Ensuring American Leadership in Automated Vehicle Technologies

Automated Vehicles 4.0

A Report by the
NATIONAL SCIENCE & TECHNOLOGY COUNCIL
and the
UNITED STATES DEPARTMENT OF TRANSPORTATION

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Letter from

The United States Secretary of Transportation and the United States Chief Technology Officer

AS the world leader in technology, American innovation and ingenuity have historically transformed how we travel and connect with one another. Under this Administration, President Donald J. Trump has stressed the importance of ensuring America's continued leadership in emerging technologies, including Automated Vehicles (AVs). With the development of AVs, America has the potential to once again transform the future of transportation, while also increasing economic growth and overall productivity. AVs—if developed properly- also have the potential to make our roadways safer by reducing crashes caused by human error, including crashes involving impaired or distracted drivers.

The release of *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0* (AV 4.0) marks another milestone in American innovation. The White House and the U.S. Department of Transportation (USDOT) developed AV 4.0 to unify efforts in automated vehicles across 38 Federal departments, independent agencies, commissions, and Executive Offices of The President, providing high-level guidance to Federal agencies, innovators, and all stakeholders on the U.S. Government's posture towards AVs.

The USDOT is actively preparing for emerging technologies by engaging with new technologies to address legitimate public concerns about safety, security, and privacy without hampering innovation. With the release of *Automated Driving Systems 2.0: A Vision for Safety* (ADS 2.0) in September 2017, the USDOT provided voluntary guidance to industry, as well as technical assistance and best practices to States, offering a path forward for the safe testing and integration of Automated Driving Systems. In October 2018, *Preparing for the Future of Transportation: Automated Vehicles 3.0* (AV 3.0) introduced guiding principles for AV innovation for all surface transportation modes, and described the USDOT's strategy to address existing barriers to potential safety benefits and progress.

Building upon these efforts, AV 4.0 details 10 U.S. Government principles to protect users and communities, promote efficient markets, and to facilitate coordinated efforts to ensure a standardized Federal approach to American leadership in AVs. It also presents ongoing Administration efforts supporting AV technology growth and leadership, as well as opportunities for collaboration including Federal investments in the AV sector and resources for AV sector innovators.

The landscape for AV innovation is complex and evolving. While significant investments and achievements are being made by industry, academia, and nonprofit organizations, further development of the technology itself is needed. Therefore, this Administration continues to evaluate its priorities for Federal research and development to ensure that investments advance AV innovations without duplicating industry efforts.

The future of transportation holds tremendous promise to strengthen the U.S. economy and make life safer and more mobile for all Americans. We look forward to continued efforts to ensure America leads the world in automated vehicle technologies.

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Executive Summary

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.

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.

I. Protect Users and Communities
- **1.** Prioritize Safety
- **2.** Emphasize Security and Cybersecurity
- **3.** Ensure Privacy and Data Security
- **4.** Enhance Mobility and Accessibility

II. Promote Efficient Markets
- **5.** Remain Technology Neutral
- **6.** Protect American Innovation and Creativity
- **7.** Modernize Regulations

III. Facilitate Coordinated Efforts
- **8.** Promote Consistent Standards and Policies
- **9.** Ensure a Consistent Federal Approach
- **10.** Improve Transportation System-Level Effects

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.

I. Automated Vehicles

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.

This document is not intended to be an exhaustive catalog of Federal efforts, roles, or responsibilities. Rather, it outlines certain past and current Federal efforts, and compiles available key resources for innovators and entrepreneurs in the surface transportation AV domain. Our purpose is to document a sample of U.S. Government investments and resources related to AVs in order to support American leadership in AV and AV-related research and development (R&D).

As such, the U.S. Government AV principles outlined here may align to a greater or lesser extent with any given Federal agency's mission and areas of responsibilities. They are not intended to define the extent of concerns, but rather to inform efforts to work together in the AV domain.

Potential Benefits of Automated Vehicle Technology

There are many potential benefits to increasing R&D efforts for AV technology and furthering its broad adoption and use in the U.S. surface transportation system. Potential benefits to the American public could include improved safety and a reduction in roadway fatalities; improved quality of life, access, and mobility for all citizens; lower energy usage; and improved supply chain management.[1] Today's Advanced Driver Assistance Systems (ADAS) that help vehicles avoid collisions form the building blocks for tomorrow's Automated Driving Systems (ADS). Advances in these technologies can reduce roadway crashes, fatalities, and injuries and assist the USDOT in "managing safety risks along the path to the full commercial integration of AV technology."[2]

The National Highway Traffic Safety Administration (NHTSA) has highlighted four main areas of potential benefit with regard to AVs: safety, economic and societal benefits, efficiency and convenience, and mobility.[3] AVs also have great potential benefit for improving public safety on roadways. NHTSA's Fatality Analysis Reporting System report of traffic fatalities for 2018 found that 36,560 people died from motor vehicle crashes in the U.S.[4] By eliminating the possibility of human error or poor human choices (e.g., impairment or distraction) while driving, ADS has enormous potential to save lives and reduce the economic burden associated with crashes.

The potential economic and societal benefits of AVs could also be substantial, including increased economic productivity and efficiency, reduced commuting time, and even the potential reduction of the environmental impact of conventional surface vehicles while increasing overall system energy efficiency.[5] In addition, adoption of AVs may provide mobility to citizens who currently face transportation challenges, increasing their access to jobs and services and their ability to live independently.[6]

AVs also have strong potential for increased benefits in more specialized operational design domains (ODD) such as, the agricultural domain, automated tractors and farm equipment have the potential to allow American farmers to track multiple vehicles and monitor field operations remotely. In addition, continued improvements in sensor technologies and software increasingly will allow equipment to operate in more complex environments and make precise observational decisions, deploying herbicides only when weeds are detected, for example.[7] In the arena of commercial freight transport, AVs have the potential to safely haul freight long distances, which could decrease long-haul transport times and improve

1 U.S. Congressional Research Service. Autonomous Vehicles: Emerging Policy Issues (IF10658 VERSION 3; May 23, 2017), by Bill Canis. https://crsreports.congress.gov/product/pdf/IF/IF10658

2 Chao, Elaine L. "AV 3.0 Roll Out remarks by USDOT Secretary of Transportation Elaine L. Chao" https://www.transportation.gov/briefing-room/av-30-roll-out

3 National Highway Traffic Safety Administration. Automated Vehicles for Safety. https://www.nhtsa.gov/technology-innovation/automated-vehicles#topic-benefits

4 National Highway Traffic Safety Administration. Automated Vehicles for Safety. https://www.nhtsa.gov/technology-innovation/automated-vehicles#topic-benefits

5 Groshen, Erica, John Paul Macduffie, Susan Helper, and Charles Carson. 2018. America's Workforce and the Self-Driving Future: Realizing Productivity Gains and Spurring Economic Growth. Washington, DC: Securing America's Future Energy. https://avworkforce.secureenergy.org/wp-content/uploads/2018/06/Americas-Workforce-and-the-Self-Driving-Future_Realizing-Productivity-Gains-and-Spurring-Economic-Growth.pdf

6 For more information, see the following NSTC report: https://www.whitehouse.gov/wp-content/uploads/2019/03/Emerging-Tech-to-Support-Aging-2019.pdf

7 McMahon, Karen. 2018. "Automated Farm Equipment Poised to Transform Production Practices." http://www.syngenta-us.com/thrive/research/automated-farm-equipment.html

supply chain management efficiencies. AV technology also has the potential to dramatically reduce congestion—one of the highest costs for freight movement—and to enable platooning technology that can reduce energy costs.[8]

Given that ADS are still currently in the R&D phase and not available for consumer purchase, data on collision rates for ADS under real-world conditions are limited at this time and a standardized vocabulary and methodology for evaluating and regulating their safety is still being developed by NHTSA, State regulators, and other stakeholders.[9] However, numerous technologies that are related to ADS, such as automatic emergency braking, lane departure warning, and adaptive cruise control, are already being incorporated into conventional vehicles and their effect on collision rates can be evaluated.

AVs hold enormous potential to promote the independence, economic opportunities, and social well-being of older Americans and persons with disabilities by offering independent mobility for daily activities. Reducing transportation related obstacles would enable new employment opportunities for individuals with disabilities and could save billions annually in healthcare expenditures from missed medical appointments.[10] Ensuring that AVs will meet the needs of Americans of all abilities will require carefully thought-out inclusive design to ensure widespread usability and market potential for persons with all types of disabilities—visual, auditory, cognitive, mobility, and others.[11]

The introduction of AVs in the coming decades has the potential to substantially affect many sectors of daily life. The U.S. Government's deliberate and forward engagement of all stakeholders—including industry, government, the workforce, and the public—could help fulfill the potential for AVs to improve the quality of life for all Americans and grow the U.S. economy.

U.S. Government Automated Vehicle Technology Principles

USDOT, through *Preparing for the Future of Transportation: Automated Vehicles 3.0,*[12] developed principles that encompassed the equities of USDOT. In order for the American public to fully reap the individual, societal, and economic benefits of AV technology, the National Science and Technology Council's (NSTC) Automated Vehicle Fast Track Action Committee (AV FTAC) expanded upon USDOT's principles and adopted a total of 10 principles to protect users and communities, promote efficient markets, and facilitate coordinated efforts. Together, these principles will foster research, development, and integration of AVs in the United States and guide consistent policy across the U.S. Government.

The U.S. Government will be proactive about AVs and will provide guidance, best practices, conduct research and pilot programs, and other assistance to help stakeholders plan and make the investments needed for a dynamic and flexible future for all Americans. We will also prepare for complementary technologies that enhance the benefits of AVs, such as communications between vehicles and the surrounding environment, but will not assume universal implementation of any particular approach.

8 DOE, Office of Energy Efficiency & Renewable Energy, Platooning Trucks to Cut Cost and Improve Efficiency. https://www.energy.gov/eere/articles/platooning-trucks-cut-cost-and-improve-efficiency

9 Fraade-Blanar, Laura, Marjory S. Blumenthal, James M. Anderson, and Nidhi Kalra. 2018. Measuring Automated Vehicle Safety: Forging a Framework. Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/research_reports/RR2662.html

10 Claypool, Henry, Amitai Bin-Nun, and Jeffrey Gerlach. 2017. Self-Driving Cars: The Impact on People with Disabilities. Boston, MA: Ruderman Family Foundation. https://rudermanfoundation.org/wp-content/uploads/2017/08/Self-Driving-Cars-The-Impact-on-People-with-Disabilities_FINAL.pdf

11 Bierstedt, Jane et al., 2014, "Effects of Next-Generation Vehicles on Travel Demand and Highway Capacity," Princeton University. https://www.fehrandpeers.com/wp-content/uploads/2015/07/FP_Think_Next_Gen_Vehicle_White_Paper_FINAL.pdf

12 Preparing for the Future of Transportation: Automated Vehicle 3.0, USDOT. https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf

I. Protect Users and 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. Prioritize Safety

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

2. Emphasize Security and Cybersecurity

The U.S. Government will support the design and implementation of secure AV technologies, the systems on which they rely, and the functions that they support to 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.

3. Ensure Privacy and Data Security

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

4. Enhance Mobility and Accessibility

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

II. Promote Efficient Markets

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

5. Remain Technology Neutral

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

6. Protect American Innovation and Creativity

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

7. Modernize Regulations

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

III. Facilitate Coordinated Efforts

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

8. Promote Consistent Standards and Policies

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

9. Ensure a Consistent Federal Approach

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

10. Improve Transportation System-Level Effects

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

II. Administration Efforts Supporting Automated Vehicle Technology Growth and Leadership

The Administration has prioritized the development of AVs, including them as part of the Fiscal Year (FY) 2021 Administration Research and Development Budget Priorities.[13, 14]

The Administration, through the NSTC and the White House Office of Science and Technology Policy (OSTP), has convened workshops and published strategy documents to inform efforts in a number of building blocks for AV technology growth, outlined below. Moreover, the U.S. Government addresses a wide range of concerns related to AVs from conceptualization, through R&D, to support of commercialization. A sample of those efforts is provided here to outline these broad investments.

Advanced Manufacturing

The NSTC released *A Strategy for American Leadership in Advanced Manufacturing* in October 2018, which presents the Administration's vision for American leadership in advanced manufacturing across industrial sectors to ensure national security and economic prosperity.[15] Advanced manufacturing offers the promise of increasing productivity and efficiency for existing product types, as well as allowing for entirely new production methods.

Artificial Intelligence and Machine Learning

On February 11, 2019, President Donald J. Trump signed Executive Order 13840 *Maintaining American Leadership in Artificial Intelligence* (AI), which launched the American AI Initiative. This initiative implements a whole-of-government national strategy in collaboration and engagement with the private sector, academia, the public, and like-minded international partners. It directs Federal agencies to pursue a multipronged approach to advance AI, including: promoting sustained AI R&D investment, enhancing access to high-quality cyberinfrastructure and data, removing barriers to AI innovation, providing education and training opportunities to prepare the American workforce for AI, and fostering an international environment favorable to American AI innovation.

Connected Vehicles and Spectrum

In June 2018, the Federal Communications Commission (FCC) released the *Facilitate America's Superiority in 5G Technology Plan* (also known as the *5G FAST Plan*). This plan includes three key components: (1) pushing more spectrum into the marketplace; (2) updating infrastructure policy; and (3) modernizing outdated regulations.[16] High-speed communications support Vehicle-to-Vehicle (V2V) and Vehicle-to-Everything (V2X) environment data exchange. Such data exchange allows AVs to receive and contribute data beyond their on-board sensors' physical range. Wireless technologies that complement the capabilities of automated vehicle technologies are a priority of the current administration.[17]

STEM Education

AVs are an application of a variety of contributing and complementary technologies, including advanced manufacturing, high-speed communications technologies, advanced computational capabilities, computer vision, advanced sensors, data science, machine learning, and artificial intelligence. As such, education in science, technology, engineering, and mathematics (STEM) and computer science plays a critical role in these technological advancements. The NSTC released

13 "Additional R&D is needed to safely and efficiently integrate autonomous driving systems and unmanned aircraft systems (UAS), including urban air mobility aircraft, onto our roadways and into the national airspace. Specifically, agencies should prioritize R&D to lower barriers to the deployment of autonomous vehicles and to develop operating standards and a traffic management system for UAS" (M-18-22, July 2018).

14 https://www.whitehouse.gov/wp-content/uploads/2019/08/FY-21-RD-Budget-Priorities.pdf

15 For the full text, see https://www.whitehouse.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf

16 The FCC's 5G FAST Plan. https://www.fcc.gov/5G

17 Emerging Technologies and Their Expected Impact on Non-Federal Spectrum Demand, https://www.whitehouse.gov/wp-content/uploads/2019/05/Emerging-Technologies-and-Impact-on-Non-Federal-Spectrum-Demand-Report-May-2019.pdf

Charting a Course for Success: America's Strategy for STEM Education in December 2018, which sets out a Federal strategy for the next 5 years based on a vision for a future in which all Americans have lifelong access to high-quality STEM education, and the United States is a global leader in STEM literacy, innovation, and employment.[18]

STEM Workforce

Advances in innovation are dependent on a vibrant, scientifically literate workforce. Federal STEM strategy encourages expansion of educator-employer partnerships that promote work-based learning experiences to offer powerful, relevant ways to ensure that STEM learning is authentic and engaging and that learners are prepared to succeed. The July 19, 2018, *Executive Order Establishing the President's National Council for the American Worker* created the Council to develop recommendations for the President on policy and strategy related to the American workforce, building upon the June 2017 Presidential Executive Order *Expanding Apprenticeships in America* intended to promote the development of apprenticeship programs by third parties and to prioritize the use of apprenticeships by Federal agencies.[19]

Supply Chain Integration

The May 15, 2019, *Executive Order on Securing the Information and Communications Technology and Services Supply Chain* banned any new acquisition, importation, transfer, installation, dealing in, or use of any information and communications technology or service (transaction) by any person subject to the jurisdiction of the United States of any products or services from a foreign-owned company or foreign person subject to a determination by the Secretary of Commerce, in consultation with the heads of other departments and agencies.[20]

Quantum Information Science

The NSTC released the *National Strategic Overview for Quantum Information Science* in September 2018, which lays out a visible, systematic, national approach to quantum information research and development.[21] Congress passed and the President signed into law the National Quantum Initiative Act in December 2018, which, among other activities, established the Subcommittee on Quantum Information Science within NSTC, and the National Quantum Initiative Advisory Committee. The Advisory Committee advises the President and the Subcommittee on the national quantum program and trends and developments in quantum information science and technology.[22] In addition, the economic and national security implications of quantum science are highlighted by additional coordination and funding in the National Defense Authorization Act of 2018.[23] Sensors, optimization, and security are areas where overlaps exist between the R&D interests for AVs and quantum information science. For example, the Global Positioning System (GPS) is a well-developed example of how quantum technologies, in this case atomic clocks in space, have revolutionized navigation. Additional sensors based on quantum technologies are transforming inertial navigation, a key backup technology to GPS. At the same time, new approaches for solving challenging multi-vehicle scheduling and optimization of machine learning systems may benefit from developments in quantum computing. Finally, the cybersecurity of automated platforms will require appropriate standards that are resistant to attack from a quantum computer, as covered in the National Institute of Standards and Technology (NIST) cybersecurity framework.[24]

18 For the full text, see https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf

19 For the full text, see https://www.whitehouse.gov/presidential-actions/3245/; https://www.whitehouse.gov/presidential-actions/executive-order-establishing-presidents-national-council-american-worker/

20 For the full text, see https://www.whitehouse.gov/presidential-actions/executive-order-securing-information-communications-technology-services-supply-chain/

21 National Strategic Overview for Quantum Information Science. https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Strategic-Overview-for-Quantum-Information-Science.pdf

22 Public Law No: 115-368 (12/21/2018) National Quantum Initiative Act.

23 https://www.congress.gov/bill/115th-congress/house-bill/2810

24 NIST Cybersecurity Framework. https://www.nist.gov/cyberframework

III. U.S. Government Activities and Opportunities for Collaboration

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.

A. 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.

Safety

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.

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'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'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 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 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 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.

Ensuring Mobility for All 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.

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 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.

USDOT hosted the Access and Mobility for All Summit to raise awareness of USDOT and government-wide efforts to improve access and mobility for persons with disabilities, older adults, and individuals of low income and identify priority Federal and non-Federal activities and innovations that can provide more efficient, affordable, and accessible vehicles and mobility services such as transit and ridesharing.

The following announcements were made by Secretary Elaine L. Chao during this summit:

1. Up to $40 Million for a Complete Trip Deployment Solicitation
2. $5 million in cash prizes for a planned Inclusive Design Challenge
3. Notice of Funding Opportunity for FTA's FY 2020 Mobility for All Pilot Program
4. A strategic plan for the Coordinating Council on Access and Mobility (CCAM)

For reference: (https://www.transportation.gov/accessibility)

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,

25 https://www.transportation.gov/accessibility

26 https://one.nhtsa.gov/cars/rules/adaptive/index.html

27 https://www.fmcsa.dot.gov/regulations/americans-disabilities-act-reporting-and-other-requirements-over-road-bus-companies

28 https://www.transit.dot.gov/regulations-and-guidance/civil-rights-ada/americans-disabilities-act

29 https://www.its.dot.gov/research_areas/attri/index.htm

30 https://www.its.dot.gov/automated_vehicle/avr_plan.htm

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 rulemaking 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.

Fundamental Research

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.

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 autosteer 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.

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. *(Photo credit: USDA)*

31 https://www.ncd.gov/publications/2015/self-driving-cars-mapping-access-technology-revolution

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.

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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 hazardous 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

32 https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503641

deactivate system functions as necessary. The DoD is developing multiple vehicle demonstration programs in support of its 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 ADS-equipped vehicle[33], congestion impacts of personally-owned AVs compared to fleet-owned mobility service AVs).

DOE is also using its unique High Performance Computing[34] (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 ADS-equipped vehicle 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

33 https://www.sae.org/news/2019/01/sae-updates-j3016-automated-driving-graphic

34 https://www.energy.gov/science/initiatives/high-performance-computing

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 Partnership[35] (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 initiative[36], 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-Energy[37] (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) Program [39]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 powertrain 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 ADS-equipped vehicle. 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.

35 https://www.energy.gov/eere/vehicles/21st-century-truck-partnership

36 https://www.energy.gov/articles/energy-department-announces-137-million-investment-commercial-and-passenger-vehicle

37 https://arpa-e.energy.gov/

38 https://www.energy.gov/articles/doe-announces-59-million-and-43-projects-accelerate-advanced-vehicle-technologies-research
https://www.energy.gov/eere/vehicles/downloads/fiscal-year-2019-advanced-vehicle-technologies-research-selections

39 https://arpa-e.energy.gov/?q=arpa-e-programs/nextcar

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.

> The U.S. Government has funded various research projects on accessible transportation technologies. Recently, FHWA and NIDILRR has funded a project on ATTRI: Assessment of Relevant Research, which was conducted by The Robotics Institute at Carnegie Mellon University. This report highlights the potential That Automated Vehicles hold for travelers with disabilities.
>
> (For reference: https://www.ri.cmu.edu/wp-content/uploads/2017/04/3_ATTRI_ARR_2017-04.pdf)

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.

40 https://www.dhs.gov/science-and-technology/technology-foraging

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 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.

CARMA[sm] is a research program designed to develop concepts for cooperative driving automation that address common traffic situations, and test and evaluate resulting applications. **CARMA**[sm] enables ADS to navigate more safely and efficiently with other vehicles and roadway infrastructure though communication and cooperation. **CARMA**[sm] aims to accelerate market readiness and the integration of cooperative automated driving systems, while advancing safety, security, data, and artificial intelligence. FHWA is conducting this work using open source software to encourage national and international collaboration and participation by a community of engineers and researchers in public, private and non-profit sectors. *(Photo credit: FHWA)*

(For reference: https://cms7.fhwa.dot.gov/research/research-programs/operations/carma-overview)

41 https://www.fhwa.dot.gov/fastact/factsheets/advtranscongmgmtfs.cfm

- **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 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.

- **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

42 Transferability of Automation Technologies https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/118161/transit-bus-automation-project-transferability-automation-technologies-final-report-fta-report-no.pdf

43 https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/114661/strategic-transit-automation-research-report-no-0116_0.pdf

44 https://www.nhtsa.gov/press-releases/us-dot-releases-new-automated-driving-systems-guidance

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 protection[45] 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-equipped vehicle 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 (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 Challenge[48], 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.

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,

45 https://www.nhtsa.gov/research-data/crashworthiness

46 NHTSA, Cybersecurity Best Practices for Modern Vehicles. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/sae2017chatipoglu_0.pdf

47 https://www.transportation.gov/av/grants

48 https://www.transportation.gov/accessibility

49 For the full text, see https://www.nasa.gov/offices/oct/home/roadmaps

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.).

(For reference: https://software.nasa.gov/software/ARC-16457-1A, https://ntrs.nasa.gov/search.jsp?R=20140013445)

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.

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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,

50 For the full text, see https://techport.nasa.gov

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 capabilities and individual sensor technologies. The USPS received numerous responses and is developing programs

51 https://ntrs.nasa.gov/

52 https://www.uspsoig.gov/sites/default/files/document-library-files/2017/RARC-WP-18-001.pdf

53 https://www.fbo.gov/spg/USPS/SSP/PhPMSC/RFI-USPS-AVC/listing.html

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.

Security and Cybersecurity

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.

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 essential 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 important 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 Act[54] 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 Center[57] (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.

54 (49 U.S.C. chapter 301) ("Safety Act")

55 49 U.S.C. § 30101

56 NHTSA, Cybersecurity Best Practices for Modern Vehicles. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/sae2017chatipoglu_0.pdf

57 https://www.automotiveisac.com/

National Institute of Standards and Technology

The NIST National Cybersecurity Center of Excellence[58] (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 Securable Internet of Things (IoT) Devices: A Starting Point for IoT Device Manufacturers*[60] 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 previously 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 Council[62] 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.

58 National Institute of Standards and Technology. National Cybersecurity Center of Excellence. https://www.nccoe.nist.gov/

59 NIST Cybersecurity Framework. https://www.nist.gov/cyberframework

60 NIST 8259 draft publication for Core Cybersecurity Feature Baseline for Securable Internet of Things (IoT) Devices: A Starting Point for IoT Device Manufacturers. https://nvlpubs.nist.gov/nistpubs/ir/2019/NIST.IR.8259-draft.pdf

61 NISTIR 8228 Considerations for Managing Internet of Things (IoT) Cybersecurity and Privacy Risks. Page IV. https://nvlpubs.nist.gov/nistpubs/ir/2019/NIST.IR.8228.pdf

62 https://www.whitehouse.gov/nsc/

63 National Security Strategy of the United States of America. https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf

Infrastructure

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.

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 Transportation[65] (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 research[66] 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 deployments[67] 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

64 https://www.ornl.gov/division/csmd/projects/multi-node-evolutionary-neural-networks-deep-learning-menndl

65 https://www.energy.gov/eere/vehicles/energy-efficient-mobility-systems

66 https://highways.dot.gov/research/research-and-development/research-programs

67 Map of Connected Vehicle (CV) Deployments in the U.S. https://www.transportation.gov//sites/dot.gov/files/docs/research-and-technology/345996/cv-deployment-locationsusamapnodetails-2.pdf

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 Exchange[68] (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.

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.

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 Program[70] 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]

68 https://github.com/usdot-jpo-ode/jpo-wzdx/blob/master/README.md

69 https://www.dhs.gov/sites/default/files/publications/19_0731_cisa_5th-generation-mobile-networks-overview.pdf

70 https://www.its.dot.gov/pilots/pilots_overview.htm

71 https://www.transportation.gov/content/safety-band

Federal Communications Commission and National Telecommunications and Information Administration

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.

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

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]

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 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 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.

B. 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

Outreach to Non-Federal Stakeholders

The Federal Government uses the Federal Register[73] 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.

72 https://www.transportation.gov/av/workforce

73 https://www.federalregister.gov/

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.

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 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 events[74] and public notices[75] 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 stakeholders[77] 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 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.

The FTC and NHTSA co-hosted a public workshop in 2017[79] 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 hosted a workshop on Consensus Safety Measurement Methodologies for ADS-Equipped Vehicles[80] 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 report[81] can be found through NIST Special Publication 1900-320.

74 https://www.transportation.gov/av/events

75 https://www.transportation.gov/av/publicnotices

76 https://www.transportation.gov/AV

77 www.transportation.gov/av/communications

78 AVS 2019: Steps Toward Putting Public Safety Community at Ease with Advanced Vehicle Technologies, https://youtu.be/oeh6u7JqgrY

79 https://www.ftc.gov/system/files/documents/reports/connected-cars-workshop-federal-trade-commission-staff-perspective/staff_perspective_connected_cars_0.pdf

80 https://www.nist.gov/news-events/events/2019/06/consensus-safety-measurement-methodologies-ads-equipped-vehicles

81 https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1900-320.pdf

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 Council[82] (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.

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.

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.

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 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 2.0[84] 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 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.

82 https://www.gsa.gov/policy-regulations/policy/vehicle-management-policy/-councils/federal-fleet-policy-council-fedfleet-enrollment

83 https://www.assp.org/news-and-articles/2019/06/25/automated-vehicles-addressing-challenges-and-opportunities

84 https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf

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 on-road 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.

Regulatory Authority and Automated Vehicles

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

85 https://www.transportation.gov/av/3

86 https://www.its.dot.gov/presentations/trb2018/TRB_NIST_CSF_Project.pdf

87 https://www.gsa.gov/policy-regulations/policy/vehicle-management-policy/federal-fleet-report

88 https://www.whitehouse.gov/omb/information-regulatory-affairs/

oversees the implementation of government-wide policies in the areas of information policy, privacy, and statistical and science policy.

Taxation, Trade, and Intellectual Property

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.

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.

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 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 Representative[90] (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

89 https://www.whitehouse.gov/presidential-actions/presidential-executive-order-establishment-office-trade-manufacturing-policy/

90 https://ustr.gov/

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.

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, executes 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.

91 https://www.whitehouse.gov/omb/office-u-s-intellectual-property-enforcement-coordinator-ipec/

92 USPTO provides access to patent and trademark information through its searchable databases, which along with other useful information may be found at: https://www.uspto.gov/learning-and-resources/inventors-entrepreneurs-resources. To facilitate searching patent documents, they are indexed or classified into classes and subclasses. For automated vehicles, the most relevant international classifications are: B60W, B60T, G01S, G05D, and G08G.

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.

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.

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 Sustainability[94] (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 procedures.

93 https://www.whitehouse.gov/ceq/

94 https://www.sustainability.gov/

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 consumer 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.

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.

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.

C. 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 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 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 business[96] 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

95 https://www.federallabs.org/flcbusiness

96 https://www.sba.gov/business-guide

97 https://www.sba.gov/local-assistance

98 http://www.sbir.gov

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-Corps™ 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's Inventor and Entrepreneur Resources

USPTO maintains a website[101] 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.

USAspending.gov

USAspending.gov[102] 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 appropriations to the Federal agencies and down to local communities and businesses. AV innovators and entrepreneurs could use this as a resource to identify potential U.S. Government funding opportunities.

Additional U.S. Government Resources

A list of all other known U.S. Government AV relevant resources available to AV innovators and entrepreneurs can be found in Appendix A. If AV innovators and entrepreneurs have questions directed at specific components inside the U.S. Government, a contact list can be found in Appendix B.

IV. Conclusion

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.

99 https://www.sba.gov/learning-center

100 https://www.sba.gov/about-sba/organization/sba-initiatives#section-header-14

101 USPTO Inventor and entrepreneur resources, https://www.uspto.gov/learning-and-resources/inventors-entrepreneurs-resources

102 https://www.usaspending.gov/#/

V. Appendix A – U.S. Government Resources

Council on Environmental Quality

- **Office of Federal Sustainability:** https://www.sustainability.gov/resources.html

Department of Agriculture

- **National Robotics Initiative 2.0:** Ubiquitous Collaboration Robots (NRI-2.0): https://nifa.usda.gov/funding-opportunity/national-robotics-initiative-realization-co-robots-acting-direct-support

Department of Energy

- **Vehicle Technologies Office:** https://www.energy.gov/eere/vehicles/vehicle-technologies-office
- **Vehicle Technologies Office Annual Merit Review and Peer Evaluations:** https://www.energy.gov/eere/vehicles/annual-merit-review-presentations
- **Vehicle Technologies Office reports and publications:** https://www.energy.gov/eere/vehicles/reports-and-publications?TechArea=Energy+Efficient+Mobility+Systems
- **DOE's Technology Commercialization Fund:** https://www.energy.gov/technologytransitions/services/technology-commercialization-fund
  - Technology Commercialization Fund (TCF) is a nearly $20 million funding opportunity that leverages R&D funding in the Department's applied energy programs to mature promising energy technologies with the potential for high impact. TCF was created by the Energy Policy Act of 2005 and catalyzes the commercial impact of the Department's portfolio of research, development, demonstration, and deployment activities. TCF funds are matched with funds from private partners to promote promising energy technologies for commercial purposes.

Department of Defense

- **Defense Technical Information Center:** https://discover.dtic.mil/products-services/

Department of Health and Human Services

- **NIOSH Center for Motor Vehicle Safety Strategic Plan for Research and Prevention, 2014-2018:** https://www.cdc.gov/niosh/docs/2014-122/pdfs/2014-122.pdf (note: An updated plan is under development and will be posted on the NIOSH docket for public comment.)
- **NIOSH Strategic Plan:** FYs 2019–2023 prioritizes research on the safety impacts of automated and connected vehicles and ADAS for truck, bus, and taxi drivers. In addition, the NIOSH plan prioritizes research on injury risks associated with new jobs that may be created by automation, and on potential stress and fatigue consequences of automation. (See Intermediate Goals 6.14 and 7.8.) https://www.cdc.gov/niosh/about/strategicplan/
- **NIDILRR's Rehabilitation Engineering Research Center on Physical Access and Transportation:** https://acl.gov/sites/default/files/about-acl/2019-01/NIDILRR%20LRP-2018-2023-Final.pdf
- **NIDILRR's research Project on Optimizing Accessible Public Transportation:** https://acl.gov/sites/default/files/about-acl/2019-01/NIDILRR%20LRP-2018-2023-Final.pdf

Department of Homeland Security

- DHS Science and Technology Directorate
  - Critical Infrastructure and Resilience: https://www.dhs.gov/science-and-technology/critical-infrastructure-and-resilience#
  - Cybersecurity: https://www.dhs.gov/science-and-technology/cybersecurity
- **DHS CISA, Cyber Storm:** Securing Cyber Space
  - https://www.dhs.gov/cisa/cyber-storm-securing-cyber-space

Department of Labor

— Office of Disability Employment Policy: https://www.dol.gov/odep/topics/Transportation.htm

Department of Transportation

- **Access and Mobility for All Summit:** https://www.transportation.gov/accessibility
- **Coordinating Council on Access and Mobility (CCAM) Strategic Plan 2019-2022:** https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/regulations-and-guidance/ccam/about/134436/ccam-strategic-plan-2019-2022.pdf
- **Mobility for All Pilot Program Grants:** https://www.transit.dot.gov/funding/grants/grant-programs/mobility-all-pilot-program-grants
- **USDOT Automated Vehicles Activities:** https://www.transportation.gov/AV
- **USDOT Research HUB 2.0:** https://researchhub.bts.gov/
- **USDOT Repository & Open Science Access Portal:** https://rosap.ntl.bts.gov/welcome
- **USDOT/BTS National Transportation Library:** https://ntl.bts.gov/
- **USDOT/FTA Transit Automation Activities:** https://www.transit.dot.gov/automation-research

Federal Communication Commission

- **FCC Reports & Research:** https://www.fcc.gov/reports-research
- **Office of Engineering and Technology (OET):** https://www.fcc.gov/engineering-technology
- **Wireless Telecommunications Bureau:** https://www.fcc.gov/wireless-telecommunications
- **Dedicated Short Range Communications (DSRC) Service:** https://www.fcc.gov/wireless/bureau-divisions/mobility-division/dedicated-short-range-communications-dsrc-service

Federal Laboratory Consortium for Technology Transfer

- **FLC Business:** https://www.federallabs.org/flcbusiness

National Aeronautics and Space Administration

- **NASA TechPort:** https://techport.nasa.gov/home
- **NTRS:** https://ntrs.nasa.gov/

National Council on Disability

- **Self-Driving Cars:** Mapping Access to a Technology Revolution: https://www.ncd.gov/sites/default/files/NCD_AutomatedVehiclesReport_508-PDF.pdf

National Institute of Standards and Technology

- **Cyber-Physical System:** https://www.nist.gov/el/cyber-physical-systems
- **Mobility Performance of Robotics Systems:** https://www.nist.gov/programs-projects/mobility-performance-robotic-systems
- **Communication Technology research:** https://www.nist.gov/programs-projects/5g-beyond
- **National Advanced Spectrum and Communication Test Network:** https://www.nist.gov/communications-technology-laboratory/nasctn
- **Applied Research – Cybersecurity and Privacy in Connected vehicles:** https://www.nccoe.nist.gov/
- **NIST Cybersecurity Framework:** https://www.nist.gov/cyberframework
- **NIST Privacy Framework:** https://www.nist.gov/privacy-framework
- **U.S. Leadership in AI:** A Plan for Federal Engagement in Developing Technical Standards and Related Tools. https://www.nist.gov/document/report-plan-federal-engagement-developing-technical-standards-and-related-tools

- **An Independent Measurement System for Testing Automotive Crash Warning Systems:** http://ws680.nist.gov/publication/get_pdf.cfm?pub_id=901038
- **Objective Test and Performance Measurement of Automotive Crash Warning Systems:** http://ws680.nist.gov/publication/get_pdf.cfm?pub_id=823603
- **Performance Evaluation of Integrated Vehicle-Based Safety System:** http://ws680.nist.gov/publication/get_pdf.cfm?pub_id=823587
- NIST Work in Support of Army Research Labs and DARPA Autonomous Vehicles for Military Operations (e.g., scouting)
  - 4D/RCS Version 2.0: A Reference Model Architecture for Unmanned Vehicle Systems: http://ws680.nist.gov/publication/get_pdf.cfm?pub_id=821823
  - Intelligent Vehicle Systems: A 4D RCS Approach https://books.google.com/books/about/Intelligent_Vehicle_Systems.html?id=A84mXxcNjlwC
- **NIST Work in Support of DARPA Mobile Autonomous Robots (MARS) and follow-on Programs to develop the foundations for a robotic chauffeur type of capability:**
  - Identifying Sensory Processing Requirements for an On-Road Driving Application of 4D/RCS https://www.nist.gov/node/683826
  - How task analysis can be used to derive and organize the knowledge for the control of AVs https://www.nist.gov/node/705571
  - Achieving Intelligent Performance in Autonomous Driving: https://www.nist.gov/node/705951
  - PRIDE: A Framework for Performance Evaluation of Intelligent Vehicles in Dynamic, On-Road Environments: https://www.nist.gov/node/761331
- **Framework for Defining and Measuring Autonomy Levels (Autonomy Levels for Unmanned Systems):**
  - Autonomy Levels for Unmanned Systems (ALFUS) Framework Volume II: Framework Models Initial Version http://ws680.nist.gov/publication/get_pdf.cfm?pub_id=823618

National Science Foundation

- **NSF Award Search:** https://nsf.gov/awardsearch/advancedSearch.jsp
- **NSF Public Access Repository (NSF-PAR):** https://par.nsf.gov/

National Transportation Safety Board

- **Completed Investigations:**
  - Collision Between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida - May 7, 2016, https://www.ntsb.gov/investigations/AccidentReports/Pages/HAR1702.aspx
  - Low-Speed Collision Between Truck-Tractor and Autonomous Shuttle, Las Vegas, Nevada, November 8, 2017, https://www.ntsb.gov/investigations/pages/HWY18FH001.aspx
  - Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian , Tempe, Arizona, March 18, 2018, https://www.ntsb.gov/investigations/AccidentReports/Reports/HAR1903.pdf
- **Ongoing Investigations:**
  - Rear-End Collision Between a Passenger Car Operating with Advanced Driver Assistance Systems and a Stationary Fire Truck, Culver City, California, January 22, 2018, https://www.ntsb.gov/investigations/pages/HWY18FH004.aspx
  - Passenger Car Operating with Advanced Driver Assistance Systems Collided with Roadway Barrier, Mountain View, California, March 23, 2018, https://www.ntsb.gov/investigations/pages/HWY18FH011.aspx
  - Collision Between a Passenger Car Operating with Advanced Driver Assistance Systems and Combination Vehicle at an Intersection, Delray Beach, Florida, March 1, 2019, https://www.ntsb.gov/investigations/pages/HWY19FH008.aspx

- **Significant recommendations:**
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-17-037
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-17-038
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-17-039
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-17-040
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-17-041
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-17-042
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-17-043
- **Recommendations for collision avoidance systems:**
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-15-004
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-15-005
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-15-006
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-15-007
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-15-008
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-15-009
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-18-008
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-18-019
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-18-029
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-18-043
  - https://www.ntsb.gov/investigations/AccidentReports/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-18-044

United States Patent and Trademark Office

- **USPTO patent search database:** https://www.uspto.gov/patents-application-process/search-patents
- **USPTO Inventor and entrepreneur resources:** https://uspto.gov/learning-and-resources/inventors-entrepreneurs-resources
- **USPTO Inventors Assistance Center:** 800-786-9199; 517-272-1000; TTY: 800-877-8339

United States Access Board

- **https:**//www.access-board.gov/guidelines-and-standards/transportation

VI. Appendix B – U.S. Government AV Contacts

Organization	Email
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DOE	EEMS@ee.doe.gov
DOI	feedback@ios.doi.gov
DOJ	automated.vehicles@usdoj.gov
EPA	OTAQ@epa.gov
FLC	support@FederalLabs.org
GSA	Vehicle.Policy@gsa.gov
NASA	Autonomous-Vehicles@mail.nasa.gov
NCD	ncd@ncd.gov
NIST	inquiry@nist.gov
NSF	info@nsf.gov
NTSB	Correspondence@ntsb.gov
United States Access Board	info@access-board.gov
USDA	askUSDA@usda.gov
USDOT	automation@dot.gov TransitAutomation@dot.gov av_info_nhtsa@dot.gov
USPS	vehicletechnology@usps.gov
USPTO	HelpAAU@uspto.gov

VII. Appendix C – Automated Vehicle Fast Track Action Committee

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EOP/IPEC

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IX. Appendix E – Acronyms

Acronym	Meaning
21CTP	21st Century Truck Partnership
AACVTE	UMTRI's Ann Arbor Connected Vehicle Test Environment
ACL	Administration for Community Living
ADA	Americans with Disabilities Act
ADAS	Advanced Driver Assistance Systems
ADS	Automated Driving Systems
AI	Artificial Intelligence
ALARC	Arid Land Agricultural Research Center
ANSI	American National Standards Institute
ARPA-E	DOE Advanced Research Projects Agency-Energy
ARS	USDA Agricultural Research Service
AS	Automated System
ASSP	American Society of Safety Professionals
ATCMTD	Advanced Transportation and Congestion Management Technologies Deployment
ATTRI	Accessible Transportation Technologies Research Initiative
AV	Automated Vehicles
AVFTAC	Automated Vehicle Fast Track Action Committee
BLS	United States Bureau of Labor Statistics
CAV	Connected and Automated Vehicle
CBP	Customs and Border Protection
CEQ	Council on Environmental Quality
CFIUS	Committee on Foreign Investment in the United States
CISA	DHS Cybersecurity and Infrastructure Security Agency
CISE	NSF Directorate for Computer and Information Science and Engineering
CMV	Commercial Motor Vehicle
CoVeR	Combat Vehicle Robotics
CV	Connected Vehicle
DHS	Department of Homeland Security
DOC	Department of Commerce
DoD	Department of Defense

Acronym	Meaning
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DOL	Department of Labor
DOS	U.S. State Department
DSRC	Dedicated Short Range Communication
ED	Department of Education
ENG	NSF Directorate for Engineering
EOP	Executive Office of the President
EPA	Environmental Protection Agency
ERDC	Army's Engineering Research and Development Center
FAST Act	Fixing America's Surface Transportation Act
FCC	Federal Communications Commission
FDII	Foreign-derived intangible income
FEDFLEET	Federal Fleet Policy Council
FFRDC	Federally Funded Research and Development Center
FHWA	Federal Highway Administration
FLC	Federal Laboratory Consortium for Technology Transfer
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standards
FOA	Funding Opportunity Announcement
FTA	Federal Transit Administration
FTAC	Fast Track Action Committee
FTC	Federal Trade Commission
FY	Fiscal Year
GPS	Global Positioning System
GSA	General Services Administration
HHS	Department of Health and Human Services
HMI	Human-Machine Interface
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HPC	High performance computing
HSSEDI	Homeland Security Systems Engineering and Development Institute
IC-DISC	Interest charge domestic international sales corporation

Acronym	Meaning
IoT	Internet of Things
IP	Intellectual Property
IPEC	Intellectual Property Enforcement Coordinator
IRS	Internal Revenue Service
ITA	International Trade Administration
ITS	NTIA Institute for Telecommunications Sciences
ITS JPO	Intelligent Transportation Systems Joint Program Office
LIDAR	Light Detection and Ranging
MCICOM	Marine Corps Installations Command
MENNDL	Multi-node Evolutionary Neural Networks for Deep Learning
MUTCD	Manual on Uniform Traffic Control Devices
NASA	National Aeronautics and Space Administration
NASCTN	National Advanced Spectrum and Communications Test Network
NCCoE	NIST National Cybersecurity Center of Excellence
NCD	National Council on Disability
NEPA	National Environmental Policy Act
NEXTCAR	Next-Generation Energy Technologies for Connected and Automated On-Road Vehicles
NHTSA	National Highway Traffic Safety Administration
NIDILRR	National Institute on Disability, Independent Living, and Rehabilitation Research
NIFA	National Institute of Food and Agriculture
NIJ	National Institute of Justice
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NPS	National Park Service
NRMC	National Risk Management Center
NSC	National Security Council
NSF	National Science Foundation
NSTC	National Science and Technology Council
NTIA	National Telecommunications and Information Administration
NTRS	NASA Technical Reports Server
NTSB	National Transportation Safety Board
NTV	Non-Tactical Vehicle
ODD	Operational Design Domain

Acronym	Meaning
ODEP	DOL Office of Disability Employment Policy
OEDR	Object and Event Detection and Response
OEM	Original Equipment Manufacturers
OFS	Office of Federal Sustainability
OGP	GSA Office of Government-wide Policy
OIRA	Office of Information and Regulatory Affairs
OMB	Office of Management and Budget
OST	Office of the Secretary of Transportation
OSTP	Office of Science and Technology Policy
OTMP	Office of Trade and Manufacturing Policy
PERF	Police Executive Research Forum
PRAM	NIST Privacy Risk Assessment Methodology
R&D	Research and Development
RCV	Robotics Combat Vehicle
RFI	Request for Information
S&T	Science and Technology
SBA	Small Business Administration
SBE	NSF Directorate for Social, Behavioral, and Economic Sciences
SBIR	Small Business Innovation Research
SDO	Standards Development Organization
SEC	Securities and Exchange Commission
SMART	DOE System Modeling for Accelerated Research in Transportation
STAR	FTA Strategic Transit Automation Research
STEM	Science, Technology, Engineering, and Mathematics
STI	Scientific and Technical Information
STTR	Small Business Technology Transfer
T2	Technology Transfer
TCF	DOE Technology Commercialization Fund
TFA	Technology Focus Area
TNC	Transportation Network Company
UGV	Unmanned Ground Vehicles
UMTRI	University of Michigan Transportation Research Institute
USDA	United States Department of Agriculture

Acronym	Meaning
USDOT	United States Department of Transportation
USPS	United States Postal Service
USPTO	United States Patent and Trademark Office
USTR	United States Trade Representative
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VERVE	Visual Environment for Remote and Virtual Exploration
VTO	DOE Vehicle Technologies Office
VTTI	Virginia Tech Transportation Institute
WZDx	Work Zone Data Exchange

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The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is to ensure science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at http://www.whitehouse.gov/ostp/nstc.

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About this Document

This document presents the United States Government's posture for surface transportation automated vehicles (AV) based on a vision in which American innovators are global leaders in AV technology, integrating this technology in the United States and around the world in a safe and secure manner. As Automated Driving Systems (ADS) come into fruition over the coming years and decades, this document is intended to provide AV innovators a single, high-level reference document to navigate the U.S. Government. The scope of this document is limited to surface transportation AVs and does not include maritime, railway, or aviation concerns.

This document is the result of extensive input from relevant stakeholders across 38 Federal departments, independent agencies, commissions, and Executive Offices of The President.

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