity research to date has focused on plug-in electric vehicles and the interconnections between vehicles, charging equipment, buildings, and the grid. However, a more holistic vehicle cyber threat assessment, including AVs, is being undertaken by Sandia National Laboratory to understand whether additional research is needed.

Department of Homeland Security :

The DHS's Cybersecurity and Infrastructure Security Agency (CISA) also has deep cybersecurity expertise and leads the national effort to defend critical infrastructure against today's threats, while working with partners across all levels of government and in the private sector to secure against the evolving risks of tomorrow. CISA's integrated operations center provides 24x7 cyber situational awareness, analysis, incident response, and cyber defense capabilities to the Federal Government; State, local, tribal and territorial governments; the private sector, and international partners. CISA provides cybersecurity tools, incident response services, and assessment capabilities to safeguard the networks that support the essen-

tial operations of Federal civilian departments and agencies. CISA coordinates security and resilience efforts using trusted partnerships across the private and public sectors and delivers training, technical assistance, and assessments to Federal stakeholders as well as to infrastructure owners and operators nationwide. CISA provides consolidated all-hazards risk analysis for U.S. critical infrastructure through the National Risk Management Center (NRMC).

Department of Justice :

DOJ focuses on enforcing Federal law, ensuring public safety, and protecting national security. DOJ's security and cybersecurity interests in AV integration into our transportation system include:

- *Enforcing the Law in Cyberspace: The computer systems involved in operating and communicating with AVs make the vehicles potential targets of domestic or international criminals. DOJ investigates and prosecutes criminal exploitation of computer systems and works with interagency, State and local, and international partners to mitigate public safety and national security threats in cyberspace. In that regard, it is import-*

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Stakeholders (continued)

ant to DOJ and its law enforcement partners that AV computer systems employ adequate cybersecurity measures to combat criminal exploitation by cybercriminals. It is also imperative that the data in those systems necessary to investigate crime be accessible to law enforcement officials, upon appropriate authorization.

- **Supply Chain Security:** To mitigate supply chain risks to sensitive technologies, such as AVs, posed by foreign adversaries, DOJ—as well as NHTSA—evaluates proposed foreign acquisitions of U.S. businesses through the Committee on Foreign Investment in the United States (CFIUS).
- **Research and Development of Best Practices for Law Enforcement:** Within DOJ, NIJ is the lead Federal agency in researching the application of technology to and for criminal justice purposes. NIJ not only funds research related to the impact of AVs on law enforcement, but also seeks to evaluate and disseminate best practices for protecting officer safety from any threats posed by AVs. Additionally, NIJ engages with State, local, tribal, and territorial law enforcement partners to identify their operational requirements relating to AVs and interacts with developers, manufacturers, and vendors of law enforcement technology to address those requirements.
- **Federal Law Enforcement Use of Automated Vehicles:** In the future, law enforcement agencies within DOJ may seek to leverage AV technology to increase their law enforcement capabilities while improving officer safety, potentially reducing costs, and ensuring the protection of privacy, civil rights, and civil liberties.

Department of Transportation :

The National Traffic and Motor Vehicle Safety Act⁵⁴ provides NHTSA with broad authority over motor vehicle and motor vehicle equipment. Congress created this broad authority for the purpose of reducing traffic crashes, deaths, and injuries resulting from traffic crashes.⁵⁵ Three key components of NHTSA's authority are its ability to develop and establish safety standards, to enforce the prohibition against covered parties making inoperative aspects of vehicles or motor vehicle equipment installed in compliance with a safety standard, and to take action to protect the public against noncompliance and defects that pose unreasonable risks to motor vehicle safety. NHTSA's broad authority allows the agency to remain nimble and responsive in the face of ever-changing technological advances, including those related to cybersecurity. While "data security" and "privacy" are important considerations within

the context of vehicles and cybersecurity, the specific possibility of software vulnerabilities and other threats or risks potentially causing a crash or safety degradation to motor vehicles or motor vehicle equipment is the primary concern for NHTSA. NHTSA has established a Vehicle Cybersecurity Response Process for Incidents Involving Safety-Critical Systems. During a significant incident, coordination will be handled through DHS's National Cybersecurity & Communications Integration Center (NCCIC), with NHTSA having an information/advisory role and performing its statutory responsibility under the Safety Act. While cybersecurity is a critical issue for NHTSA, the emphasis for addressing cybersecurity ultimately must be with the industry, which must be the primary mover and leader in this field. The agency has taken several other concrete steps to prepare for the eventuality of an automotive cyber incident that affects safety. In order to encourage industry to face this emerging issue, NHTSA has issued non-binding best practices.⁵⁶ Also, in 2015, the industry formed the Automotive Information Sharing and Analysis Center⁵⁷ (Auto-ISAC) as an industry led clearinghouse to share cybersecurity information. The Auto-ISAC is one of the few ISACs formed prior to a sector incident. In July 2016, the Auto ISAC published its own set of best practices to the public. While general consumer privacy is an important secondary concern for NHTSA, the agency works with Federal Trade Commission (FTC), which has primary jurisdiction over privacy issues not related to motor vehicle safety.

National Institute of Standards and Technology :

The NIST National Cybersecurity Center of Excellence⁵⁸ (NCCoE) conducts research to accelerate the deployment and use of secure, standards-based risk management solutions. NCCoE is a collaborative hub where industry organizations, government agencies, and academic institutions work together to address businesses' most pressing cybersecurity issues. It is the responsibility of AV 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 AV. The Federal Government will promote the NIST Cybersecurity Framework—already a de facto common measure for cybersecurity in industry—for AV stakeholders. ⁵⁹ NIST's draft publication for Core Cybersecurity Feature Baseline for Secureable Internet of Things (IoT) Devices: A Starting Point for IoT Device Manufacturers⁶⁰ is intended to help IoT device manufacturers understand the cybersecurity risks their customers face. Many IoT devices are the result of the convergence of cloud computing, mobile computing, embedded systems, big data, low-price hardware, and other technological advances. IoT devices can provide computing functionality, data storage, and network connectivity for equipment that pre-

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viously lacked them, enabling new efficiencies and technological capabilities for the equipment, such as remote access for monitoring, configuration, and troubleshooting.⁶¹ The draft NIST publication defines a core baseline of cybersecurity features that any manufacturers may voluntarily adopt for IoT devices they produce, and also provides information on how they can identify and implement the features most appropriate for their customers. This publication can be used as a resource by AV innovators to better understand cybersecurity risks to their customers and provides a core baseline of cybersecurity features that can be used for potential IoT devices embedded in AVs.

National Security Council :

The National Security Council⁶² team, with the departments and agencies, enables the President to plan and execute integrated national security strategies to protect American citizens and the homeland while

prioritizing national interests and values. These national security strategies are informed by the National Security Strategy (2017)⁶³ and its four pillars: (1) Protect the American people, the homeland, and the American way of life; (2) Promote American prosperity; (3) Preserve peace through strength; and (4) Advance American influence. The U.S. Government will prioritize the transportation sector as one of seven sectors to prioritize cyber risk-reduction activities. The U.S. Government will prioritize emerging technologies critical to economic growth and security, such as AV technologies. The U.S. Government will also promote and protect its National Security Innovation Base, defined as the American network of knowledge, capabilities, and people that turns ideas into innovations, transforms discoveries into successful commercial products and companies, and protects and enhances the American way of life.

3. Privacy & Data Security*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. Mobility & Accessibility*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... Freedom of mobility is fundamental to the American way of life. AVs—whether passenger vehicles or State, local, and private transportation systems—have the potential to expand access and ease of movement and travel, particularly for people with limited mobility due to disability, injury, or age. Therefore, the U.S. Government is dedicated to ensuring that AVs are designed to offer independent mobility for daily activities as well as promote economic opportunities and overall social well-being for all Americans.

Stakeholder(s):

Department of Health and Human Services :
The National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) is the primary research arm of the Administration for Community Living (ACL) within the Department of Health and Human Services (HHS). Its mission is to generate new knowledge and promote its effective use to improve the abilities of individuals with disabilities to perform activities of their choice in the community,

and to expand society's capacity to provide full opportunities and accommodations for citizens with disabilities.

Department of the Interior :

The National Park Service (NPS) in the Department of the Interior (DOI) is dedicated to conserving the

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natural and cultural resources and values of the NPS for the enjoyment, education, and inspiration of this and future generations. NPS sees AV opportunities in the near future as potential mobility aids in key locations. Exploration of AV technology will provide contexts to learn how it can be integrated into NPS operations, what hurdles exist for future automation opportunities, and how automation will best fit within the agency's mission. Currently, NPS is establishing program and technical connections with USDOT for support of information on technical and programmatic opportunities regarding AVs, support for information gathering, and potential pilot testing at National Park sites.

Department of Justice :

The Department of Justice (DOJ) enforces regulations under the Americans with Disabilities Act (ADA) that ensure equal access to private transportation systems for persons with disabilities. DOJ also investigates complaints regarding disability discrimination in public transportation that it receives directly or that are referred by USDOT. The precise applicability of the ADA's regulations and DOJ's role will depend on the type of AV at issue, who is providing or using it, and how the vehicle is being used. However, covered entities that choose to adopt AVs would need to do so in compliance with the ADA.

Department of Transportation :

USDOT encourages AV developers and operators 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. 25 NHTSA has the authority to set performance requirements for adaptive motor vehicle equipment and develop exemptions that permit the modification of motor vehicles used by persons with disabilities. 26 Additionally, ADA regulations require accessible, timely public transportation service for passengers with disabilities, including wheelchair users. 27 FTA works to ensure nondiscriminatory and integrated mobility services in support of FTA's mission to enhance the social and economic quality of life for all Americans. 28 Additionally, USDOT's Accessible Transportation Technologies Research Initiative 29 (ATTRI) is a joint USDOT initiative, co-led by the

FHWA, FTA, and the Intelligent Transportation Systems Joint Program Office 30 (ITS JPO), with support from NIDILRR and other Federal partners. The ATTRI Program is leading efforts to develop and implement transformative applications to improve mobility options for all travelers, particularly those with disabilities.

National Council on Disability :

The National Council on Disability (NCD) is an independent Federal agency comprised of Presidential and congressional appointees. Pursuant to its statutory mandate, 29 U.S.C. § 781, the Council is charged with reviewing Federal laws, regulations, programs, and policies affecting persons with disabilities to assess the effectiveness of such laws, regulations, programs, and policies in meeting the needs of individuals with disabilities, and making recommendations to the President, Congress, officials of Federal agencies, and other Federal entities regarding ways to better promote equal opportunity, economic self-sufficiency, independent living, and inclusion and integration into all aspects of society for Americans with disabilities. The NCD provided policy recommendations on the advantages of AVs for persons with disabilities in its 2015 publication: *Self-Driving Cars: Mapping Access to a Technology Revolution*. 31 The report explores the emerging revolution in automobile technology and the promise it holds for persons with disabilities, as well as the obstacles the disability community faces.

U.S. Access Board :

The U.S. Access Board is an independent Federal agency that promotes equality for persons with disabilities through leadership in accessible design and the development of accessibility guidelines and standards. While the Access Board does not have rule-making authority in the area of AVs, the agency has hosted presentations by USDOT and the Department of Labor (DOL) on issues related to ensuring AV accessibility for individuals with disabilities and has provided technical assistance on making AVs accessible to them. In addition, the Board has a Frontiers Committee that engages partners on many aspects of AVs and released the 2018 Final Rule on Section 508 for access to technology procured and used by the U.S. Government.

II. Markets

Promote Efficient Markets

Stakeholder(s)

Department of Justice :

The DOJ is the executive branch agency charged with promoting and protecting competition for the benefit of American consumers. DOJ enforces the antitrust laws so that markets for innovative technologies, such as those related to AVs, are dynamic, competitive, and free of collusion. For example, DOJ is charged with prosecuting criminal antitrust conduct, such as price fixing, bid rigging, and market allocation agreements that have no economic benefit and harm competition and innovation in dynamic markets. In addition, DOJ interacts with industry, including as to the role of antitrust enforcement to promote innovation in the standard-setting context, emphasizing open, balanced, and competitive processes. Free market competition enabled by the DOJ's enforcement will support innovation and consumer welfare in emerging markets for automated vehicles.

Federal Trade Commission :

The FTC is the Nation's principal consumer protection agency. The FTC enforces Section 5 of the FTC Act, 15 U.S.C. § 45, which prohibits unfair or deceptive acts or practices in or affecting commerce. In the AV context, the FTC could, for example, use its Section 5 authority to take action against a company that makes deceptive claims about the performance capabilities or limitations of AVs or their component systems. The FTC could also use its Section 5 authority to take action against a company that makes deceptive claims with respect to consumer data that is collected, used, or maintained in connection with automated or connected vehicles or that has inadequate privacy or security practices. The FTC uses a variety of measures—

such as policy initiatives, including issuing reports or holding workshops, and consumer and business education efforts—to protect consumers.

Securities and Exchange Commission :

The U.S. Securities and Exchange Commission's (SEC) mission is to protect investors, maintain fair, orderly, and efficient markets, and facilitate capital formation. The laws and rules that govern the securities industry in the United States derive from a simple and straightforward concept: all investors, whether large institutions or private individuals, should have access to certain basic facts about an investment prior to buying it, and so long as they hold it. To achieve this, the SEC requires public companies (e.g., publicly traded AV technology companies) to disclose meaningful financial and other information to the public. This provides a common pool of knowledge for all investors to use to judge for themselves whether to buy, sell, or hold a particular security. Only through the steady flow of timely, comprehensive, and accurate information can people make sound investment decisions. The SEC oversees the key participants in the securities world, including securities exchanges, securities brokers and dealers, investment advisors, and mutual funds. Here the SEC is concerned primarily with promoting the disclosure of important market-related information, maintaining fair dealing, and protecting against fraud. Crucial to the SEC's effectiveness in each of these areas is its enforcement authority. Typical infractions SEC may pursue include insider trading, accounting fraud, and providing false or misleading information about securities and the companies that issue them.

AVs offer a dynamic area for R&D. To promote rapid development of the technologies underlying AVs, the U.S. Government will promote market efforts for American investment and innovation... Competition, Privacy, and Market Transparency — The U.S. Government will ensure the security of data and the public's privacy as AV technologies are designed and integrated. The U.S. Government will enforce existing laws to ensure entities do not make deceptive claims or mislead the public about AVs technologies or publicly traded AV technology companies.

5. Tech Neutrality

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. Innovation & Creativity

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... The U.S. Government fosters research, development, and integration of AVs and supports many ongoing and future Federal investments. Advancing AV innovation and expanding the potential role of AVs in daily life requires thoughtful and effective design, research, demonstration, testing, and validation. Numerous Federal agencies carry out or support academic research on AVs and complementary technologies... Across the U.S. Government, many agencies are invested in diverse infrastructure R&D that will allow for American entrepreneurship and innovation. This research explores both utilizing current infrastructure and exploring new infrastructure to maximize the potential of AVs.

Stakeholder(s):

Department of Agriculture :

The U.S. Department of Agriculture (USDA) conducts research on AVs related to agricultural production and processing. The research areas include unmanned ground vehicles (UGV), and autosteering equipment. The USDA is heavily involved in the design and development of numerous AVs, supporting technologies and tools for precision agriculture and for crop breeding such as: sensor development, lighting systems, voice response systems, predictive modeling, AI/machine learning, rapid response control systems, robotics, big data analytics, and best management practice decision support tools. The USDA's research includes a focus on developing AV tools and systems that decrease labor requirements for managing animals in ranching operations. Robotics is another primary research area. Much of this research is funded through USDA's National Institute of Food and Agriculture's (NIFA) contribution to the National Robotics Initiative 2.0.32 These robotics-centered projects include precision pollination, precision grazing, precision orchard harvesting, precision herbicide application, livestock health monitoring, plant phenotyping, and cooperative human-robotic networks for agricultural applications. A new generation of automated high clearance tractor is being equipped for crop field-based trait analyses with an array of sensors for use by breeders at the USDA Agricultural Research Service (ARS) Arid Land Agricultural Research Center (ALARC) in Maricopa, AZ. This technology will replace the human piloted sensor platform shown below that is tasked with analyzing wheat for multiple traits simultaneously.

Department of Defense :

Autonomy plays a major role in the Department of Defense's (DoD) military missions, and its role in future military missions will likely expand as the technology continues to develop. The DoD's R&D for military purposes contributes to R&D for civilian applications of AVs as well. The role of autonomy within the DoD is not to directly replace humans, but rather to extend and complement human capabilities in a number of ways. The DoD's investments in autonomy focus on developing systems that will facilitate performing complex military missions in dynamic environments with the right balance of warfighter involvement. Increased investment in autonomy will enhance joint warfighter capability in haz-

ardous and degraded environments, heighten speed of action, and provide scalability beyond human capability. Autonomy is not a single-threaded R&D program, but rather a collection of smaller programs and demonstrations. The DoD is pursuing advanced technology development programs as well as several other efforts to conduct fundamental research. For example, the Automated Ground Resupply program also investigates improved operations of manned platforms through the application of a wide variety of sensing and autonomy technologies developed for unmanned systems. These include maneuver and tactical behavior algorithms, driver assistance techniques, autonomy kits, teleoperation, advanced navigation and planning, vehicle self-protection, local situational awareness, advanced perception, vehicle and pedestrian safety, active safety, and robotic command and control. The DoD has a wide-ranging effort to improve the sensors and networking technologies for autonomous platforms. This includes efforts in improving relative navigation through improvements in the GPS and inertial navigation systems driven by advances in quantum science. This also covers new approaches to active and passive sensing, such as improved Light Detection and Ranging (LIDAR) and sensor arrays for better situational awareness. In another example, the Combat Vehicle Robotics (CoVeR) program researches, designs, and develops technologies that enable scalable integration of multi-domain teamed robotic and automated system capabilities supporting Army combat formations. It also investigates, researches, and evaluates ground vehicle technologies for both military and commercial applications in collaboration with industry, universities, and other government agencies. The Research in Vehicle Mobility program is working to develop human cognitive models to represent behavioral dynamics to work side-by-side with control algorithms in a semi-automated robotic system engaged in extreme mobility scenarios, thereby replacing the need for real human-in-the-loop assessments. The DoD aims to field a Joint Force architecture by 2030 that will fully integrate robotic and automated systems, supplementing and augmenting manned systems and forces in an attempt to counter threats from adversaries across multiple domains. However, humans must remain in the loop and play an oversight role, with the ability to activate or deactivate system functions as necessary. The DoD is developing multiple vehicle demonstration programs in support of its

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2030 Joint Force architecture goal and to improve DoD's Non-Tactical Vehicle (NTV) mobility options. Examples include:

- **High Mobility Multipurpose Wheeled Vehicle (HMMWV) Autonomy:** This effort will develop a cost-effective upgrade to the existing HMMWV platform that will enable drive-by-wire control. Converting the vehicle controls from mechanical linkages to electronic actuation will enable connection to computers for autonomous operation, as well as to process, communicate, and store diagnostic/sensor data for use in localization and maintenance functions.
- **Off Road Autonomy:** This effort will look at several new techniques for executing off road autonomy built onto the current Army ground autonomy architecture. This effort focuses on developing new path planning and perception techniques with the intent of increasing reliability and performance for off-road unmanned maneuver systems for Robotics Combat Vehicle (RCV) and other platforms.
- **Situational Awareness in Dynamic Environments:** This research investigates and establishes the components required for embodied intelligent ground robotic systems to achieve understanding of dynamic, highly unstructured environment to support reasoning over time and space given multi-modal sensory input.
- **NTV Automated Shuttle Pilot:** Marine Corps Installations Command (MCICOM) and Army Headquarters are sponsoring a 3-month automated non-tactical shuttle pilot on Joint Base Myer Henderson Hall. This industry-led pilot facilitates an opportunity for the Army's Engineering Research and Development Center (ERDC) to shadow the performers in order to create future automated shuttle programs on other military installations.

Department of Energy :

The Energy Efficient Mobility Systems program at the U.S. Department of Energy (DOE) is conducting fundamental research to understand the transportation "system level" impact from connected and automated vehicle technologies. DOE researchers are creating and using large-scale agent-based models to simulate current and future mobility technologies and services, including transportation network companies (TNCs), public transit systems, and other modes for transporting freight and people. These models will allow users to better understand the second and third order impacts from adding a technology like AVs (e.g., induced traffic congestion due to "empty" AV miles or new patterns for land use and development) or to compare the system-wide impacts of different technologies (e.g., traffic flow

impacts of SAE Level 4 versus Level 5 automation³³, congestion impacts of personally-owned AVs compared to fleet-owned mobility service AVs). DOE is also using its unique High Performance Computing³⁴ (HPC) and AI capabilities at the National Laboratories to develop methods to use AVs or connectivity to anticipate and reduce or prevent congestion. Projects are underway utilizing roadway and vehicle data from the Los Angeles and Chattanooga metropolitan areas. Although in its early stages, as more data from AVs becomes available and HPC capability increases, it will increasingly become possible to optimize traffic flow, and reduce costs. DOE is also studying how to fundamentally extend computing capability, which will likely be needed to safely operate SAE Level 5 AVs in a real-world, consumer-acceptable package. Given the amount of computational capability necessary and the size, weight, and power constraints on a motor vehicle, dramatic improvements in the energy efficiency, performance, and cost of the underlying computer systems will be needed. Because transportation accounts for nearly one-third of the energy used in the United States, technologies such as AVs, which could reduce energy use associated with driving, play valuable roles in America's energy future. DOE's role with respect to AVs is to develop technologies, tools, and insights that enhance the affordability, effectiveness, and energy efficiency of the overall transportation system. DOE leads the multi-agency 21st Century Truck Partnership³⁵ (21CTP). This public/private partnership includes DoD, USDOT, the Environmental Protection Agency (EPA), and DOE, along with industry partners. This non-funded research partnership focuses on pre-competitive information exchange across four technical focus areas: internal combustion engines, electrified powertrains, operational efficiency, and safety. AVs and related mobility technologies are key parts of 21CTP's Freight Operational Efficiency and Safety technical teams. DOE also funds the SuperTruck II initiative³⁶, a competitive funding opportunity initiated in FY 2016 aimed at developing innovative, cost-effective technologies that can double the freight efficiency of Class 8 trucks. Automation and connectivity are among the technologies being considered by the five teams selected for cost-shared financial assistance awards. With respect to the development of AVs for personal use, the DOE Vehicle Technologies Office (VTO) and the Advanced Research Projects Agency-Energy³⁷ (ARPA-E) have made numerous cost-shared financial assistance awards focused on automated and connected vehicles and efficient mobility. VTO also had a recent Funding Opportunity Announcement (FOA) for mobility research (~\$7 million) that included AV projects.³⁸ ARPA-E's NEXTCAR (Next-Generation Energy Technologies for Connected and Automated On-Road Vehicles) Program³⁹ provided approximately \$32 million in FY 2016 for 11 projects to use connected and AV technologies to improve vehicle level fuel efficiency through improvements in vehicle dynamics and pow-

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Stakeholders (continued)

ertrain controls. A 2019 DOE award will build on the progress of NEXTCAR by adapting a NEXTCAR AV algorithm for use in a SAE Level 4 AV. The project will also implement an infrastructure-based solution that offloads computing from the vehicles to roadside units for centralized perception processing at intersections that can be utilized by any connected vehicle. This project aims to reduce system-level energy consumption by 15%. A second 2019 DOE financial assistance award will develop deep-learning algorithms for AVs that smooth mixed highway traffic (human-driven and automated vehicles) and reduce system-wide energy consumption by 10% through just 5% AV penetration. In 2018, DOE awarded over \$26 million to 18 projects that will bring together key stakeholders in partnerships to provide data on the impact of mobility services and solutions through real-world testing (evaluation/assessment) and validation. The data, analysis, and insights from this work will fill critical information gaps to inform mobility research needs, as well as near- and long-term transportation planning that maximizes energy efficiency and affordability. In 2018, DOE made \$5 million in financial assistance awards to demonstrate the real-world application of Class 8 Truck Platooning to identify remaining roadblocks to practical application of commercial AV technology. The DoD U.S. Army Futures Command is a major participant in one of the projects. This builds on experimental work on which DOE and FHWA have collaborated for a number of years, proving the capability and energy savings from heavy truck platooning. In 2017, VTO financial assistance awards funding to the Virginia Tech Transportation Institute (VTTI), University of California–Riverside, and Clemson University to conduct research that evaluates energy savings benefits from connected and automated vehicles. The Clemson University project is developing anticipative and predictive AV control algorithms and building a novel vehicle-in-the-loop testbed to demonstrate energy savings of 10% AVs in traffic that includes both automated and human-driven vehicles.

Department of Health and Human Services :

NIDILRR's Rehabilitation Engineering Research Center on Physical Access and Transportation at Carnegie Mellon University is researching potential reference designs and vehicle interior concepts intended to promote and facilitate the accessibility of AVs for persons with disabilities. This center is also conducting R&D to generate new knowledge about how AVs can help address transportation barriers that are experienced by persons with disabilities in the first or last mile of a trip. NIDILRR's Research Project on Optimizing Accessible Public Transportation, at the State University of New York–Buffalo, is generating new knowledge about innovative securement systems for wheelchair users in transit buses and paratransit vehicles. This project includes research into the ramifications of introducing automated securement systems for wheelchair users in

automated transit vehicles. In order to provide community input into the R&D process, NIDILRR's Rehabilitation Research and Training Center on Community Living Policy collected data from persons with disabilities and other critical stakeholders to inform recommendations for a future research and standards/architecture development effort for fully accessible and fully automated vehicles. The National Institute for Occupational Safety and Health (NIOSH) Strategic Plan, FYs 2019–2023, prioritizes research on the health effects of AVs for truck, bus, and taxi drivers. It also prioritizes research on injury risks associated with new jobs that may be created by automation and on potential stress and fatigue consequences of automation. NIOSH is conducting simulator-based research that will lead to recommendations for the capabilities of automation sensors and driver-vehicle interfaces used in heavy trucks (for example, the minimum time required for sensors to issue a warning in time for the driver to safely re-assume control of the vehicle).

Department of Homeland Security :

The Department of Homeland Security (DHS) Science and Technology (S&T) Directorate conducts R&D on a range of technologies related to AVs, focusing on understanding their potential utility and vulnerabilities.⁴⁰ Examples of DHS AV R&D include operating an AV test bed, spoofing protection for global navigation satellite systems, analytics for evaluating performance of ADAS, and using AI and machine learning for automated systems. Research examples include:

- DHS's Homeland Security Systems Engineering and Development Institute (HSSEDI) is a Federally Funded Research and Development Center (FFRDC) in the process of developing an open-architecture platform to develop and evaluate AV technology. The purpose is to have an environment to demonstrate multi-agent autonomy, cybersecurity challenges, and communications architectures applicable to potential future networked, unmanned systems. This effort will develop the next generation of AV test bed.
- Since the need for resilient positioning, navigation, and timing will only increase with the advent of AVs, DHS's HSSEDI FFRDC is studying methods of spoofing protection for global navigation satellite systems.
- Active safety and driver assistance systems can potentially save lives and avoid crashes, but usage and safety performance of the systems remains poorly understood. DHS's HSSEDI FFRDC is researching analytics for evaluating performance of ADAS.

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Stakeholders (continued)

Department of Justice :

DOJ's National Institute of Justice (NIJ) awarded \$50,000 to Purdue University to identify vulnerabilities of AVs' computer systems to cyber threats and to develop measures to counter those threats. NIJ also provided funding to RAND Corporation to host a workshop on AVs in July 2019 with the Police Executive Research Forum (PERF). The workshop highlighted and explored specific public safety scenarios involving AVs that have been or will be faced by law enforcement, ranging from routine police interactions with specific individual vehicles (e.g., traffic stop, accident report) as well as small- or large-scale emergency situations that may require interaction with large numbers of vehicles at once (e.g., detours, evacuations).

Department of Transportation :

Several USDOT modal administrations are conducting a wide array of research and demonstration projects related to surface transportation AVs.

FHWA :

FHWA is:

- Investigating different roadway/automated driving scenarios with a focus on the data and systems that will be needed to enable ADS to exchange data to successfully navigate challenging roadway scenarios.
- Developing new modeling and simulation capabilities to analyze the impact of connected and automated vehicles (CAVs) on the highway system, including developing new traffic simulation algorithms that incorporate CAVs and conducting case studies to analyze impacts of CAV technologies on traffic flow and operations.
- Pursuing an update of the Manual on Uniform Traffic Control Devices (MUTCD). The upcoming new edition will propose updated technical provisions to reflect advances in technologies and operational practices; incorporate recent trends and innovations; and set the stage for ADS as those continue to take shape.
- Funding grants for through the annual \$60 million Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) program.⁴¹ The Fixing America's Surface Transportation Act (FAST Act) established ATCMTD to make competitive grants for the development of model deployment sites for large scale installation and operation of advanced transportation technologies to improve safety, efficiency, system performance, and infrastructure return on investment.

FMCSA :

FMCSA is:

- Conducting research to increase understanding of the human factors and address specific areas such as driver readiness, the human-machine interface (HMI), adaptation to advanced technologies, and communication with others outside the vehicle.
- Researching safety performance of critical items such as sensors, brakes, and tires in AV CMV operations, truck platooning, emergency response, and roadside inspections.
- Conducting research to ensure that the CMV industry is adequately equipped and able to prevent or respond to cyber threats.

FTA :

FTA is:

- Conducting research to assess both user acceptance and human factors design considerations for high-priority transit automation use cases involving passengers, bus operators, and other transit users to apply and conduct practical research in demonstrations and to identify and study potential customer acceptance issues associated with fully driverless operations due to perceived security issues or distrust of technology.
- Developing non-binding guidance, based on earlier research results and demonstration findings, on Federal funding programs that may be relevant to transit automation investments.
- Working to produce a practical reference guide for transit agencies covering key transition areas, such as vehicle maintenance; human factors, labor, and training issues; customer communications; maintaining consistency in the passenger experience; and transit service planning.
- Exploring the potential transferability of AV technologies and capabilities from light and commercial vehicles to bus transit.⁴²
- Launching a series of seven demonstrations, organized by use case categories, in real-world transit environments as defined in the FTA Strategic Transit Automation Research (STAR) Plan.⁴³ The demonstrations will create a testbed for study of technical issues, user acceptance, operational and maintenance costs, and institutional issues, and will further assess needs for standards development to ensure interoperability.

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Stakeholders (continued)

NHTSA :
NHTSA is:

- Researching unintended regulatory barriers. Historically, the Federal Motor Vehicle Safety Standards (FMVSS) have been based on the concept of a human operating the vehicle. With the introduction of ADS, the driving tasks are increasingly shifted to the vehicle. The absence of a human driver creates opportunities for vehicle manufacturers to design new vehicle architectures that may remove driving controls, change seating configurations, and establishing new interfaces for occupants.
- NHTSA has published non-binding guidance to support the automotive industry and other key stakeholders as they consider and design best practices for the testing and safe integration of Automated Driving Systems, along with technical assistance to States and Best Practices for Legislatures.⁴⁴
- Researching alternative metrics and safety assessment models. This research will identify the methods, metrics, and tools to assess how well the ADS perform at a system level to avoid crashes including system performance and behavior relative to the system's ODD and stated Object and Event Detection and Response (OEDR) capabilities. Research will be conducted to explore the functional performance and safety benefits of ADS implementations. Research also will be performed to study the feasibility and methods to assess normal driving capabilities of an ADS. The dynamic driving tasks (previously undertaken by the human driver) as behavioral competencies or maneuvers that can be measured and tested much in the way a human driver is evaluated to ensure driving competency.
- Researching functional safety and ADS subsystems. The safe operation and reliable performance of ADS are critical to public acceptance and successful integration of future ADS. As the dynamic driving tasks are transferred from the human driver to the ADS, human sensing and cognition functions are essentially being relegated to the machine through a collection of integrated hardware and software subsystems. Accordingly, methods and tools are necessary to assess the functional safety of ADS subsystems and their building block components.
- Researching occupant protection⁴⁵ in alternative vehicle designs. Vehicle crash mechanics and occupant restraint systems are not directly affected by vehicle

automation. However, occupant behavior and the enhanced sensor systems will affect priorities for a vehicle's safety in the event of a crash.

- Researching human factors for ADS Vehicles, for example, vehicles that are designed in a manner where it can be operated by both a driver and an ADS (e.g., dual-mode), involving control handoff between drivers and ADS in certain circumstances. A driver's readiness to resume control in SAE Level 3 ADS is critical to safety. Driver engagement with the ADS is influenced by several issues, including the human-machine interface, the driver's experience and training with the system, and other situation-specific factors that affect behavioral responses.
- Researching accessibility considerations in ADS vehicles. ADS vehicles are expected to provide mobility options not previously afforded to persons with disabilities, regardless of cognitive, physical, or even the degree of condition. Research has been initiated to explore the information needs of persons with disabilities and how these needs could be implemented effectively within a HMI.
- Conducting cybersecurity research to promote a layered approach to cybersecurity by focusing on a vehicle's entry points, both wireless and wired, which could be potentially vulnerable to a cyber-attack. A layered approach to vehicle cybersecurity reduces the possibility of a successful vehicle cyber-attack, and mitigates the potential consequences of a successful intrusion. NHTSA has published non-binding guidance to the automotive industry for improving motor vehicle cybersecurity,⁴⁶ which it is currently working on updating

Office of the Secretary of Transportation :

Office of the Secretary of Transportation (OST) announced:

- \$60 million in Federal grant funding for a competitive grant program that awarded 8 recipients for ADS demonstrations.⁴⁷
- A planned Inclusive Design Challenge⁴⁸, which will make up to \$5 million in cash prizes available to innovators who design solutions to enable accessible automated vehicles. USDOT aims to increase availability and decrease cost of aftermarket modifiers that improve accessibility of vehicles today and spark development for future automated vehicles.

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Stakeholders (continued)

National Aeronautics and Space Administration :

While the National Aeronautics and Space Administration's (NASA) mission relates to space and aviation, in service of that mission NASA is developing and maturing a broad range of technologies that are also relevant to surface AVs. These technologies are primarily described by the "Robotics and Autonomous Systems" Technology Roadmap.⁴⁹ NASA's investment in this area includes work in sensing and perception, mobility, manipulation, human-system integration, system-level autonomy, autonomous rendezvous and docking, and systems engineering. Autonomy (both system- and subsystem-level), cognition, and machine learning are integral parts that span all sub-areas, including object, event, and activity recognition; robot navigation; dexterous manipulation; intent recognition and reaction; and rendezvous and docking. NASA develops and deploys a wide range of operator interfaces to remotely monitor and supervise space robots, including planetary rovers that drive autonomously in uncertain environments. These interfaces, such as the NASA open-source "Visual Environment for Remote and Virtual Exploration (VERVE)", are used to visualize robot sensor data, telemetry, and remote environments as well as to interactively handle contingencies and exceptions. Numerous AV companies are currently developing similar systems to support monitoring and supervision of AV services (delivery, taxi, etc.). NASA's technology investments (including internal projects and external awards) can be tracked and analyzed using TechPort, a web-based, publicly available, software system that serves as NASA's integrated technology data source.⁵⁰ Research products are archived in NASA Technical Reports Server (NTRS), which provides access to scientific and technical information (STI) created or funded by NASA including conference papers, journal articles, meeting papers, patents, research reports, images, movies, and technical videos.⁵¹ Technologies with foreseeable application beyond aviation, space, and planetary exploration include development of higher resolution 3D range imaging sensors allowing an AV to perceive the surrounding landscape, map-based position estimation for navigation by surface vehicles, natural and human-made object recognition algorithms, improved routing and optimization techniques, and adaptive autonomous surface navigation systems.

National Science Foundation :

The National Science Foundation (NSF) supports the development of AVs, as well as analysis of the potential benefits and challenges of their introduction into the current transportation system through a variety of programs, primarily in the Computer and Information Science and Engineering (CISE); Engineering (ENG); and Social, Behavioral, and Economic Sciences (SBE) Directorates. NSF funds basic research in the three broad categories of sensing, reasoning, and acting.

- Basic research in sensing may include improved computer vision, radar, LIDAR, mapping, and other sensing modalities, as well as sensor fusion.
- Basic research in reasoning may include real-time machine learning, perception and localization, safety guarantees for control in uncertain environments, and multi-objective optimization under constraints.
- Basic research in action may include ensuring the safety of the AV occupants as well as other road users—bicyclists and pedestrians, trajectory and path planning, vehicle dynamics, model-predictive control, and blended control.

In addition, NSF funds basic research and workshops to address communication issues between AVs, social issues surrounding the adoption of AVs, and a future transportation system that incorporates surface AVs. As part of NSF's broad portfolio of basic research in communications, infrastructure, and human factors, NSF funds basic research and workshops in:

- Communications including spectrum research for V2V and V2I communication,
- Security of AV systems
- How human responses to sharing roads with AVs can help to foster trust in automated technology.
- The relationship between user privacy and the architecture of AV sharing services.
- How the emergence of automated trucks affects the trucking workforce and the U.S. economy.
- How repurposing time currently taken up by driving can enhance economic productivity and worker wellbeing

U.S. Postal Service :

The U.S. Postal Service (USPS) operates the largest civil agency fleet of vehicles in the country with well over 200,000 vehicles. The use of AVs offers an opportunity for USPS to improve operational efficiency and enhance the safety of postal workers and the public. USPS's use of advanced technology to improve efficiency is part of the charter that recreated the organization in the early 1970s. USPS is conducting three AV demonstration programs:

- Automated Rural Delivery Vehicle (Zippy) Program:⁵² The program created a prototype in conjunction with the University of Michigan to identify current capabilities and value of AVs.
- Request for Information (RFI) for Autonomous Vehicle Capability:⁵³ USPS issued an RFI on an advanced automated delivery vehicle program to produce a mail delivery vehicle for improved productivity and to evaluate current AV

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Stakeholders (continued)

capabilities and individual sensor technologies. The USPS received numerous responses and is developing programs to pursue targeted research on automated technology for its vehicles. In addition to the research projects, USPS will be exploring partnerships with industry leaders to leverage its vast fleet that drives to every door, every day at typically low speeds to deliver the Nation's mail.

- **Automated Semi-Truck:** This is an automated tractor-trailer proof of concept program operating (with safety engineer and driver present) on defined routes between major distribution centers in the southwest United States. USPS recently completed a pilot program that included five round trips between Dallas, Texas and Phoenix, Arizona. All of the automated trips were either on time or early to the respective facilities.

Department of Energy :

DOE's national laboratories have access to the world's fastest HPC facilities, as well as expertise in AI and big data analytics. DOE has developed high-performance computing infrastructure for modeling and simulating AV software for perception, planning, and control. DOE's work in this area related to automation falls into two main areas: (1) efforts to optimize transportation systems to reduce congestion and improve throughput, and (2) developing improved AI or computing needed for AVs. As an application of this computing infrastructure, Oak Ridge National Lab is working closely with a vehicle manufacturer to use advanced AI software (e.g., Multi-node Evolutionary Neural Networks for Deep Learning—MENNDL)⁶⁴ to reduce the development time and improve the performance of AV software for perception, planning, and control. The DOE System Modeling for Accelerated Research in Transportation⁶⁵ (SMART Mobility) national laboratory consortium was created in 2016 to produce new knowledge, insights, and understanding about the future of mobility. The consortium is developing modeling and simulation tools that scale from the vehicle/traveler level to the city/regional level, and incorporates new and emerging mobility technologies and services. These modeling efforts include estimates of land use changes and charging infrastructure demand using UrbanSimw and EVI-Pro through an iterative closed-loop simulation with regional agent-based models (POLARIS and BEAM). The agent-based models provide information on travel time, cost, distance, and other factors by travel mode and time-of-day that are then utilized to simulate future population shifts, employment, market penetration of electric vehicles, and electric vehicle charging demand. The research community, local governments and transportation planners, and other Federal agencies can use the tools to understand the outcomes of future mobility scenarios in terms of

energy consumption, affordability, time and convenience, and access to opportunities. The first phase of SMART Mobility will be completed at the end of FY 2019 with a comprehensive set of modeling and simulation tools that, in combination, can fully model current and potential future states of a large metropolitan area. A broad range of new mobility technologies and services, including different levels and effectiveness of automation, will be included.

Department of Transportation :

FHWA is responsible for providing stewardship over the construction, maintenance, and preservation of the Nation's highways, bridges, and tunnels. Through research⁶⁶ and technical assistance, the FHWA supports its partners in Federal, State, and local agencies to accelerate innovation and improve safety and mobility. FHWA facilitates uniformity in traffic control devices through its MUTCD. As of early 2019, there are 89 connected vehicle deployments⁶⁷ that are either planned or deployed around the country, and the number is growing rapidly. Based in part on the insights afforded by FHWA's National Dialogue, FHWA will facilitate the development of a national roadway automation integration readiness strategy. The strategy will define a flexible framework for coordinated planning among State and local transportation agencies, and with ADS developers. FHWA—in partnership with FMCSA—awarded contracts to three teams to develop detailed proposals for a field test of truck platoons. The field tests will collect technical and operational data related to the vehicles, environment, and drivers to assess safety, efficiency, and mobility impacts of truck platoons on the transportation system. In addition, FHWA is conducting research to better understand the impacts truck platoons may have on roadway infrastructure, e.g., pavement and bridges. FHWA—in coordination with the ITS JPO—is supporting a Work Zone Data Exchange⁶⁸ (WZDx) initiative for AVs. Accurate and up-to-date information about dynamic conditions occurring on the roads—such as work zones—can help AVs navigate safely and efficiently. The WZDx initiative seeks to set the foundation for development of other data set that will facilitate AV integration in to our Nation's roadway systems.

Department of Commerce :

Economics and Workforce Research — Complementary to the U.S. Government's role in advancing AV innovation and technology, the DOC, HHS, DOL, and USDOT are collaborating in support of research on the Impact of Automated Vehicle Technologies on (Professional Drivers) Workforce.⁷²

Bureau of Labor Statistics :

DOL's Bureau of Labor Statistics (BLS) is currently conducting a literature review that summarizes and synthesizes economic theory on the interaction between labor and capital in the workplace and how this is affected by new technologies such as automation, digitization, and AI. This review will be the

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basis for developing a comprehensive list of constructs that need to be measured to allow researchers to determine the effect of these new technologies on the workforce.

FTA :

FTA is researching economics and workforce considerations associated with AVs, including:

- Analyzing labor and workforce-related considerations with transit bus automation for non-driving tasks of bus operations (e.g., management of bus yard operations).
- Researching the availability and costs of automation-related systems and products with an emphasis on the U.S. domestic bus market.
- Developing methods and tools that transit agencies can use to assess the business case for investing in bus automation.
- Studying the potential impacts of automation-related changes to transit service patterns, such as an increase in point-to-point service using smaller vehicles.

Automated Vehicle Sector Innovators :

U.S. Government Resources for Automated Vehicle Sector Innovators — The role of the U.S. Government is to create an environment in which innovators can iterate new technologies to meet market needs. As such, the U.S. Government has resources available to support AV innovators.

Federal Laboratories :

Federal Laboratories Test Beds and Technology Transfer — Leveraging the Federal Government's investments in R&D for societal benefit necessarily involves the transfer of technologies created with Federal money to the open market. The Federal Laboratory Consortium for Technology Transfer (FLC) is a nationwide network of over 300 Federal laboratories, agencies, and research centers that fosters commercialization best practice strategies and opportunities for accelerating Federal technologies from out of the laboratories and into the marketplace.⁹⁵ The FLC's mission is to promote, educate, and facilitate Federal technology transfer (T2) among its member laboratories and institutions so they can reach their commercialization goals, and create social and economic impacts with new innovative technologies. One of the FLC's growing service initiatives is the Technology Focus Area (TFA) program. TFA provides an annual spotlight on a specific technology that addresses a public need and supports Federal laboratories' research and technology transfer missions as well as government-wide economic development goals. The TFA for Automated Systems (AS) program is designed to facilitate commercialization activity by cultivating valuable connections between Federal laboratories and innovators. Through the TFA AS program, the FLC provides innovators with a dedicated online platform for

identifying relevant AS Federal laboratory technologies, intellectual property, programs, and expertise. The program serves as a pathway of introduction for innovators to access the Federal resources and contacts they need to establish T2 relationships and agreements for accelerating their R&D.

Small Business Administration :

Small Business Administration Resources — The U.S. Small Business Administration (SBA) helps Americans start, build, and grow businesses. It provides access to capital through an array of financing mechanisms, free counseling and low-cost training for both new entrepreneurs and established small businesses, facilitates access to contracts with Federal agencies and departments, and advocates on behalf of small businesses with government policy makers. SBA offers detailed guides for planning, launching, managing, and growing a business⁹⁶ as well as District Offices that can provide assistance focused on particular local conditions.⁹⁷ SBA provides policy guidance and leadership for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs,⁹⁸ coordinating across 11 Federal agencies and departments to help innovative small businesses meet Federal R&D needs and commercialize those innovations. SBA assists small businesses interested in pursuing SBIR/STTR opportunities across the Federal Government through outreach, training resources, and by helping entrepreneurs connect to local resources. SBA offers a wide variety of courses designed to help entrepreneurs research, plan, and turn ideas into businesses.⁹⁹ Training includes the Emerging Leaders Initiative, an intensive program that provides free entrepreneurship education and training for executives of small, poised-for-growth companies that are potential job creators in America's underserved cities.¹⁰⁰ The NSF I-CorpsTM program prepares scientists and engineers to extend their focus beyond the university laboratory and accelerates the economic and societal benefits of NSF-funded, basic-research projects that are ready to move toward commercialization.

United States Patent and Trademark Office :

United States Patent and Trademark Office's Inventor and Entrepreneur Resources — USPTO maintains a website¹⁰¹ linking to resources related to protecting intellectual property (IP) and ensuring innovators understand how and when to register their IP. Information on the IP lifecycle as well as legal resources are available to enable innovators to best protect their efforts.

USA Spending.gov :

USA Spending.gov¹⁰² is the official source for spending data for the U.S. Government. Its mission is to show the American public what the U.S. Government spends every year and how it spends the money. You can follow the money from the congressional appro-

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Stakeholders (continued)

priations to the Federal agencies and down to local communities and businesses. AV innovators and en-

trepreneurs could use this as a resource to identify potential U.S. Government funding opportunities.

7. Regulations

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, that are as performance-based and nonprescriptive as possible and do not discriminate against American technologies, products, or services... Environmental Quality — The U.S. Government will focus on opportunities to improve transportation system-level efficiency, while avoiding negative transportation system-level environmental impacts from AV technologies.

Stakeholder(s):

Department of Transportation :
USDOT's modal administrations regulate aspects of AVs. For more details, please refer to the Safety, and Security and Cybersecurity sections, above.

General Services Administration :

The GSA develops Federal motor vehicle management regulations, issues guidance on Federal fleet operations, and provides reports on the Federal fleet, which was estimated as 644,545 non-tactical vehicles in FY2018.⁸⁷ Federal regulations on fleet management include requirements regarding agencies' acquisition, use, and disposal of motor vehicles, and cover home-to-work transportation, among other requirements. The GSA Office of Government-wide Policy (OGP) also issues guidance to help agencies manage their motor vehicle fleets effectively. Guidance includes bulletins on various aspects of fleet management, including fleet management information systems, and methodologies for determining the optimal fleet size for agency fleets. GSA OGP will consider guidance for how to integrate AVs into Federal fleets.

Office of Management and Budget :

The Office of Information and Regulatory Affairs (OIRA)⁸⁸ is a Federal office established by Congress within the Office of Management and Budget (OMB), which is an agency within the Executive Office of the President. OIRA reviews draft proposed and final regulations under Executive Order 12866 from Federal agencies, including USDOT. OIRA also reviews Federal agencies' collections of information from the public under the Paperwork Reduction Act, and develops and oversees the implementation of government-wide policies in the areas of information policy, privacy, and statistical and science policy.

Council on Environmental Quality :

Council on Environment Quality (CEQ)⁹³ was created by the National Environmental Policy Act

(NEPA) and is a Federal agency located within the Executive Office of the President. CEQ oversees NEPA implementation through regulations and guidance. The development and implementation of AV-related technology and infrastructure may require Federal permits or other authorizations that would trigger a NEPA analysis. CEQ would support Federal agencies as they undertake the NEPA process for AV-related projects. CEQ also houses the Office of Federal Sustainability⁹⁴ (OFS), which coordinates policy across the Federal Government to promote energy and environmental sustainability in Federal operations. OFS implements Executive Order 13834 which directs Federal agencies to manage their operations to optimize energy and environmental performance, reduce waste, and cuts costs, which includes vehicles. In order to meet statutory requirements for petroleum reductions and optimize efficiency, some agencies have decided to implement telematics as well as EV infrastructure to manage their fleets. The development and implementation of AV-related technology and infrastructure would require consideration of the existing use of telematics and electric vehicles in the Federal fleet to ensure coordination and interoperability. OFS assists Federal agencies that decide to use AV technology to meet their statutory requirements related to vehicles in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment.

Environmental Protection Agency :

As the Federal Government's lead regulator for clean air and other environmental programs, EPA is charged with developing rules and policies to ensure its public health goals are met. All vehicles offered for sale in the U.S., for example, must receive an EPA certificate of conformity before introduction to the market. Automobile manufacturers must demonstrate compliance with environmental regulations over a wide range of operating conditions and test pro-

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Stakeholders (continued)

cedures. The introduction of ADS technologies could modify how these vehicles operate under these test conditions requiring updates in testing to provide a complete environmental profile. EPA's National Vehicle and Fuel Emissions Laboratory has begun to monitor, measure, and assess ADS and ADAS vehicle technology improvements and innovations, so that policy actions targeted toward ADS and ADAS performance that impact fuel economy (as regulated by NHTSA), energy consumption, tailpipe emissions, and vehicle activity profiles account for and have the latest, best technical information available. EPA provides the Federal Government's official measured testing for tailpipe emission, fuel economy, and con-

sumer information. As AVs come to market those tests must accurately account for ADS and ADAS, which may mean developing and employing special test methods. As appropriate, EPA will update vehicle testing regulations to address unique AV operational considerations that may arise. As data become known, EPA will also incorporate into vehicle performance models and policy tools the benefits (reductions) or dis-benefits (increases) in emissions and energy consumption associated with ADS and ADAS performance on auto-emissions compliance requirements.

DEMONSTRATION ONLY

III. Coordination

Facilitate Coordinated Efforts

Stakeholder(s)

Automated Vehicle Sector :

U.S. Government Investments in the Automated Vehicle Sector — The U.S. Government is actively funding AV R&D and investing in the development of technologies to enable and complement an efficient transition toward a transportation system in which AVs and conventional surface vehicles operate seamlessly and safely. These investment areas include safety, mobility, security and cybersecurity, infrastructure, and connectivity.

Department of Energy :

DOE-sponsored research has shown that in addition to safety benefits, connectivity can be a significant enabler to reducing congestion on our roadways. Congestion increases fuel consumption and comes at a significant economic cost to businesses, causing delays for consumers, increasing emissions, and contributing to fatalities and injuries. Connectivity also enables vehicles to drive more efficiently in a range of settings—including on freeways, arterial roads, when merging, and at intersections—saving significant amounts of fuel/energy. These benefits require complementary technologies such as vehicle-to-vehicle and vehicle-to-infrastructure connectivity that has very high bandwidth and low latency.

Department of Homeland Security :

In July 2019, DHS's CISA released a risk and resilience note providing an overview of risks introduced by 5G adoption in the United States.⁶⁹ It highlights a number of risk management mitigations including ensuring robust security capabilities for 5G applications and services.

Department of Transportation :

USDOT is collaborating with public and private partners, including State and local governments, vehicle and device manufacturers, and academia, to advance connected vehicle development and implementation. ITS JPO is working with modal administrations within USDOT to coordinate and foster the advancement of connected vehicle technologies. Significant progress has already been made in testing connected vehicle technologies and applications in real-world situations. USDOT's Connected Vehicle Safety Pilot Program⁷⁰ provided large amounts of valuable data on how these technologies, applications, and systems perform in the hands of everyday drivers. USDOT strongly supports preserving the ability for transportation safety applications to function in the 5.9GHz Safety Band.⁷¹

Federal Communications Commission :

The FCC is the United States' primary authority for communications law, regulation, and technological innovation and is responsible for management of the electromagnetic spectrum (i.e., the radio airwaves) that is vital to nearly all facets of the modern economy.

National Telecommunications and Information Administration :

The FCC works with colleagues in the National Telecommunications and Information Administration (NTIA), a part of the Department of Commerce (DOC), on spectrum mat-

ters affecting Federal Government users. NTIA is the executive branch agency that is principally responsible for advising the President on telecommunications and information policy issues. NTIA's programs and policymaking focus largely on expanding broadband internet access and adoption in America, expanding the use of spectrum by all users, and ensuring that the internet remains an engine for continued innovation and economic growth. Many of the technologies central to enabling vehicle function, added-value features, and driver comfort require spectrum access to function. These include, for example, radars and the transmission of data from cameras used for safety and driver assistance features; GPS for navigation; toll tags, tire pressure monitors, garage door openers, and key fobs that aid and augment the driving experience; stolen vehicle recovery systems that help locate and recover vehicles; and radios (satellite and terrestrial) and Bluetooth/Wi-Fi connections that provide entertainment and in-cabin connectivity. Today's vehicles incorporate or make use of a wide range and increasing number of spectrum-dependent technologies. They must have the capability to integrate a multitude of services and devices to operate most effectively and provide the functions and features that drivers want. Areas where the FCC has seen particular interest include radar technologies (such as those in the 76-81 GHz band that is reserved for vehicular applications), vehicle-to-vehicle and vehicle-to-infrastructure communications protocols and increasingly widespread network connectivity that will be enabled by ubiquitous terrestrial 5G systems. Through its general spectrum management policies and rules, the FCC creates an environment that permits the development and deployment of communications technologies, including those used in vehicles, while leaving it to innovators to create and integrate those technologies. The FCC focuses primarily on preventing harmful interference between competing uses while relying on flexible rules that enable innovative devices and services to develop and deploy. This core principle is well suited to the fast-moving world of AV technologies. We expect that developers of technologies and applications will draw increasingly on the different spectrum authorization mechanisms that the FCC offers—whether through use of various frequencies that are assigned to specific users through licensing or for use by the general public without a specific license, or a combination of both. The FCC will continue efforts to ensure that its policies promote the type of modern approach to spectrum management that affords maximum flexibility to all innovators—including those who are working to advance AVs in the United States. NTIA's Institute for Telecommunication Sciences (ITS) staff monitor C-V2X and 5G communications technology specifications development activities through observation at 3GPP Working Group meetings and plenary sessions at international or domestic settings to identify how each input might affect transportation. This includes the identification of significant shifts to specifications that arise due to technology innovations that come through the working groups. The 5G use cases 3GPP is targeting are focused

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Stakeholders (continued)

on remote driving, automated driving, sensing, and platooning.

National Institute of Standards and Technology :
NIST, part of the Department of Commerce, advances industrial competitiveness by furthering measurement science, standards, and technology in ways that enhance economic security and improve quality of life. The National Advanced Spectrum and Communications Test Network (NASCTN) is a multi-agency partnership headquartered at and led by NIST that organizes a national network of Federal, academic, and commercial test facilities to provide testing, modeling, and analysis necessary to develop and deploy spectrum-sharing technologies and inform future spectrum policy and regulations. NASCTN's mission is to provide robust test processes and validated measurement data necessary to increase access to the spectrum by both Federal agencies and non-Federal spectrum users. NIST also conducts metrology research related to AVs, including the development of measurement techniques, test protocols, calibration services, modeling and simulation techniques that will help with predicting and testing certain connectivity aspects, such as signal propagation, wireless co-existence, and antenna performance as well as minimize radio interference in crowded airwaves. These tools are critical for reliable communications among connected vehicles, roadway infrastructure, and central control centers, and thus generate confidence in the safety of connected vehicles.

Automated Vehicle Sector :

U.S. Government Enabling Activities in the Automated Vehicle Sector — The U.S. Government is actively pursuing a range of regulatory and non-regulatory activities that will enable the adoption of AVs, with the overall goal to facilitate the safe and full integration of AV technologies into the national surface transportation system. Integration would help realize the great potential AV technologies have for enhancing public safety, making systems more efficient, and facilitating economic vitality. — Fostering Collaboration with Government:

Non-Federal Stakeholders :

Outreach to Non-Federal Stakeholders — The Federal Government uses the Federal Register⁷³ to make it easier for citizens and communities to understand the regulatory process and to participate in Government decision-making. Many Federal agencies are also reaching out to stakeholders in State, local, tribal and territorial governments, in industry, and elsewhere as part of the activities described above. These outreach activities are often conducted in collaboration with multiple Federal entities.

Office of Disability Employment Policy :

For example, through a series of listening sessions and online dialogues, most co-hosted with USDOT, the DOL's Office of Disability Employment Policy (ODEP) has engaged Federal agencies, academic researchers, original equipment manufacturers (OEMs), TNCs, State legislators, and disability advocates in a conversation about the role of the Federal Government in ensuring that AVs will be accessible to persons with mobility, sensory, and cognitive disabilities once deployed. The data from these events and

meetings will be used in the development of Federal and State policy recommendations.

SMART Mobility Lab Consortium :

DOE's SMART Mobility Lab Consortium has convened an external Executive Advisory Board of 12 prominent experts in a broad range of sectors impacting AVs, including manufacturing, transit, delivery, mobility, regulatory, technology, academia, and non-governmental organizations. The board advises the SMART Consortium, providing feedback on the Consortium's research portfolio, advising on industry needs and trends, and making recommendations for improving the quality, relevance, and impact of the SMART Mobility Consortium's research and development.

USDOT :

USDOT has lead numerous public events and published various public notices on the topic of AV to ensure the widest possible outreach to non-Federal stakeholders. These public events⁷⁴ and public notices⁷⁵ are compiled at an USDOT AV central webpage. ⁷⁶ USDOT has supported industry efforts to ensure public access to accurate and clear information about ADAS and ADS can encourage their safe use and adoption. In July 2019, USDOT brought together a diverse group of stakeholders⁷⁷ to discuss current issues around communication, terminology, and language regarding AVs and how it influences consumer perception of AV technologies. Additionally, during the Automated Vehicle Symposium, also in July 2019, a panel discussion was held on Steps Towards Putting the Public Safety Community at Ease with Advanced Vehicle Technologies. ⁷⁸

Cities :

Cities and local communities manage much of the transportation system within which AVs will operate. They have been asking how they should prepare for this new technology. EPA and DOE have been engaging with these communities to understand their needs and develop tools and information they can use to help consider potential environmental impacts of increasing AV operation.

FTC :

The FTC and NHTSA co-hosted a public workshop in 2017⁷⁹ to explore privacy and security issues related to AVs. FTC staff issued a paper summarizing the important themes from the panelist discussions during the full-day workshop.

NIST :

NIST hosted a workshop on Consensus Safety Measurement Methodologies for ADS-Equipped Vehicles⁸⁰ in June 2019 in collaboration with USDOT. This workshop's objectives was to identify and develop criteria that should be satisfied for any approach to automated vehicle decision-making safety, to review existing or proposed methodologies for the establishing safety requirements and safety measurement approaches, to identify gaps and key challenges, and to explore opportunities for progress, including identifying alternative methodologies that should be considered. The workshop report⁸¹ can be found through NIST Special Publication 1900-320.

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General Services Administration :

Trans-Federal Coordination — In addition to working with non-Federal stakeholders, several agencies lead activities intended to foster interagency coordination and the development of unified Federal approaches to AVs. For example, The General Services Administration's (GSA) Office of Government Policy promotes interagency collaboration through various committees and councils, including the

Federal Fleet Policy Council⁸² (FEDFLEET). FEDFLEET provides a mechanism for coordinating Federal vehicle management programs and policies, and analyzing the impact of current and proposed regulations, laws, Executive orders, and international agreements. It is composed of representatives of Federal agencies that operate Federal motor vehicle fleets.

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... The U.S. Government has invested in the development of foundational and complementary technologies for AVs to advance novel science and technology and provide support to innovators and entrepreneurs bringing technological advances to market. This continued investment will ensure public safety in a rapidly changing technological landscape, promote greater economic productivity and more efficient consumption of available resources, protect intellectual property, and safeguard the privacy of individuals and the security of the Nation... Spectrum and Connectivity — As AVs become more prevalent on American roads, access to spectrum cooperation and connectivity may become increasingly important. Therefore, the U.S. Government will focus on the use and management on this important spectrum.

8. Standards & Policies

Promote Consistent Standards and Policies

The U.S. Government will prioritize participation in and advocate abroad for voluntary consensus standards and evidencebased 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... Voluntary Consensus Standards and Other Guidance — The U.S. Government will promote voluntary consensus standards as a mechanism to encourage increased investment and bring cost-effective innovation to the market more quickly. Voluntary consensus standards can be validated by testing protocols, are supported by private-sector conformity assessment schemes, and offer flexibility and responsiveness to the rapid pace of innovation. Furthermore, many SDOs utilize existing processes that allow industry participation in the development of voluntary consensus standards... Tax Incentives for AV Research — To ensure American leadership and growth in AV technology, the U.S. Government offers attractive tax incentives for AV innovators and entrepreneurs to conduct AV R&D in the United States.

Stakeholder(s):

Department of Health and Human Services :

In other voluntary standards-setting efforts, NIOSH served on the subcommittee convened by the American Society of Safety Professionals (ASSP) and National Safety Council, which developed the American National Standards Institute (ANSI)/ASSP Z15.3 technical report, Management Practices for the Safe Operation of Partially and Fully Automated Motor Vehicles. ⁸³ The report is intended to help organizations develop policies, procedures, and management processes to control risks associated with the operation of AVs.

for inclusion in USDOT's Volpe Center's upcoming "Government Fleet Manager's Guide to Medium and Heavy Truck Cybersecurity Best Practices" that have applicability to AVs. CBP also collaborates with USDOT through its participation in the Government Cybersecurity Vehicle Steering Committee and the Commercial Truck Cybersecurity Working Group.

Department of Transportation :

In 2017, NHTSA provided voluntary guidance through Automated Driving Systems 2.0: A Vision for Safety (ADS 2.0). ADS 2.0⁸⁴ revised and streamlined to emphasize the voluntary nature of the guidelines—no compliance requirement or enforcement mechanism. ADS 2.0 focuses on the New Operating Guidance on SAE Level 3 and above Automated Driving Systems. Additionally, ADS 2.0 clarifies that assessments are not subject to Federal approval and

Department of Homeland Security :

In another Federal collaboration, in March 2019, DHS's U.S. Customs and Border Protection (CBP) authored six vehicle cybersecurity threat scenarios

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that there is no waiting period or delay to begin testing or deployment. Furthermore, it revises priority safety elements, focusing on 12 aspects that are ready for implementation in the near term. Elements involving privacy, ethical considerations, registration, and the sharing of data beyond crash data remain important and are areas for further discussion and research. In 2018, USDOT presented further voluntary guidance for AV development across all surface modes through *Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0)*.⁸⁵ AV 3.0—developed with input from a diverse set of stakeholder engagements throughout the Nation—builds upon ADS 2.0, further expanding the scope to all surface onroad transportation systems. AV 3.0 is structured around three key areas: 1) Advancing multi-modal safety, 2) Reducing policy uncertainty, and 3) Outlining a process for working with USDOT. USDOT's Volpe National Transportation Systems Center and NCCoE collaborated with three Connected Vehicle (CV) Pilots (Wyoming, New York, and Florida) and the University of Michigan Transportation Research Institute (UMTRI) to develop the CV Pilot Cybersecurity Framework Profile and conduct a privacy risk analysis. This included applying the NIST Privacy Risk Assessment Methodology (PRAM) to UMTRI's Ann Arbor Connected Vehicle Test Environment (AACVTE) research implementation. This research resulted in a Cybersecurity Framework Profile in 2018.⁸⁶

National Institute of Standards and Technology :

NIST supports the development and use of measurement science in voluntary consensus standards, conformity assessment, and related tools. This work is enabling the development, deployment and assurance of ADS. NIST's Cyber-Physical Systems Program is developing methods for measuring AV trustworthiness (safety, security, resilience, reliability, and privacy) to support performance measurements for ADS. The goal is to enhance existing methods for validating vehicle trustworthiness—for example to support new modeling and simulation capabilities in ADS-equipped vehicles.

Department of the Treasury :

The Department of the Treasury and the Internal Revenue Service (IRS) promote innovation in the AV industry through publication of administrative rules and other guidance on current Federal income tax law incentives. Taxpayers can immediately expense the cost of research and developmental activities that are experimental in nature with the purpose of eliminating uncertainty when developing or improving a product. Qualifying activities may include developing a patent and inventing technologies to improve the fuel efficiency of AVs or to enhance driver experiences with AVs. A Federal income tax credit of up to 20% of the eligible spending for research and developmental activities is also available. Taxpayers may also immediately expense the cost of qualified business property purchased after September 27, 2017

and before January 1, 2023. Additionally, AV innovators can immediately expense the cost of purchasing new or used manufacturing equipment, the AVs they operate or lease, and computer hardware and software. Understanding that AV companies may have more operating expenses than revenues in their early years of business, the tax code allows the carryover of net operating losses to offset 80% of taxable income generated in future years. The indefinite carryover of net operating losses to future years ensures the benefit of the operating expenses will be utilized when a company generates profits. Taxpayers may immediately expense start-up and organizational costs of up to \$5,000 (for each category) in the year the business begins operations. The \$5,000 deduction is reduced by the amount of the start-up or organizational costs that exceeds \$50,000; the remainder of the costs may be deducted over a 180-month period. The start-up costs include any amounts paid in connection with creating an active trade or business or investigating the creation or acquisition of an active trade or business. Organizational costs include the cost of creating a corporation or partnership. Tax incentives are available to promote domestic manufacturing for export, including AVs. U.S. corporations have a reduced U.S. Federal income tax rate through a 37.5% deduction for their directly earned foreign-derived intangible income (FDII) for the 2018 through 2025 tax years (reduced to 21.875% thereafter). The FDII deduction is akin to an Innovation Box tax regime designed to incentivize American corporations to maintain U.S.-based operations and intangibles while exporting more goods and services to foreign markets. The FDII deduction is provided for all export-related income in excess of a fixed return on tangible assets to incentivize all U.S. export-based operations. An “interest charge domestic international sales corporation” (IC-DISC) can be utilized to eliminate the Federal corporate income tax on foreign sales of tangible goods that are manufactured or produced in the United States. The earnings from the IC-DISC are taxed only when they are distributed to its shareholders, and usually at a 20% tax rate for qualified dividends. Unlike the FDII deduction, the IC-DISC rules require a substantial amount of U.S. activity in manufacturing or producing the sold good, and thus this regime specifically incentivizes U.S. production for export.

American AV Innovators :

Trade Promotion Related to AVs — The U.S. Government will ensure American AV innovators have fair access to foreign markets. The U.S. Government will seek rules, both at home and abroad, that are as performance-based and non-prescriptive as possible and do not discriminate against U.S. technologies, products, or services.

Department of State :

With respect to international trade promotion for AVs, the mission of the Department of State's Bureau of Economic and Business Affairs is to advance

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America's prosperity and other national interests by supporting American business overseas; fostering good governance through economic transparency, accountability and sustainability; and fostering inclusive economic growth and prosperity. The Bureau of Economic and Business Affairs is the Department's lead bureau on economic engagement, international trade, transportation and telecommunications policy, and commercial advocacy.

Department of Transportation :

The USDOT's Office of International Transportation and Trade provides departmental leadership on international multimodal transportation and trade policies and initiatives, including technical assistance and cooperation programs, as well as trade facilitation and advocacy activities. The office provides the Secretary of Transportation with information and analysis to aid in developing international transportation policy and other international responsibilities. These include exchanging technical information with foreign counterparts, facilitating open and liberalized global transportation markets, reducing technical barriers to trade in the transportation sector and resolving market access issues created by other countries' standards and regulations. The office also represents the Department in global transportation organizations and trade fora. It conducts in-depth analysis and provides policy recommendations to address emerging and ongoing international transportation issues, and in consultation with the Department's operating administrations, it also develops the Department's positions on the negotiation or implementation of international trade agreement provisions affecting transport.

International Trade Administration :

The International Trade Administration (ITA) within the United States Department of Commerce promotes United States exports of nonagricultural U.S. services and goods. ITA is working with U.S. regulators and industry to collaborate with foreign partners while the technology is still being developed to attain convergent technical specifications and requirements that enable trade and continued U.S. exports because regulatory divergence acts to unnecessarily raise costs while also restricting road vehicle trade. ITA has found that it is much easier to achieve convergent standards and regulations if work begins prior to their initial development to bridge differences prior to investments being made. ITA can also work with smaller technology developers to both find foreign buyers and to help protect intellectual property

Office of Trade and Manufacturing Policy :

The Office of Trade and Manufacturing Policy (OTMP) was created by Executive order within the Executive Office of the President (EOP) in 2017.⁸⁹ One of OTMP's primary roles is to support the ability of the United States to manufacture products, particularly technologically advanced products such as AVs, domestically. This can be done through a variety of

policy options, including trade policies and government procurement programs (such as "Buy American" preference programs). OTMP has a particular focus on the nexus of economic and national security issues, and works closely with the DoD and other agencies on defense procurement policies, which may include purchase commitments and loan guarantees for production capabilities with critical defense implications.

Office of the U.S. Trade Representative :

The Office of the U.S. Trade Representative⁹⁰ (USTR) is responsible for developing and coordinating U.S. international trade, commodity, and direct investment policy, and overseeing trade negotiations with other countries. USTR's role in transportation automation is to engage with trading partners as appropriate to pursue fair and reciprocal market access abroad for U.S.-developed and U.S.-manufactured transportation automation-related technologies, vehicles, and services. This includes protecting U.S. transportation automation-related intellectual property internationally and working with trading partners to shape regulatory environments abroad so that they do not discriminate against U.S. technologies, products, or services.

American Innovators :

Intellectual Property Protection—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.

Office of the U.S. Intellectual Property Enforcement Coordinator :

The Office of the U.S. Intellectual Property Enforcement Coordinator (IPEC)⁹¹ in the Executive Office of the President coordinates and develops policy and strategy to promote innovation and creativity, and ensures effective intellectual property protection and enforcement, domestically and abroad, with respect to all forms of intellectual property. As is the case for other critical technologies, AV technology will rely heavily on intellectual property in the form of patents, trade secrets, copyrighted software, and trademarked goods. For the United States to successfully adopt this technology, the intellectual property of American innovators—and the safety of the American public—will both need to be protected. In this regard, establishing and maintaining secure supply chains for AV technologies will be essential for protecting safety, security, and intellectual property.

Department of Justice :

DOJ, through the Computer Crime and Intellectual Property Section (CCIPS) in its Criminal Division, as well as through its National Security Division, ex-

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ecutes national strategies in combating intellectual property crimes—including those involving AV technology—worldwide. DOJ attorneys prevent, investigate, and prosecute intellectual crimes by working with other government agencies, the private sector, academic institutions, and foreign counterparts. These attorneys work to improve the domestic and international infrastructure (legal, technological, and operational) to pursue criminals most effectively. They also regularly run complex investigations, resolve unique legal and investigative issues raised by emerging computer and telecommunications technologies; litigate cases; provide litigation support to other prosecutors; train Federal, State, and local law enforcement personnel; comment on and propose legislation; and initiate and participate in international efforts to combat computer and intellectual property crime.

United States Patent and Trademark Office :

The United States Patent and Trademark Office (USPTO) is the Federal agency responsible for issuing patents and registering trademarks.⁹² The agency's mission is to foster innovation, competitiveness, and economic growth, domestically and abroad. It does this through a three-pronged approach:

- *delivering high quality and timely examinations of patent and trademark applications;*

- *guiding domestic and international intellectual property policy; and*
- *delivering IP information and education worldwide.*

Innovators and entrepreneurs in the AV field should be aware of USPTO, as securing a patent, trademark, or both serves not only to afford them important legal rights, but also to help preserve the United States' technological edge, which is key to our current and future competitiveness in AV technologies. In particular, a patent grants a property right to an inventor providing the exclusive right to exclude others from "making, using, offering for sale, or selling" an invention in the United States, or for importing a patent-protected invention into the United States. Generally, patent rights for an invention will last for a term of 20 years from the date on which the application was filed in the United States. A trademark is a word, name, symbol, or device that is used in trade in goods to indicate the source of the goods and to distinguish them from the goods of others. Trademark rights may be used to prevent others from using a confusingly similar mark, but not to prevent others from making the same goods or from selling the same goods or services under a clearly different mark. Trademarks that are used in interstate or foreign commerce may be registered with USPTO. U.S. patents and trademarks are open to applicants around the world, and provide the aforementioned rights within the borders of the United States.

9. Consistency

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. Effects

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.