Formal Recommendations

of the

Transforming Transportation Advisory Committee

to the

US Department of Transportation

on

Artificial Intelligence, Automated Driving, Project Delivery, *and* Innovation for Safety

TTAC

as adopted by the Committee on December 13, 2024.

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2 Introduction to the Report

The Secretary of the US Department of Transportation (USDOT) convened the Transforming Transportation Advisory Committee (TTAC) in 2024 to advise the Department on innovation.[1] In particular, the Committee was asked to address:

- **The Safe and Responsible Use of Artificial Intelligence in Transportation** (at the direction of the President of the United States),[2]
- **Automated Driving Policy Needs on Data, First Responders, and the Workforce**,
- **The Role of Technology in Improving Project Delivery**, and
- **Emerging, Overlooked, and Underleveraged Innovation for Safety** (on the advice of TTAC itself).

This report formally presents TTAC's recommendations to USDOT on these four topics. Although transportation encompasses more than walking, biking, driving, and riding, the Committee's primary expertise and hence its advice center on surface transportation. Several key themes cut across TTAC's recommendations.

First, both transportation and innovation must be about making life better for people today and tomorrow. Our policy choices will shape not only our lives but also the lives of those who succeed us on this planet. They will determine whether our friends, neighbors, children, and grandchildren can cross a street, reach a doctor's office, afford their food, spend time with their family, breathe clean air, and celebrate another birthday.

Second, the status quo is not satisfactory. A hundred Americans will die deaths of violence on our roads today, and thousands will be injured.[3] Roads in Canada, Australia, and many other countries are far safer than those in the United States.[4] On a per capita basis, driving is nearly *ten times* as deadly in South Carolina as in the United Kingdom.[5] Traffic fatality statistics do not even account for the dozens of Americans who today will die from transportation-related pollution.[6]

[1] Charter of the Transforming Transportation Advisory Committee; January 18, 2024 TTAC Meeting.

[2] Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence (October 30, 2023).

[3] NHTSA Traffic Safety Facts, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813643

[4] IIHS Fatality Facts, https://www.iihs.org/topics/fatality-statistics/detail/state-by-state; OECD Data Explorer, https://stats.oecd.org

[5] Id.

[6] Air pollution benefits from reduced on-road activity due to COVID-19 in the United States, https://pmc.ncbi.nlm.nih.gov/articles/PMC10825624

Third, automated driving, other applications of artificial intelligence, and other emerging technologies have important roles to play in transforming this status quo. Automated and connected vehicles could reduce crashes, speed up emergency response, and better integrate the entire transportation system. Better datasets could reveal overlooked opportunities to make the transportation system more equitable and responsive. A universal digital payment platform could help grant recipients begin their work more quickly.

Fourth, innovation is about more than just new technologies. It's also about new approaches, policies, and frameworks. The Safe System Approach embraces redundancy so that death is not the inevitable result of failure.[7] The Americans with Disabilities Act (ADA) boldly envisions a society just as open to those with mobility issues and other disabilities as to those without. Of course, we are still far from these goals. And yet every day, to take just one example, hundreds of millions of ADA-required curb cuts provide equal access to people in wheelchairs—and benefit parents who are pushing strollers, travelers who are pulling suitcases, and people who might otherwise stumble on a step.

Fifth, the United States can innovate. Examples abound and astound. American ingenuity inside and outside government—and almost always in combination—has led to air travel, the Internet, automated driving, artificial intelligence, and myriad other marvels of our world. The Committee believes strongly in our country's potential to continue to transform itself for the better.

Sixth, the US Department of Transportation can foster and harness this innovative spirit in service to safety, mobility, equity, sustainability, economic opportunity, privacy, autonomy, community, and other essential public policy goals. The dedication, experience, and insight of USDOT employees has been evident to the Committee throughout its work. The Department has a convening authority that is unmatched in the transportation world. It is also in a unique position to model the trustworthiness that will be essential in a world that could be shaped by developers, supervisors, and users of advanced artificial intelligence tools.

While the Transforming Transportation Advisory Committee cannot predict the future,[8] it can highlight principles important to that future and approaches consistent with these principles. This is the intent of the inchoate advice that follows. The Committee's recommendations therefore represent merely one step in the Department's laudable journey to transform transportation for the better. They also signify a commitment to accompany USDOT on that journey for as long as TTAC can assist.

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[7] What is a safe system approach?, https://www.transportation.gov/NRSS/SafeSystem

[8] To use one example, at the point that automated driving can fully replace human drivers, "it will likely be an afterthought in a world that has already been revolutionized in a hundred other ways." How Reporters Can Evaluate Automated Driving Announcements, https://ssrn.com/abstract=3747036

3 Abbreviations

ACC .... Adaptive Cruise Control
ADA .... Americans with Disabilities Act
ADAS .... Advanced Driver Assistance System
ADB .... Adaptive Driving Beams
ADCMS .... Accelerating Advanced Digital Construction Management Systems Program
ADS .... Automated Driving System(s)
AEB .... Automatic Emergency Braking
AI .... Artificial Intelligence
ARPA-I .... Advanced Research Projects Agency - Infrastructure
AV .... Automated Vehicle
BIL .... Bipartisan Infrastructure Law
BIM .... Building Information Modeling
BLS .... Bureau of Labor Statistics (of the Department of Labor)
CE .... Categorical Exclusion
CMV .... Commercial Motor Vehicle
CRSS .... Crash Report Sampling System
CV .... Computer Vision
DBE .... Disadvantaged Business Enterprise
DDT .... Dynamic Driving Task
DOJ .... Department of Justice
DOL .... Department of Labor
DOT .... Department of Transportation
DSS .... Decision Support System
DSSS .... Driver Safety Support System
EDC .... Every Day Counts Program
EIS .... Environmental Impact Statement
EO .... Executive Order
ETA .... Employment and Training Administration
EV .... Electric Vehicle
FAA .... Federal Aviation Administration (of USDOT)
FAQ .... Frequently Asked Questions
FARS .... Fatality Analysis Reporting System
FCC .... Federal Communications Commission
FCW .... Forward Collision Warning
FHWA .... Federal Highway Administration (of USDOT)
FMCSA .... Federal Motor Carrier Safety Administration (of USDOT)
FMVSS .... Federal Motor Vehicle Safety Standard(s)
FOIA .... Freedom of Information Act
FTA .... Federal Transit Administration (of USDOT)
FTC .... Federal Trade Commission
GHG .... Greenhouse Gas
GNSS .... Global Navigation Satellite System
HMI .... Human-Machine Interaction
HVE .... High Visibility Enforcement
ISAC .... Information Sharing and Analysis Center

IAPP........................ International Association of Privacy Professionals
LCA........................ Lane-Centering Assistance
LDW........................ Lane Departure Warning
LKA........................ Lane-Keeping Assistance
LLM........................ Large Language Model
LTAP........................ Local Technical Assistance Program
LTL........................ Less than Truckload
ML........................ Machine Learning
MUTCD........................ Manual on Uniform Traffic Control Devices
NCAP........................ New Car Assessment Program
NEPA........................ National Environmental Protection Act
NIST........................ National Institute of Standards and Technology
NHTSA........................ National Highway Traffic Safety Administration (of USDOT)
NRSS........................ National Roadway Safety Strategy
NTIA........................ National Telecommunications and Information Administration
NTSB........................ National Transportation Safety Board (*distinct from* USDOT)
NLP........................ Natural Language Processing
ODD........................ Operational Design Domain
OMB........................ Office of Management and Budget
OSSS........................ Occupant Safety Support System
OST........................ Office of the Secretary of Transportation
PA........................ Programmatic Agreement
PARTS........................ Partnership for Analytics Research in Traffic Safety
PCE........................ Programmatic Categorical Exclusion
PD........................ Project Delivery
PII........................ Personally Identifiable Information
RFI........................ Request for Information
ROW........................ Right-of-Way
SAE........................ SAE International (formerly Society of Automotive Engineers)
SAFO........................ Safety Alert for Operators
SSS........................ Safety Support System
SGE........................ Special Government Employee
SGO........................ Standing General Order (of NHTSA)
SHSP........................ Strategic Highway Safety Plan
SMART........................ Strengthening Mobility and Revolutionizing Transportation
STEM........................ Science, Technology, Engineering, and Math
TA........................ Technical Assistance
TL........................ Truckload
TRB........................ Transportation Research Board of the National Academies
TSMO........................ Transportation Systems Management and Operation
TTAC........................ Transforming Transportation Advisory Committee (“the Committee”)
US........................ United States
USDOT........................ United States Department of Transportation (“the Department”)
V2X........................ Vehicle-to-Everything Communications
VLM........................ Vision Language Model
VRU........................ Vulnerable Road User
WAV........................ Wheelchair Accessible Vehicle
WIA........................ Workforce Impact Assessment

4 Artificial Intelligence

4.1 Table of Contents

4.2 Preface

4.2.1 The Opportunity and Challenge of AI

Artificial Intelligence (AI) offers transformational opportunities for individuals, for communities, and for the United States as a whole. If harnessed effectively and responsibly with smart policy decisions and investments, AI can enhance US global competitiveness, foster economic growth, and safeguard national security interests. For people, AI can improve how we live and move by increasing equitable access to a safer, comfortable, and sustainable transportation system. Realizing these significant opportunities requires significant engagement and a different approach from the status quo.

An innovative and cutting-edge mobility sector in the United States is critical to our national and economic security. Other nations have developed integrated transportation technology solutions, powered by AI, creating product and service offerings that place the US at a potential competitive disadvantage in both domestic and international markets. As a result, this country faces a risk of slowing benefits that technological innovation can provide to our society.

The US Department of Transportation (USDOT) should recognize and embrace the opportunities that AI provides to improve safety, convenience, and performance while strengthening its commitment to privacy, security, equity, and access to transportation. Responding to this competitive challenge requires the Department to develop a comprehensive yet nimble policy framework that encourages innovation, improves outcomes, and manages risks.

With this unique opportunity to leverage AI comes the need to ensure these technologies are serving society. TTAC's efforts therefore aim to foster within USDOT the safe, responsible, and appropriate development and use of AI.

Not surprisingly, for a technological evolution of this magnitude, there are members of TTAC with varying levels of optimism and caution regarding AI. It is imperative for the reader to understand that, in developing its advice for USDOT, TTAC aimed to find consensus among stakeholders and to highlight not only risks that the Committee was instructed to address but also opportunities that the Committee decided should be highlighted and embraced.

As such, the recommendations, issues, and applications in this chapter do not fully represent any specific individual's perspective. Rather, they reflect a consensus viewpoint of TTAC's AI Subcommittee that TTAC in turn believes[9] will help USDOT navigate the challenges ahead in order to maximize AI's potential in positively transforming the nation's transportation system. Readers may recognize notes of caution in the text. This is because maximizing the benefits of AI requires a robust understanding of these technologies in context.

TTAC accordingly offers its recommendations in the hope they provide a foundation for USDOT to foster broader dialogue with all stakeholders on these important topics to improve transportation safety, mobility, equitability, and sustainability in a way that enhances economic competitiveness and opportunity.

4.2.2 Overview

This Artificial Intelligence (AI) chapter of TTAC's report has three primary sections:

- The **AI Recommendations** section advises USDOT to take specific steps to prepare for AI, to foster a trustworthy culture with respect to AI, to realize AI's benefits, and to manage AI's risks.
- The **AI Issues** section discusses key cross-cutting issues associated with AI that USDOT should carefully consider.
- The **AI Applications** section highlights transportation-specific applications of AI that USDOT could help realize and associated risks that USDOT could help manage.

TTAC recognizes that each of these sections is necessarily incomplete. This chapter's silence on a topic does not negate the potential interest in or importance of that topic.

4.2.3 Defining AI

TTAC does not seek to define AI. Numerous definitions have already been offered by others, including in statute,[10] in public discourse,[11] and elsewhere.[12] Whereas intelligence was for

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[9] The Committee's vote to adopt this chapter included an abstention from Nat Beuse and a negative vote from Tekedra Mawakana.

[10] "A machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. Artificial intelligence systems use machine- and human-based inputs to perceive real and virtual environments; abstract such perceptions into models through analysis in an automated manner; and use model inference to formulate options for information or action." 15 U.S.C. 9401(3).

[11] ITS America, AI Decoded (June 2024), https://itsa.org/news/ai-decoded

[12] "Artificial intelligence refers primarily to the ability of an automated system to resolve uncertainty using experience." Bryant Walker Smith, Ethics of Artificial Intelligence in Transport, in The Oxford Handbook of Ethics of Artificial Intelligence (Markus Dubber, Frank Pasquale & Sunit Das, eds., 2020).

many years implicitly characterized as "whatever machines haven't done yet,"[13] growing popular and commercial interest in AI has recently led to much broader application of this term, including to automation techniques that have been common in the transportation domain for decades.

Behavior that is probabilistic rather than deterministic—in other words, where the same inputs do not always produce the same outputs—may be one of the hallmarks of AI in a narrower sense. Nondeterministic tools do indeed present important issues for their development, deployment, and use. It should be noted, however, that individuals are also functionally nondeterministic (as are societies, governments, companies, and even some existing products such as pharmaceuticals).

Given wide variation in definition and function, the critical question is not "what is AI?" but, rather, "what issues does a given application of a given technology present for a given context?" (Indeed, uses of AI that few expect or even recognize could ultimately be as transformative as the applications that currently preoccupy public and regulatory attention.) This question should be asked for every application, and the answers may vary. The AI chapter of this report, which attempts to identify key commonalities across the likely answers, is only the beginning and should be updated as the capabilities and impacts of AI-enabled systems continue to evolve.

4.2.4 Scope of Work

The President ordered the Secretary of Transportation to "direct appropriate Federal Advisory Committees of the DOT to provide advice on the safe and responsible use of AI in transportation" and specified that the "committees shall include the Advanced Aviation Advisory Committee, the Transforming Transportation Advisory Committee, and the Intelligent Transportation Systems Program Advisory Committee."[14]

The Secretary of Transportation accordingly conveyed this direction to TTAC along with additional context, and TTAC in turn proposed adjustments to reflect the committee's make-up and to more fully account for opportunities as well as risks. The following scope shows USDOT's original direction plus TTAC's modification (in underlined text for additions and struck-through text for deletions):

> ***Artificial Intelligence (AI) Impacts on Transportation:*** *Provide recommendations on how USDOT can foster the safe, responsible, and appropriate <u>development and</u> use of AI in <u>surface</u> transportation.*[15] *Recommendations are requested with respect to the*

[13] Larry Tesler, https://www.nomodes.com/larry-tesler-consulting/adages-and-coinages

[14] Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence (October 30, 2023), https://www.federalregister.gov/documents/2023/11/01/2023-24283/safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence

[15] TTAC's members work primarily in urban transit and road transportation, and the Advanced Aviation Advisory Committee is advising specifically on aviation. TTAC recognizes that gaps remain, including in the domains of maritime, freight rail, long-distance passenger rail, and pipeline transportation. Many of the issues that this chapter discusses may also apply to these other domains.

application of AI across the transportation system, particularly beyond its use as a foundational technology underpinning Automated Driving Systems.[16] Key tasks:

1. *Identify applications of AI to transportation that USDOT should be monitoring most closely.*
2. *Identify transportation-specific needs for guidance on the application of AI. Additional questions/issues to consider:*
   a. *Is there existing guidance that can be repurposed or adapted? ~~How might standards adopted in other countries apply or run afoul with existing U.S. statutory authorities?~~[17]*
   b. *When should USDOT provide guidance?*
   c. *Are there beneficial practices, standards or applications that USDOT should encourage? If so, how mature are these? What role could USDOT play? Are there specific actions required?*
   d. *What are objective sources for best practices in such a specialized emerging area?*
   e. *How might recommendations differ based on the specific transportation context, operational setting, or other factors?*
3. *Identify transportation-specific risks from AI that USDOT should monitor (e.g., security, privacy, social equity biases, etc.). What role should USDOT play in oversight with respect to these risks?*
4. *Identify transportation-specific benefits from AI that USDOT should embrace. How should USDOT contribute to achieving these benefits?[18]*

4.3 AI Recommendations

4.3.1 Introduction

This section recommends specific steps that the US Department of Transportation (USDOT) should take to:

1. Prepare USDOT and its partners for AI.
2. Foster a trustworthy culture that is proactive, open, and responsible with respect to AI.

[16] USDOT requested that TTAC address automated driving as a standalone topic, and TTAC has accordingly issued separate recommendations in the automated driving chapter of this report. Many of the issues that this AI chapter discusses may also apply to automated driving.

[17] This question, which would involve specific legal analysis, is beyond TTAC's competency.

[18] TTAC has accordingly advised USDOT of the importance of considering AI's opportunities alongside its risks. TTAC's report on AI applications considers both in answering USDOT's question about the applications of AI that the Department should monitor most closely.

3. Realize the benefits of AI.

4. Manage the risks of AI.

Six key considerations infuse these recommendations.

First, USDOT should model principles for the trustworthy development and deployment of AI by openly and proactively showing its work. This should include publicly describing its successes, challenges, and even failures concerning the AI tools it regulates or uses. The lodestar for this effort should be that trust is not to be simply given or assumed; instead, trust is to be continually earned over time.

Second, USDOT should identify goals and corresponding expectations for the use of AI tools throughout the lifecycles of these tools, including safety, transparency, privacy, and equity. USDOT has immense if imperfect experience in reviewing transportation projects with a view toward their safety, equity, and environmental impacts (including benefits). The agency should bring at least equal rigor to its evaluation of AI tools and their impact on the lifecycle of transportation technologies.

Third, USDOT should recognize that AI depends on data. It should therefore assess, improve, and accelerate its data expertise, data analysis, data guidance, and data protection. These efforts may be especially helpful to USDOT's partners, especially where state and local agencies lack the necessary resources. Protecting privacy, seeking data equity, and respecting intellectual property are essential to this work.

Fourth, USDOT should regularly engage with a much wider set of public and private sector stakeholders than it has historically. The Department already has unique convening authority and unique reach. It should use these assets to connect with communities, advocates, and companies that go beyond traditionally regulated industries. It should also create and support mechanisms for feedback and reporting to identify potential opportunities and risks as soon as possible.

Fifth, USDOT should strategically use the full scope of its authority. This includes pursuing a focused and transparent research agenda, incentivizing a "race to the top" mentality among industry (that recognizes and rewards companies that achieve safety milestones and innovate toward other key policy goals, with NCAP as one example), and promulgating regulatory standards that then build on this research and these incentives. Because these three prongs are intertwined, USDOT should also consider whether and if so when regulatory flexibility, especially when designed to encourage continual process improvement and paired with appropriate guardrails, can help incentivize socially beneficial innovation and advance important research. In doing so, USDOT should also consider when regulatory flexibility is not appropriate and binding regulation is needed.

Finally, many of the recommendations included within this section may prove challenging for USDOT, particularly at a time when it is struggling to deliver on some of its core responsibilities. The Department will not be able to navigate emerging policy areas, such as artificial intelligence, without a fully functional organization with the trust and confidence of the public and the entities it regulates. As the Department considers these recommendations, we urge it to also recommit itself to organizational changes that could support executing more effectively on its foundational responsibilities and obligations.

4.3.2 Prepare USDOT and Its Partners for AI

To prepare itself and its partners for AI, USDOT should:

1. Recognize that AI will be and, in some cases, already is ubiquitous and dynamic; that new AI-based models, tools, and systems will rapidly evolve; and that USDOT will need to adapt to meet its objectives of improving transportation system safety, equity, sustainability, access, and mobility.
2. Develop a comprehensive yet nimble policy framework across all modes that encourages innovation, improves outcomes, and manages the risks described in this chapter.
3. Develop an approach to categorize and inventory the types of AI technologies within the transportation system[19] (e.g., clusters like machine learning (ML), computer vision (CV), large language models (LLMs), and Vision Language Models (VLMs)) to improve USDOT's understanding of where AI-based tools are used.
4. Assess the need for (and if necessary, develop) a system to increase transparency around using AI and related data collection approaches to earn trust in the transportation system.
5. Develop and institutionalize robust and ongoing mechanisms for engaging a wide range of transportation stakeholders (beyond just regulated industries) generally and in relation to AI data sources, tools, and applications, including consumers, community and civil rights advocates, and innovators not traditionally connected to transportation.
6. Triage to identify AI tools, topics, and issues on which USDOT should:
    a. Be a leader in the federal government (e.g., low-latency, safety critical, high-risk applications of AI in the physical world?).
    b. Be a fast follower (e.g., administrative use of AI tools with tools built in to identify and address unintended bias and equity concerns?).
    c. Defer or delegate to other agencies where appropriate per statutory jurisdiction (e.g., national security implications of AI?).
7. Highlight and build on the work of existing USDOT initiatives such as ARPA-I, PARTS, SMART, and the Inclusive Design Challenge.
8. Accelerate the release of USDOT data (with the application of appropriate aggregation, anonymization, or other privacy-enhancing methods), analyses, and research so that insights are not rendered obsolete by technological developments.

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[19] ITS America, AI Decoded (June 2024), https://itsa.org/news/ai-decoded

9. Accelerate the development of resources for transportation practitioners that outline best practices, guidelines, and repeatable evaluation methods for AI based on research and analysis.
10. Distill lessons from the Safe System Approach that could be applied to AI (e.g., how do we design systems that include nondeterministic humans, nondeterministic computers, and deterministic computers so that an AI or human failure does not mean a system failure?).
11. Conduct a broad internal survey to identify work needs within USDOT and its partners to help understand whether and how AI tools might be useful.
12. Identify regulatory frameworks that are built on an assumption of human performance, and consider whether and if so how these should be clarified or changed.
13. Compare and contrast the delegation to humans of authorities statutorily entrusted to the “Secretary” or the “Administrator” with the potential delegation of these authorities to AI tools while considering and addressing equity concerns.
14. Initiate the development of a multi-agency task force on the impact of AI on the transportation workforce and develop a comprehensive gap analysis of evolving workforce needs, scenario planning and corresponding training and programs to support the transportation workforce.
15. Create a standing advisory committee charged with advising USDOT on technological, societal, and other elements in which evolving AI systems may impact the safety and operations of and equitable access to the transportation system.
16. Consider when AI presents issues of national security. Assess partnerships with relevant Information Sharing and Analysis Centers (ISACs) with a view to applying these mechanisms to AI more generally. Encourage the expansion of the Automotive ISAC (or replication of the Automotive ISAC) to address AI-related risks and opportunities in parallel with cybersecurity and as an essential part of national security.
17. Create an office within the Office of the Secretary of Transportation (OST) charged with monitoring AI-related risks within and outside of USDOT. The office should have responsibility for preparing for and facilitating USDOT-specific responses including but not limited to, within department response, multi-agency responses, non-governmental responses, etc.
18. Leverage USDOT's discretionary grantmaking power to learn and stay up to date about how AI is being used, by requiring applicants to explain if and how AI will be used and how any risks are identified and mitigated.

4.3.3 Foster a Trustworthy Culture

To foster a trustworthy culture that is proactive, open, and responsible with respect to AI, USDOT should:

1. Establish responsible technology governance at USDOT that:

a. Assigns responsibility for overseeing how benefits and risks are identified, assessed, and managed within transportation.

b. Sets departmental expectations on the use of technology by transportation providers.

c. Draws on guiding principles from the US Executive Order on AI that are most pertinent to transportation, including privacy, safety, fairness/equity, sustainability, and accuracy.

2. Follow the National Institute of Standards and Technology (NIST)'s AI Risk Assessment Framework,[20] Cybersecurity 2.0 Framework,[21] and Privacy Framework;[22] align with US positions on respecting human rights;[23] and extend these best practices to grants and other USDOT activities.

3. Model trustworthiness in the AI-related activities of USDOT and its partners, especially by publicly sharing internal examples of AI-related success, failures, questions, and challenges (including through less-redacted submissions to the Federal AI Use Case Inventory).

4. Incentivize members of the transportation ecosystem to embrace trustworthiness in the use of AI-related tools and associated data collection.

5. Develop transparency guidelines and standards of explainability for the use of AI applications in transportation.

6. In messaging, training, and incentives, encourage USDOT staff at all levels to embrace curiosity, candor, competence, and caution when using AI tools. Build responsible use awareness among USDOT users of generative AI tools, especially safe and secure data management practices.

7. Create mechanisms and incentives for bottom-up experimentation within USDOT and its partners. Make a set of enterprise generative AI tools (such as Copilot given USDOT's current use of Microsoft tools) available to all USDOT staff so they can begin understanding the applications, limitations, and continuing evolution of at least one set of AI functionalities.

8. Leverage USDOT's unique convening authority to host formal and informal meetings with a diverse set of stakeholders on the role of AI in transportation across research, policy, and implementation, with a particular focus on state-of-the-art developments,

[20] NIST AI Risk Management Framework, https://www.nist.gov/itl/ai-risk-management-framework

[21] NIST Cybersecurity Framework, https://www.nist.gov/cyberframework

[22] NIST Privacy Framework, https://www.nist.gov/privacy-framework

[23] OECD AI Principles, https://www.oecd.org/en/topics/ai-principles.html; Office of the United Nations High Commissioner for Human Rights, Guiding Principles on Business and Human Rights, https://www.ohchr.org/sites/default/files/documents/publications/guidingprinciplesbusinesshr_en.pdf

changes in conditions, and background assumptions, scenario planning, break-the-glass plans for emergencies and other contingencies, and topical deep dives.

9. Engage USDOT researchers to bring investigative rigor to AI tool deployments within USDOT to ensure that the accuracy and impacts of these deployments can be correctly measured.
10. Leverage USDOT's information-sharing ability to collate, coordinate, distill, and disseminate all the work that is happening on AI in transportation, including at USDOT's partners—in part to help these partners avoid duplication and identify and address bias and equity concerns. Create a section on the Smart Communities Resource Center specifically for AI lessons learned, best practices, and guidelines.
11. Develop parallel AI-based "shadows"[24] for USDOT functions and objectives so that traditional processes in which humans analyze data to make decisions can be compared formally to processes in which more of that analysis and decision-making is delegated to AI tools.

4.3.4 Work to Realize the Benefits of AI

To realize AI's potential benefits, USDOT should:

1. Pursue AI that advances safety and operational effectiveness and mitigates harm while working systematically to meet USDOT's obligations to assure equitable transportation solutions.
2. In close consultation with USDOT staff at all levels, develop and maintain a "wishlist" of internal goals and needs to which AI might be relevant. Prioritize these items and consider whether and how new targeted grants, RFPs, and internal staff incentives could bring AI tools to bear on them.
3. Catalog and communicate ways in which the status quo is imperfect (e.g., dangerous roads, invidious biases in enforcement decisions, backlogged FOIA requests) so that the risks and benefits of AI applications can be fairly compared to this status quo.
4. Develop and implement better transportation data governance to ensure the integrity, consistency, availability, usability, privacy protection, anonymity, and timeliness of transportation data that might be useful for training AI models.
5. Develop and maintain a national curated repository for AI datasets, tools, and expertise that is available across USDOT and its partners to provide greater insight into transportation, reduce local burdens, and accelerate innovation.
    a. Fund the creation of datasets to accelerate innovation (e.g., roadway inventory, naturalistic driving data, research observation data).

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[24] See, e.g., Jon Harper, Pentagon May Take a Page out of Tesla's Playbook and Run AI in "Shadow Mode" (2022), https://defensescoop.com/2022/09/26/pentagon-may-take-a-page-out-of-teslas-playbook-and-run-ai-in-shadow-mode

b. Pursue a nationwide model of ground transport in the United States that integrates and augments the datasets of the National Transportation Atlas Database[25] and that can be used by transportation planners to supplant, support, or complement their region- or project-specific travel models.[26]

c. Expand the Fatality Analysis Reporting System (FARS) to include critical vehicle-based metadata (e.g., ADAS features present and software versions) and modernize the Crash Report Sampling System (CRSS) to address contextual factors related to ADAS features (e.g., road class and weather).

d. Explore integrating and encouraging Privacy Enhancing Technologies (PETs) in creating and using these datasets.

6. Prioritize data experts and expertise in USDOT's staffing plans, including expertise on data security, data privacy, and the relationship between data and vulnerable or marginalized communities and individuals.

7. With consideration for mitigating potential risks, pursue opportunities for incidental data collection and generation as part of projects (e.g., embedding sensors in new bridges).

8. Explore—through research, cooperation with stakeholders, and coordination across federal agencies—how AI tools might be used to help individuals:

   a. Understand the privacy implications of a given technology, application, or activity.

   b. Identify products and services that align with their privacy preferences, saving them time and money.

   c. Coordinate automatically with others who share their particular privacy preferences to build identifiable consumer blocks that aggregate the buying power of individuals.

9. Experiment with providing limited, iterative, and closed-loop regulatory flexibility where appropriate, potentially including regulatory thresholds, exceptions, forbearance, and sandboxes where new technologies can be tested—each with robust feedback mechanisms and clear guidelines for safety parameters, civil rights protections, and stakeholder engagement to build consensus. Ensure that these mechanisms are transparent and achieve a level of safety equivalent to or greater than that established by otherwise applicable regulations.

10. Facilitate collaborations with researchers and technology companies by developing clear partnership agreements, mechanisms for centralized coordination, and frameworks for equitable intellectual property sharing.

[25] Bureau of Transportation Statistics, National Transportation Atlas Database, https://www.bts.gov/ntad

[26] See, e.g., Transportation Modeling, https://www.mwcog.org/transportation/data-and-tools/modeling

11. Increase support for research and development focused on AI-relevant innovations that are traditionally unattractive to private investment because they:
    a. Involve a long developmental runway,
    b. Are dependent on traditional infrastructure,
    c. Are likely to involve low profit margins or low scalability,
    d. Warrant significant initial attention to safety, security, and data protection.
12. Expand the use of grant-based funding to accelerate proactive safety developments leveraging AI and other related data-centric tools. Specifically target funding for cross-industry advances (e.g., automakers investing in technology that would reduce insurance losses, etc.).
13. Pursue quick wins identified in the section on AI applications, including:
    a. Support research on the relationship between AI tools and spectrum (e.g., using AI to enhance spectrum utilization, using spectrum to facilitate off-board computing).
    b. Support research on the use of AI tools to enable lower-cost safety retrofits for vehicles and infrastructure (e.g., aftermarket or smartphones apps).
    c. Accelerate the deployment of driver safety support systems, including those currently (and unhelpfully) referred to as "driver monitoring."
    d. Encourage investments that seek improvements in advanced driver assistance systems such as automated braking for vehicles and pedestrians.
    e. Accelerate use of AI-based intersection safety assessment tools to increase safety for all road users.
14. Create awards for the most innovative and socially beneficial uses of AI inside USDOT and in the transportation sector generally.

4.3.5 Work to Manage the Risks of AI

To identify, understand, and manage the risks of AI, USDOT should:

1. Create early-warning systems, whistleblower and anonymous-reporting[27] mechanisms, programs for voluntary disclosure, regulatory feedback loops, and structures for continual process improvement to recognize and address potential AI harm at an early stage (including in USDOT and its partners, in regulated industries, and in research).
2. Monitor for potential concentrations or redistributions of economic and political power that are enabled or exacerbated by AI, especially in regulated industries.

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[27] Memorandum on Advancing the United States' Leadership in Artificial Intelligence; Harnessing Artificial Intelligence to Fulfill National Security Objectives; and Fostering the Safety, Security, and Trustworthiness of Artificial Intelligence, https://www.govinfo.gov/app/details/DCPD-202400945

3. Develop or adopt processes and tools to quickly identify and address instances of regulatory gaming through AI (e.g., generating astroturf public comments).[28]
4. Consider AI's project-specific impacts in existing analyses of cost and benefit, safety impacts, biases, potential harm, and environmental impacts (including environmental justice).
5. Identify and scope potential harms that may come from AI deployed in transportation, either at the individual, community, or society level**.** Define high-risk use cases.
6. Develop key responsible AI principles in the context of transportation.
7. Develop methodologies for AI assurance[29] in the transportation system to optimize the impact on society (safety, productivity, etc.) and reduce unintended harms.
8. Adopt concrete guidelines for assessment and ongoing evaluation of the risks and impacts of operating AI systems, and communicate these guidelines to partners and transportation providers. Periodically review and update these guidelines as needed to keep pace with technological developments. Determine when guidelines should be supplanted with regulatory requirements.
9. Conduct standalone AI risk assessments that draw on existing approaches for analyzing cost and benefit, safety impacts, biases, potential harm, and environmental impacts (including environmental justice). In particular, consider the individual, community, and societal harm or other consequences of getting a particular determination factually, legally, or equitably "wrong."
10. Where appropriate, develop or adopt testing, evaluation, verification, and validation process guidance and resource documents to account for complete AI and associated digital systems lifecycles.
11. Train relevant USDOT staff on safe data management practices in a way that protects and respects personal privacy and security.
12. Leverage USDOT-specific tools (e.g., grantmaking, procurement, contracting) to embed AI risk-mitigating principles and protections in transportation system operations.
13. Develop and update privacy principles for USDOT itself, project partners (e.g., state and local agencies), and regulated industries (e.g., motor vehicle manufacturers) that is cognizant of AI. This guidance should:

[28] See, e.g., Administrative Conference of the United States, Managing Mass, Computer-Generated, and Falsely Attributed Comments (2021), https://www.acus.gov/sites/default/files/documents/Final%20-%20Managing%20Mass%20Computer-Generated%20and%20Falsely%20Attributed%20Comments.pdf

[29] See USDOT Highly Automated Systems Safety Center of Excellence, AI Assurance Program, https://www.transportation.gov/hasscoe/highlights/AI-assurance; MITRE, AI Assurance, https://www.mitre.org/news-insights/publication/ai-assurance-repeatable-process-assuring-ai-enabled-systems

a. Incorporate privacy principles, developed with stakeholder input and referencing the extensive work done in both transportation and non-transportation contexts, for data protection, security, and transparency.

b. Recognize and integrate the NIST Privacy Framework[30] for organizational management.

c. Consider privacy risks for society at large and for all potentially impacted individuals and communities (both users and nonusers, including members of communities that are at risk or historically marginalized as well as other members of the general public).

d. For a technology, application, or activity that poses a privacy risk, trigger a privacy impact assessment commensurate with that risk which should include steps that may be taken to mitigate risk. Relevant resources provided by the IAPP (formerly the International Association of Privacy Professionals) include those on privacy impact assessment[31] and, possibly, AI.[32]

e. Envision a holistic examination of the safety, security, purpose, and functionality of the technology, application, or activity.

f. Treat data anonymization, data protection, and limitations on data storage, transfer, sharing, or use as measures to potentially mitigate risks to privacy rather than as measures to obviate a privacy impact assessment.

g. Emphasize the importance of using clear and correct language, including appropriate categorizations, to apprise stakeholders of where and how their data is processed, including the purpose for any processing, associated privacy risks, implemented mitigation measures, and any steps available to them to limit or mitigate data processing.

14. In public categorizations of technologies, applications, and activities, emphasize the need for clear and careful terminology to communicate accurately and consistently with ordinary people.

a. In particular, avoid the terms “monitoring” or “surveillance” for technologies, applications, or activities where such categorization would cause confusion or fear or that present only *de minimis* privacy risk when mitigations are implemented or mandated.

b. In other cases, deliberately use the terms “monitoring” or “surveillance” where that use is appropriate and important, especially where application of an AI tool dramatically empowers a government or company vis-a-vis an individual or may be used by law enforcement.

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[30] NIST, Privacy Framework, https://www.nist.gov/privacy-framework

[31] IAPP, Data Protection and Privacy Assessments, https://iapp.org/resources/topics/privacy-impact-assessment-2/

[32] IAPP, Artificial Intelligence, https://iapp.org/resources/topics/artificial-intelligence-1/

15. Consider the resilience of AI and AI-dependent systems in conjunction with supply chain risks in general and, specifically, Homeland Security Presidential Directive 7 on critical infrastructure. In particular, assess whether AI dependencies could make the transportation system more vulnerable to disruptions.
16. Establish controls to check—or requirements for AI providers to check and confirm—that data was obtained responsibly, with consent, and decent working conditions for data enrichment workers.
17. Assess whether, and if so how, AI might weaken or strengthen mechanisms that have traditionally complemented governmental regulation such as markets, insurance, litigation, and reporting, and if additional protections are needed to respond to those risks and to emphasize potential benefits.

4.4 AI Issues

4.4.1 Introduction

This section discusses some of the key issues associated with artificial intelligence (AI) that the US Department of Transportation (USDOT) should carefully consider.

The disruptive nature of AI-enabled tools creates risks as well as opportunities. Both are important, and neither should be overlooked. As such, it is critical for USDOT to engage in discussions that account for all potentially affected stakeholders. Individuals, industries, regulators, and civil society may have different perspectives on AI's potential for positive, negative, mixed, and neutral impacts.

Indeed, AI tools have the potential to dramatically shift power dynamics among governments, companies, communities, and individuals. On one hand, an AI tool that enables more equitable public engagement during a transportation planning process could better account for traditionally underrepresented stakeholders. On the other hand, an AI tool that dramatically reduces the skills needed for a cyberattack could subject critical transport infrastructure to the whims of individuals acting with malice. Depending on how they are deployed, AI tools could also increase or decrease the market power of consumers, workers, or companies throughout the transportation supply chain.

This question of power cuts across many of the issues identified in this section, including privacy, invidious bias, environmental justice, and others. Similarly, safety in a broad sense is implicit in all the issues discussed in this section—and deeply intertwined with many of the applications, risks, and especially opportunities identified later in this chapter.

AI is also a critical factor in the future of our nation's economic competitiveness. As such, AI policy should involve all of USDOT's modal administrations (including the Office of the Secretary (OST)) and, where appropriate, other federal agencies.

USDOT cannot be the only actor to work on these questions. But the Department can play an especially important role in regularly convening broad sets of stakeholders to discuss and address these questions in a way that empowers people and ultimately earns public trust.

Importantly, this section is a work in progress—even more so than the rest of this report. Its discussion informs the specific recommendations offered earlier. More broadly, TTAC encourages USDOT to accord these issues the attention they deserve. After all, while this section raises these issues in the context of AI, many of the same issues are already present in our transportation system's alarming status quo. Whether AI exacerbates or mitigates today's problems will depend in part on how USDOT engages now and in the future.

4.4.2 Privacy Protection

Protecting privacy (including personally identifiable information (PII) and other personal data) is a complex that is being discussed among multiple stakeholders within and outside of USDOT and that is beyond what can be fully addressed in this document. As such, TTAC advises that, through its continued work or in other USDOT-specific venues a range of viewpoints on privacy protection must be heard. With input from all stakeholders, USDOT can consider the benefits and risks of transportation-specific privacy protections.

Adequate privacy protections are essential to generating consumer acceptance and earning public trust in AI-enabled solutions and realizing benefits of future transportation systems that improve safety, reduce costs, and enhance convenience.

There are many uses of AI that do not implicate personal data and have low or no privacy risk. However, as USDOT is aware, general risks related to the misuse or abuse of personal data in the transportation sector may include loss of trust in a given device or the system more broadly, actual or perceived loss of autonomy for individuals or communities, and, in some cases, the use of "self-help" to disable sensors or opt out of programs that may undermine the protections that the system could offer. Risks may also be specific to the role of the individual in the transportation space. The contractual relationship, if any, between operators and users of a given technology could shape the information and rights available to those users with respect to the collection and use of their data. Privacy risks are also deeply related to risks related to security, cybersecurity, bias and discrimination, the transportation workforce, and so-called "monitoring."

When evaluating applications of AI in transportation, USDOT should prioritize considerations around privacy as a key mechanism to earn public trust. Where necessary, appropriate, and in line with its jurisdiction, USDOT should adopt or develop security and privacy safeguards and standards. Through the consideration and evaluation of current regulatory frameworks that protect privacy, USDOT should determine best practices for privacy and data protection that can be implemented at the national level, state level, regional or local level, and program or contractor level.

4.4.3 Automated Detection and Monitoring

This topic is entangled with the topic of privacy, complex, and beyond what can be fully addressed in this document. As such, TTAC advises that through its continued work or in other USDOT-specific venues, a range of viewpoints on so-called monitoring must be heard. With input from all stakeholders, USDOT can consider the benefits and risks of transportation-specific applications that automatically collect and process data.

In these public discussions, USDOT should strive for clear and careful terminology to communicate accurately and consistently with ordinary people.

For example, USDOT should avoid the terms "monitoring" or "surveillance" for technologies, applications, or activities for which such categorization would cause confusion or fear or which present only *de minimis* privacy risk, including once specific mitigations are implemented or mandated.

In other cases, using the terms "monitoring" or "surveillance" may be appropriate and important, especially where application of an AI tool dramatically empowers a government (including law enforcement) or company vis-a-vis an individual.

Considerations of the appropriate use of automated detection technologies are essential to protecting individual liberties while ensuring safety and security in current and future transportation systems. AI tools can play an important role if used thoughtfully and with input from all stakeholders but can also present risks.

There are many uses of AI in automated detection technologies, each with varying benefits and risks. As an illustration, AI can be used in conjunction with automated detection technologies to enforce bus-only lanes, in transit facilities to monitor public safety, and transportation-related workspaces to supervise employees and onboard transit or on-demand vehicles. AI can sift through large amounts of data quickly and can include the use of facial recognition technology. AI can provide the ability to track almost all movement on our transportation infrastructure and create fewer in-person engagements with law enforcement and an increased sense of safety for some but increase actual or perceived surveillance and disparate impacts for others (based on race, gender, disability, or other factors). AI can be used to support a Safe System Approach and law enforcement activities while also generating cybersecurity, workforce, privacy, constitutional, and civil rights concerns.[33]

USDOT should continue engagements with transportation agencies, community members and organizations, law enforcement, labor organizations representing transportation employees and other stakeholders and consider guidance on the equitable use of automated detection and enforcement technologies, consistent with proper processes and procedures for protecting personal privacy and evolving technological capabilities. Transparency is a core consideration in the ongoing discussion of and use of detection.

4.4.4 Invidious Bias and Discrimination, Equity, and Accessibility

AI tools could ameliorate some existing invidious biases but could exacerbate or introduce others. Promoting fairness requires strategies and mechanisms to detect invidious bias in data collection and algorithm development. AI learns from data and programming. A training data set with gaps in it, for example, could lead to inaccurate outputs and would not be able to respond correctly under a full range of operating conditions. Without diverse data

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[33] For analysis of these issues in the context of road traffic enforcement, see Bryant Walker Smith, Jeffrey Michael, and Johnathon Ehsani, Ideal Enforcement: How Do We Achieve Optimal Enforcement of Traffic Law as Ubiquitous Enforcement Becomes Technologically Conceivable? (2023), https://repository.law.umich.edu/cgi/viewcontent.cgi?article=1064&context=mtlr

sources, AI systems have and could make conclusions that perpetuate invidious biases and inequities.

USDOT should adopt or develop guidance on the equitable development, deployment, and use of AI tools. This guidance should involve and contemplate communities likely to be impacted by invidious bias.

Memos issued by the Office of Management and Budget (OMB) on artificial intelligence[34] provide an important starting point for this work. OMB specifies minimum practices to address safety- and rights-impacting AI for performance in real-world environments and for providing additional human oversight, intervention, and accountability. The practices developed could be used as a guide for rulemaking such as safety standards and as a source of requirements or criteria in grantmaking.

4.4.5 Impacts on Human Health (Including Climate and Environment)

AI impacts on the environment should be researched and tracked with a view to environmental risks and benefits. For example, large computing models have been shown to require great amounts of energy and electricity drawing from electrical grids and water supplies. However, AI could also contribute to reducing climate impacts. By using AI systems for predictive maintenance on roadways, the State of Hawaii saved approximately 23,000 pounds of carbon emissions per vehicle per year by taking unnecessary maintenance trucks off roadways.[35] Hawaii is using AI-based modeling tools to measure and predict climate impacts to roadways so future investments and infrastructure planning are targeted to where they are needed most.

USDOT should work with other agencies to develop a voluntary system for reporting the environmental impacts of artificial intelligence. Research should be prioritized to study the impact of AI, especially on traditionally marginalized communities, and identify strategies for appropriate application, supervision, and mitigation.

4.4.6 Testing

Where appropriate and practical, USDOT should develop testing, evaluation, verification, validation process guidance, and resource documents to account for complete AI and associated digital systems lifecycles, with emphasis on transparency, explainability, and currentness. Because the costs and complexity of maintaining AI systems in many cases

[34] Office of Management and Budget, Memo M-24-18, Advancing the Responsible Acquisition of Artificial Intelligence in Government (September 24, 2024), https://www.whitehouse.gov/wp-content/uploads/2024/10/M-24-18-AI-Acquisition-Memorandum.pdf; Office of Management and Budget, Memo M-24-10, Advancing Governance, Innovation, and Risk Management for Agency Use of Artificial Intelligence (March 28, 2024), https://www.whitehouse.gov/wp-content/uploads/2024/03/M-24-10-Advancing-Governance-Innovation-and-Risk-Management-for-Agency-Use-of-Artificial-Intelligence.pdf

[35] Blyncsy, Hawaii DOT Switched to Blyncsy to Automate Roadway Condition Assessment and Damage Detection, https://www.blyncsy.com/active-projects/hawaii-department-of-transportation

may exceed that of development, front-end consideration of lifecycle impacts will be critical to system effectiveness.

4.4.7 Human Skills

USDOT should address the potential displacement or degradation of human skills, knowledge, and availability.[36] In 2013 the FAA issued a SAFO (Safety Alert for Operators) acknowledging that "continuous use of autoflight systems could lead to degradation of the pilot's ability to quickly recover the aircraft from an undesired state."[37] AI-enabled technologies could further erode what were once core human skills across all modes. This risk demands proactive consideration of the minimum human capabilities to supervise or perform intended activities as well as activities to promote human skill development and retention. By reducing the day-to-day need for skilled human control or facilitating last-minute supply chains (e.g., just-in-time delivery), AI applications could also leave systems more vulnerable to disruptions.

4.4.8 Human-Machine Interaction (HMI)

USDOT should holistically address issues of human-machine interaction, including shifts in the performance of tasks from humans to machines and the potential for unrealistic expectations for human oversight. Where relevant, USDOT should advise on, or require the level of acceptable or preferred human interaction with AI-enabled tools. Human interaction can exist on a scale that includes a human in the loop on design and implementation, human involvement in operation, and/or human oversight of decisions and impacts. Increased research in human factors will be important as technologies continue to advance and change the traditional division of tasks from manual control to human supervised and automated.

4.4.9 Automation Bias

Individuals and even institutions often over trust automated processes and outcomes.[38] "Automation bias" can describe the differential between actual and justified trust in automated systems. It can also describe the differential between actual trust in automated systems and actual trust in humans.[39]

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[36] Later in this report, TTAC provides more specific workforce recommendations in the context of automated driving.

[37] FAA, SAFO 13002 (2013), https://www.faa.gov/sites/faa.gov/files/other_visit/aviation_industry/airline_operators/airline_safety/SAFO13002.pdf

[38] See, e.g., Lisanne Bainbridge, Ironies of Automation (1983), https://ckrybus.com/static/papers/Bainbridge_1983_Automatica.pdf; Kate Goddard, Abdul Roudsari, and Jeremy C. Wyatt, Automation Bias: A Systematic Review of Frequency, Effect Mediators, and Mitigators (2012), https://pmc.ncbi.nlm.nih.gov/articles/PMC3240751/; Computer Says No, https://en.wikipedia.org/wiki/Computer_says_no

[39] See, e.g., Eric Bogert, Aaron Schecter, and Richard T. Watson, Humans Rely More on Algorithms than Social Influence as a Task Becomes More Difficult (2021), https://www.nature.com/articles/s41598-021-87480-9

Frequent and obvious failures of automated systems at least provide reminders of their fallibility to the humans who use or interact with them. (Think rudimentary lane-keeping systems in motor vehicles or early grammar tools in word processors.) But as automation failures become less common, individuals and institutions may be less alert to and less prepared for those failures.

In other words, the increasing capability, reliability, and mundanity of AI tools could increase the risk of automation bias. These human factors issues are already evident in the dangerous misuse of some advanced driver assistance systems.[40] If an automated system has worked well for 99 instances or miles or hours, few would expect (or perhaps even recognize) a catastrophic 100th.

Automation bias can also exacerbate the effects of invidious bias insofar as individuals and institutions treat AI-based determinations either as “objective” (which they are not) or at least as less subjective than equivalent human determinations (which they may or may not be).

4.4.10 Administration

AI could—and indeed should—impact how USDOT carries out its work and engages with the public, including regulated industries.

For example, at least some modal administrations appear to be facing a yearslong backlog in satisfying or even responding to Freedom of Information Act (FOIA) requests. AI tools might increase the number of these requests and might also help USDOT process these requests more quickly.

Similarly, USDOT faces challenges processing the huge amount of data that it receives and generates (including sectoral research, industry reporting, and public comments). AI tools might increase the amount of data and might also help USDOT analyze these data more quickly and effectively.

Some of these AI tools might be developed in-house, while others might be developed outside of government. In particular, determinations that were previously made by USDOT or its partners might in effect be delegated to third-party vendors offering AI tools. They could also incorporate other explicit or implicit value judgments that are not fully appreciated by the agency or the public. USDOT may face difficulty discerning which tools are valuable, procuring these tools, and documenting how they work.

USDOT should specifically consider the use of AI tools within the agency and develop appropriate policies and procedures for such use (including any use that USDOT wishes to prohibit or limit) and communicate those policies and procedures widely to all USDOT leaders, staff, and contractors. Such policies should consider documentation and code sharing requirements such that USDOT has the needed information to continually reevaluate policies and compliance.

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[40] See, e.g., IIHS, First Partial Driving Automation Safeguard Ratings Show Industry Has Work to Do (2024), https://www.iihs.org/news/detail/first-partial-driving-automation-safeguard-ratings-show-industry-has-work-to-do; Consumer Reports, Active Driving Assistance Evaluation Report (2023), https://data.consumerreports.org/reports/active-driving-assistance-evaluation-report/

4.4.11 Law

Existing federal and state statutes, administrative regulations, and judicial precedents may apply to AI systems in ways that are ambiguous, inadequate, or undesirable, especially if these AI systems replace or change the role of human actors, are not fully deterministic, are capable of being remotely operated or updated, increase data collection, or create new demands on USDOT's modal administrations. At the same time, just because a technology or application is novel does not mean that it is necessarily illegal or unregulated. Existing federal and state statutes, administrative regulations, and judicial precedents may sufficiently apply to AI even if they do not explicitly mention AI or were initially adopted without consideration of AI tools and applications. USDOT should interpret its existing statutes and regulations in a way that is clear, candid, and public.

4.4.12 Security (Including Cybersecurity)

Solutions are now becoming systems of systems, which greatly complicates how they are secured. Security applications leveraging AI will continue to expand, and thus associated cybersecurity threats will as well. AI can be used in ways that impact both digital security and physical security. It may be an asset to secure networks and detect anomalous patterns that indicate malicious activity, but it may also be a tool for bad actors to increase the volume, reach, and sophistication of activities intended to compromise systems and data. Specifically, AI may be used outside of the transportation ecosystem to develop code, messaging, or strategy to plan or execute an attack that exploits vulnerabilities in physical security, cybersecurity, or both. Further, certain AI systems could unintentionally reveal data that could lead to a security compromise. Any AI system should be analyzed for its security risks and benefits. USDOT should work with other agencies and the public sector stakeholders, including regulated industries, to formulate plans for mitigating the effects of AI and digital systems security and cybersecurity vulnerabilities to the transportation system.

4.4.13 Workforce

Labor is vital to the economy, to society, and to identity. It is therefore especially important to consider how AI-enabled technologies will affect the nature of work in ways that could change, eliminate, or create jobs—in some cases quickly and dramatically. AI could help improve workplace safety and productivity, and changes will demand adaptations across the transportation system. This includes training the existing workforce on leveraging AI tools and solutions to support their work. AI should be used for decision support and task augmentation, not as a replacement. Further, AI tools should be implemented in the workforce for the health, safety, and well-being of workers. It is critical to ensure workers are supported, including through retraining and upskilling programs within the evolving transportation sector. USDOT should work with other agencies and all relevant public sector stakeholders, including labor organizations representing transportation workers, to initiate a scenario planning exercise on the impact of AI on the transportation workforce to inform future directives.

4.4.14 Risk Mitigation

Many of the above considerations relate to potential risks created or exacerbated by the implementation and use of AI systems. AI tools also have the potential to create significant benefits in terms of safety and security, among other areas. A guiding principle in USDOT's work to promote and support AI should be to equitably mitigate actual and potential risks for individuals and communities implicated by the use of AI tools while maximizing the safety and societal benefit of those tools. The Safe System Approach offers an instructive analogy for this exercise that should be propagated through USDOT's investments in AI-based technologies.

4.4.15 Economic Competitiveness

An innovative and cutting-edge mobility sector in the United States is critical to our national and economic security. Other nations have developed integrated transportation technology solutions, powered by AI, creating product and service offerings that place the US at a potential competitive disadvantage in both domestic and international markets and slowing the benefits innovation provides to our society. USDOT should recognize and embrace the opportunities AI provides to improve safety, convenience, and performance while ensuring a continued commitment to privacy, security, equity, and access to transportation. Responding to this competitive challenge requires the Department to develop a comprehensive yet nimble policy framework that encourages innovation, improves outcomes, and manages risks.

4.5 AI Applications

4.5.1 Introduction

This section highlights transportation-specific applications of artificial intelligence (AI) that USDOT should help realize and associated risks that USDOT should help manage. The handful of examples we have selected—for surface vehicles, infrastructure, transit, and freight—represent only a small part of the overall puzzle. This is because AI will be both ubiquitous and dynamically thread throughout all aspects of technology used within the transportation system.

As with our other AI sections, the analysis in this section is therefore incomplete in space and time. AI tools will impact every aspect of our transportation systems, from public to private, from planning to operation, from sea to sky, and from obscure to obvious. Moreover, AI-enabled tools and systems will continue to evolve rapidly, both in the underlying technologies and in the numerous applications of those technologies.

Ultimately, uses of AI that few expect or even recognize could be as transformative as the applications that preoccupy public and regulatory attention. Two separate chapters of this report illustrate this spectrum. On one end, automated driving is probably the most famous transportation application of AI. It could play an important role in addressing what USDOT rightly calls a "crisis on our roadways"—one in which more than 100 Americans die every day and which disproportionately affects people of color. On the other end, digitalization in project delivery is far less well-known. But it too could play an important role by reducing the immense cost and time required to build and maintain the safer and more inclusive roads that are foundational to the Safe System Approach.

The potentially disruptive nature of AI-enabled tools creates risks as well as opportunities. Individuals, industries, regulators, and society at large may have difficulty keeping pace with the rapid changes that AI could unleash. While we address some of the potential workforce impacts of automated driving in a separate chapter, it is important to recognize that professional drivers will not be the only—and may not even be the first—set of workers to grapple with profound challenges and even competition from AI.

As AI tools are increasingly incorporated into the transportation system, it is imperative that agencies, users, and developers ensure that their tools are developed, deployed, and used safely. Earning public trust should be foundational to scaling the deployment and use of AI tools. This includes applying these tools in ways that are transparent, equitable, and beneficial to individuals and their communities. While AI offers great promise, caution must be exercised when used in safety-critical applications. The nondeterministic nature of these tools does not guarantee reproducible behaviors, complicates the debugging of systems, can obscure invidious biases, and can hide value judgments.

USDOT, other government agencies, and even the most advanced private sector technology producers do not fully appreciate all these opportunities or fully envision all these risks. We also recognize that USDOT cannot act outside its statutory authorities or its budget authorizations. But the Department can, within these limits, take steps to anticipate, appropriately facilitate, create the flexibility to adapt to, and model principles for the broad adoption of AI in our transportation system. We recommend specific actions throughout this section.

4.5.2 Vehicle Connectivity: Managing Communications Spectrum

4.5.2.1 Supporting Connected Vehicle Technology

Facilitating real-time safety-critical communications.

USDOT Action: USDOT should support the application of AI in innovative ways to ensure optimal driver alerting, facilitate effective use of spectrum, and accelerate the adoption of V2X technology. USDOT should actively support research and pilot projects focused on the use of AI to: specify conditions for issuing safety alerts to drivers; address challenges with limited spectrum availability; and enhance V2X capabilities by potentially dynamically adjusting communications and alerts according to roadway environment conditions.

Why: Connected vehicle technologies can help improve roadway safety and prevent crashes by allowing vehicles to communicate directly with other vehicles and with roadway infrastructure to provide drivers with additional situational awareness of the driving environment. As connected vehicle technologies become more prevalent, AI can be used to help manage spectrum usage, reduce congestion that can reduce performance, and ensure that the most critical communications are prioritized. AI can also be used to improve the storage and dissemination of the large amounts of data that is continuously created.[41]

Risks: Messages and alerts to drivers must be appropriately delivered in terms of frequency, timing, and relevancy to ensure the driver is able to take action while also preventing driver

[41] Massive deployment of connected vehicle technologies will require significant spectrum availability.

distraction, annoyance, or disregard. Optimal use of the remaining 30 MHz of spectrum is paramount to ensure safety critical messages are triaged appropriately.

Benefits: AI aligned with a Safe System Approach has the potential to ensure that alert parameters are appropriate for drivers and vulnerable road users, both in the context of establishing base parameters and potentially in reacting to the environment during the time of alerting (for instance by adjusting parameters based on ambient noise, driver attention, driver action, or an evolving roadway environment). AI also has the potential to allow for spectrum use optimization through message prioritization or potentially spectral use modification based on the actual roadway environment (such as by varying message frequency or by changing message triggers based on environmental or contextual factors).

Note: Many of the recommendations in this document rely on connected vehicle technology, which requires adequate and protected spectrum. USDOT should actively collaborate with FCC and NTIA to ensure protection of the remaining 30 MHz of dedicated spectrum and provide additional spectrum so that all lifesaving V2X applications can be realized.

4.5.3 Vehicle Systems

4.5.3.1 Advanced Driver Assistance Systems (ADAS)

Enabling active safety features and augmenting vehicle motion control.

USDOT Action: Monitor AI-enabled ADAS features to robustly categorize real-world performance and unintended consequences, prioritize human life and safety, and protect privacy and security of drivers, passengers, and bystanders. Accelerate the implementation of NHTSA's update of NCAP and commit to a plan that allows for frequent updates to keep pace with technology advances and cost reductions. NHTSA should collaborate with industry and other stakeholders with the goal of developing aligned research objectives in furtherance of shared goals.

Why: Advanced driver assistance systems (ADAS) include a wide variety of systems[42] designed to leverage sensors, computational, and actuation capabilities to enhance safety by alerting drivers of unsafe conditions or temporarily performing parts of the dynamic driving task to avoid such conditions. Systems can offer more convenient driving experiences through sustained performance of parts of the dynamic driving task and simplify complex tasks for drivers. Systems often leverage AI-enabled componentry at

[42] ADAS features that, depending on their implementation and use, may have safety and convenience benefits include Automatic Emergency Braking (AEB), Reverse-AEB, Forward Collision Warning (FCW), Lane-Keeping Assistance (LKA), and Lane Departure Warning (LDW). ADAS features that are primarily intended for driver convenience include Adaptive Cruise Control (ACC), Lane-Centering Assistance (LCA), Active Driving Assistance, and Parking Assistance. See Consumer Reports, AAA, J.D. Power, National Safety Council, Partners for Automated Vehicle Education, and SAE International, Clearing the Confusion: Updated Common Naming for Advanced Driver Assistance Technologies (2022), https://advocacy.consumerreports.org/research/clearing-the-confusion-updated-common-naming-for-advanced-driver-assistance-technologies/

multiple levels (e.g., sensing, actuation, and interfaces) to improve safety, comfort, and convenience as well as enable holistic driver support features.

Risks: ADAS may fail to perform as the driver expects in real-world conditions which may lead to consumer confusion as to intent (e.g., safety vs. convenience) and create unintended consequences (e.g., unsafe use, over- or under-underutilization, etc.). Risks may also occur as a result of biases in training data, overcollection or misuse of personal data, judgments under uncertainty, lifecycle sensor deterioration, cybersecurity, etc. When developing automatic emergency braking, companies may fail to collect sufficient training data focused on detecting pedestrians who use mobility devices and service animals.[43]

Benefits: If developed and deployed effectively (e.g., via the Safe System Approach), ADAS has the potential to increase vehicle safety, driver comfort, and access to convenient mobility solutions as such enabling more people without alternate transportation options to gain and maintain independent mobility.

4.5.3.2 Automated Driving Systems (ADS)

Enabling automated driving systems.

USDOT Action: A federal regulatory framework is essential to mitigate risk and reap the benefits of ADS while also promoting appropriate public acceptance of these technologies. As part of that framework, USDOT must make an explicit decision about whether it will regulate the performance of the ADS as a whole or individual systems or subsystems of an ADS. It may also wish to pursue complementary regulatory environments across all relevant modal administrations. USDOT must also develop a robust research and rulemaking plan that advances its identified approach and considers industry, safety, civil rights, and disability community expertise. Finally, USDOT should focus on developing resources (or partnering with others) to educate and inform the public about ADS and industry about underserved communities' needs.

Why: Automated driving systems (SAE Levels 3-5) allow for removing human drivers from the dynamic driving task within the systems' operational design domains. ADS may mitigate or eliminate certain crashes (examples include those caused by speeding; distracted, impaired, and reckless driving; and fatigue), and it holds significant potential to reduce certain crashes that result in serious injuries and fatalities.[44] The capabilities and impact of this technology are potentially linked to advancements in AI for vehicle motion control, teleoperation, and other elements of a safe system. ADS offer the potential for safer and/or lower-cost mobility but more data is needed to assess safety and efficacy as the technology advances.

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[43] For example, NHTSA's recent proposal for automatic emergency braking does not include test scenarios accounting for pedestrians in wheelchairs. See NHTSA, Federal Motor Vehicle Safety Standards: Automatic Emergency Braking Systems for Light Vehicles, Notice of Proposed Rulemaking (2023), https://www.federalregister.gov/documents/2023/06/13/2023-11863/federal-motor-vehicle-safety-standards-automatic-emergency-braking-systems-for-light-vehicles

[44] Distracted driving was a factor in at least 3,308 fatalities in 2022. NHTSA Traffic Safety Facts (2024). Distracted Driving in 2022. DOT HS 813 559). Impaired driving was a factor in at least 13,524 fatalities in 2022. NHTSA Traffic Safety Facts (2024); Alcohol-Impaired Driving, DOT HS 813 578.

Risks: AI systems that support or enable ADS have higher risk due to the safety implications of the technology than many other systems that rely on artificial intelligence. ADS is likely to be one of the first applications in which AI may make decisions that have imminent safety-of-human-life implications. These include risks around cybersecurity, privacy, bias, robustness, safety, resilience, equity, and trustworthiness. There may be significant risks associated with ADS if the data that is used to train ADS is not high quality, diverse, and representative of the vast array of situations an ADS may encounter.

Benefits: If developed and deployed effectively, ADS has the potential, in the areas in which it is deployed, to increase road and motor vehicle safety; increase access to mobility for those who cannot drive for any number of reasons or do not otherwise have access to reliable transportation; and make the movement of goods more cost-effective.

4.5.3.3 Driver Safety Support Systems (DSSS)

Helping ensure that drivers are attentive, capable, and supported.

USDOT Action: As USDOT continues its consideration of a mandate for advanced impaired driving prevention, it should ensure that the risks identified—particularly with respect to privacy, security, and trustworthiness—are appropriately considered and mitigated. In addition, USDOT should consider additional ways to facilitate appropriate public acceptance and adoption of these and other driver safety support systems. USDOT should avoid the term “monitoring” for technologies, applications, or activities where such categorization would cause confusion or fear or that present only *de minimis* privacy risk when mitigations are implemented or mandated.

Why: Safety support systems have the potential to play a critical role in the Safe System Approach by focusing efforts on mitigating driver errors through a technological solution aimed at improving the allocation of attention in under- and over-load conditions as well as targeting aberrant driving behavior including drunk, drugged, and drowsy driving. While such technology has long offered great promise, the technological feasibility for real-world implementation is nascent (only recently enabled by advances in AI), and there may be risks associated with data privacy, equity, security, and performance targets across a range of modes, driving contexts, and capabilities.

Risks: Safety support systems can use AI to infer impairment which may impact a driver’s ability to safely engage in the driving task. These systems may store data that could pose risks to driver or passenger privacy or personal safety. In addition, as with other AI systems, there may be additional risks around equity, robustness, safety, resilience, and trustworthiness of AI-enabled safety support systems. Furthermore, these systems can possibly provide false positive and false negative detections of driver distraction or impairment which can put a driver in a more dangerous situation that they will need to resolve.

Benefits: If deployed correctly, safety support systems have the potential to improve roadway safety by helping to mitigate major behavioral risk areas, including distracted or impaired driving, or identifying situations where a driver is experiencing a medical emergency. Safety support systems can also help ensure that drivers are using ADAS or ADS appropriately and as intended. Companies can also leverage such systems as part of a driver education and support system to improve safety and operational performance.

4.5.3.4 Occupant Safety Support Systems (OSSS)

Helping ensure that occupants in private, shared, and transit vehicles are safe and supported.

USDOT Action: USDOT should expeditiously implement the directive in the Bipartisan Infrastructure Law (BIL) to mandate for new vehicles "a system to alert the operator to check rear-designated seating positions after the vehicle engine or motor is deactivated by the operator…". In seeking to prevent pediatric heatstroke, the Department should ensure that the risks identified—particularly with respect to privacy and trustworthiness—are appropriately considered and mitigated. In addition, USDOT should consider additional ways to facilitate appropriate public acceptance and adoption of these and other occupant safety support systems. USDOT should avoid the term "monitoring" for technologies, applications, or activities where such categorization would cause confusion or fear or that present only *de minimis* privacy risk when mitigations are implemented or mandated.

Why: Occupant safety support systems are increasingly being used to identify children left behind in a vehicle, to support more precise airbag and seatbelt controls, and to detect occupant behaviors of concern in ride-share and ADS-equipped vehicles. While offering clear benefits, these features have the potential to identify or profile vehicle occupants and open a range of concerns related to privacy, equity, cybersecurity, such that applications of use are equitable.

Risks: Occupant safety support systems may use imaging technology and artificial intelligence to detect the presence of occupants in the vehicle. These systems generate data and may pose risks to driver or passenger privacy or risk of over-monitoring by employers. A challenge exists in educating the public about the capabilities and limitations of these systems, especially in situations where the user has no relationship with an operator, dealer, or manufacturer. In addition, as with other AI systems, there may be risks around equity, robustness, safety, resilience, and trustworthiness of AI-enabled occupant safety support systems.

Benefits: If deployed correctly, occupant safety support systems have the potential to improve safety. This may include reducing the risks of heatstroke for children unintentionally left in vehicles and improving seatbelt and airbag controls. Finally, in general these systems can play a key part of a Safe System Approach to roadway safety by contributing to emergency crash notifications that facilitate appropriate post-crash care, including notifications to first responders about the existence and/or status of occupants.

4.5.4 Infrastructure and Operations

4.5.4.1 Intersection Safety

Protecting all users, especially the Vulnerable Road Users (VRUs) who are outside a vehicle.

USDOT Action: USDOT should support the development of technology enabled intersection safety systems. These systems require many technologies working together to reduce conflicts between vehicles and people outside the vehicle. The increased reliance on multiple technologies enhances “human-machine cooperative” decision-making at intersections. This includes identifying potential conflicts and incidents and developing standards and protocols to include, where feasible, V2X communication shared with vehicles and people outside the vehicle in real-time. The result assures greater safety and accessibility for all users and all modes.

Why: One fourth of all fatalities happen at intersections. AI allows systems to identify safety issues undetectable through other means as it can process large amounts of data in real-time from sensors, connected vehicles, cellphones, and other connected devices to reveal safety issues, dangerous behavior (speeding, hard braking, hard acceleration), wrong way driving that goes undetected, and dangerous crossings, providing agencies real-time insights to take action to address safety issues. AI combined with perception devices and adaptive signals can in real time delay signal phasing to allow people time to safely cross an intersection (e.g., wheelchair users, elderly, mobility limited and people who are blind or low vision).

Risks: Cost and ease of use for communities with less funding may be a barrier to adoption. Highest benefit requires prioritizing installation and use in areas of greatest need but can be more easily identified with access to data. There is a challenge with scalability of the systems to implementations in new locations because the informal protocols that govern VRU interactions with drivers vary so widely with location. Systems that require VRUs to travel with a smartphone or wearable device to ensure safety can restrict benefits.

Benefits: AI combined with perception devices and adaptive signals can in real time delay signal phasing to allow people who need more time to safely cross an intersection.

4.5.4.2 Complete Streets

Ensuring streets and public-rights-of-way are designed and operated to enable safe and increased mobility for all users, including people of all ages and disabilities, drivers, pedestrians (including wheelchair users), bicyclists, and public and on-demand transportation riders.

USDOT Action: USDOT should amplify support for its Complete Streets Artificial Intelligence Initiative which aims to foster decision-support tools to help state and local governments design and deploy a network of Complete Streets.[45] Program grantees and USDOT should engage with communities that would most benefit and consider ways AI developers and other industry stakeholders can assist in collection of data. USDOT should update its Complete Street Guidance to include a digital infrastructure layer as an integral component of a Complete Street and consider additional incentives for cities to adopt both physical and digital infrastructure improvements.

Why: Without Complete Streets pedestrians, including wheelchair users, may be forced to travel in the street with cars, increasing safety risks and contributing to loss of life and

[45] To increase mobility for all users (including paratransit and transit riders), datasets should incorporate signs, sidewalk surface conditions, fixed obstructions, curb management solutions, and other relevant features.

serious injury.[46] Real-time sidewalk condition, curb cut, and pedestrian signal data could be used to increase safety, improve global navigation satellite system (GNSS) maps for pedestrians, and identify high-need snow clearance, repair, and installation areas. Digital map layers can provide insights as to what is happening on a given street to make needed investments and provide situational awareness to road users that augments physical improvements.

Risks: As with any given solution, the remedy must meet the problem and be evaluated based on the expected benefits, costs and return on investment, and other factors. AI can provide a critical redundant safety layer and many communities across the United States have not yet implemented basic infrastructure improvements due to cost. Some technologies in Complete Streets systems may incentivize the collection of large amounts of personal data which could then be mis-used or used in ways that are unexpected and diminish trust in the transportation ecosystem.

Benefits: AI can help improve safety for people on foot, in wheelchairs, and on bicycles by augmenting, processing, and fusing datasets, analyzing data to provide actionable insights, and enabling intersection safety features. For example, transportation agencies can use traffic signal systems that detect pedestrians in real-time and dynamically adjust signal timing to provide adequate crossing time. Transportation agencies can also use AI tools to identify and analyze patterns with respect to areas of particular concern for the safety of vulnerable road users.

4.5.4.3 Construction Management

Optimizing the design of construction sites, identifying safety concerns, and optimizing execution of the build process.

USDOT Action: Development of tools and processes that can enhance the management of site conditions, assist in more effective use of construction sites (by improving safety and reducing cost/schedule), and improve safety for work crews. Tools are needed that introduce variances in weather and geographic conditions as these both significantly impact the construction process. USDOT should provide training and provide financial incentives to embrace using new AI-based technology.

Why: AI, generative AI, in particular, can detect patterns that humans cannot and offers potential solutions humans would not have considered. AI also excels at merging multiple complex datasets as is needed in planning and modeling. This AI offers an opportunity to optimize the construction process and sequence, reducing cost and saving time. Digital twins for instance can be used for simulation before construction begins.

Risks: Acceptance of this technology might be difficult (e.g., aging workforce and institutional history). Different stakeholders have differing needs so developing tools to meet all the needs could be a challenge. The adoption of technology could be at odds with insurance

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[46] The fatality rate for pedestrians using wheelchairs is 36 percent higher than for the general pedestrian population. See John D. Kraemer and Connor S. Benton, Disparities in Road Crash Mortality Among Pedestrians Using Wheelchairs in the USA: Results of a Capture–Recapture Analysis, BMJ Open (2015), https://bmjopen.bmj.com/content/bmjopen/5/11/e008396.full.pdf

solutions that typically don't encourage updating to new processes (because these provide unknowns). Automation bias or over-reliance on AI solutions could put construction workers at risk by lowering their awareness to hazards.

Benefits: Using AI tools to proactively manage a construction site may reduce schedule/costs as well as providing better environments for work crews and the traveling public.

4.5.4.4 Asset Management

Addressing the strategic and systematic processes of operating, maintaining, and improving physical assets.

USDOT Action: Provide technical assistance to local agencies who are looking to procure AI tools for asset management. Include AI for asset management as a priority under ARPA-I and other research efforts.

Why: Infrastructure and fleet maintenance are critical to ensuring road user safety and preventing potential crashes and fatalities. AI can be combined with sensors, drones, and other tools for predictive maintenance of infrastructure (bridges, roads, etc.) to monitor stress, wear and degradation, and alert agencies before a catastrophic event. Having this information allows agencies to prioritize resources where they are needed most.

Risks: AI systems that support infrastructure and fleet maintenance have some of the same general risks as any other system that relies on artificial intelligence, including risks around cybersecurity and privacy.

Benefits: Using AI, transportation agencies can predict maintenance needs proactively for infrastructure assets and fleets and reduce maintenance costs. AI tools can help agencies identify structural issues in bridges and roads early on and monitor for further wear-and-tear. AI tools can also be used to reduce the burden of guardrail inspections and for compliance with MUTCD requirements. New applications use computer vision AI, virtual reality tools, and drones to collect images and videos of roads and bridges, which may also be used to improve training for repair and upkeep.

4.5.4.5 Transportation Systems Management and Operations (TSMO)

Improving traffic flow, detecting and coordinating the emergency response to incidents, enhancing road safety, especially for pedestrians, bicyclists, motorcyclists, and other vulnerable road users (VRUs).

USDOT Action: Encourage AI-based Decision Support Systems (DSS) that leverages regional level data from multiple sources to make operational and planning recommendations based on real-world use cases to improve overall safety. Applications can include traffic signal management, roadway safety, performance analysis of projects, environmental impact, and modeling. Encourage procurement solutions that demonstrate cost savings and operational improvements.

Why: Agencies can optimize traffic flow and reduce the risk of road accidents, improve response times of emergency services, and improve crash clearance time and safety enhancements through AI integrated into real-time transportation management systems. AI can be used to improve the operations and retiming of traffic signals resulting in improved operations and cost savings. Integrating traffic control devices across agencies is facilitated by AI-based systems and provides an overall improved transportation experience.

Risks: State and local departments of transportation (DOTs) are not necessarily well versed the procurement of complex software systems. As available data expands exponentially, new techniques for data management must be used, and yet differentiating solutions can be difficult for a traditional state or local DOT workforce. Current procurement rules are not designed to procure software or technology products that require ongoing services such as licenses, cloud services, data integrity updates and cybersecurity updates. USDOT should evaluate how to reform procurement to support evolving technology. As available data expands exponentially and software as a service becomes more commonplace, new techniques for procuring these types of ongoing services should be explored. Outcomes-based procurement is currently not supported in all states, which complicates efforts to obtain new tools. Increased education for public agency staff involved in procurement of technology is essential.

Benefits: Decisions rooted in field-generated data (as opposed to theoretical models) will greatly impact transportation users. Leveraging data from multiple infrastructure owners/operators will provide insights not currently available.

4.5.4.6 Demand Management

Planning routes, reducing congestion, facilitating TSMO, and managing supply chains.

USDOT Action: Develop programs that encourage using a wide variety of data (e.g., signals, parking, transit, incidents, traffic flow) across regions (to include crossing state lines) providing proactive control to transportation systems to more effectively move people and goods around congestion and encourage mode swapping to reduce transportation time.

Why: AI can leverage multiple data sets (e.g., traffic management systems, connected vehicles, sensors, crowd-sourced, etc.) to determine optimal routing based on the stated goal(s)—safety, sustainability, etc. Timing patterns and recommendations for traffic control devices such as signals and variable speed limit signs can be optimized through the use of AI applications to real-time traffic conditions. AI tools can help address the challenge of scaling transportation systems across larger geographical environments.

Risks: Transportation users are creatures of habit and tend to want to follow known pathways and dynamic changes between transportation modes will be a change for many people. Automated determination of traffic flows may lack critical consideration for discrimination against certain demographics (e.g., low-income neighborhoods).

Benefits: More productive use of existing infrastructure assets and existing capacity balanced across the needs of users to align with common outcomes of improved safety, reduced congestion and emissions, while getting more value out of existing investments.

4.5.5 Transit Systems

4.5.5.1 System Improvements

Planning routes and timetables; improving bus, microtransit, and paratransit services; identifying available accessible service and needs; facilitating platooning to improve bus rapid transit, precision docking, and transit signal prioritization; and improving traffic safety, especially for pedestrians, bicyclists, motorcyclists, and other vulnerable road users (VRUs).

USDOT Action: Develop case studies and guidance for the use of AI in system improvements that provide equitable access to transit. Provide technical assistance to communities and other users and develop equity measures. Encourage agencies to engage directly with riders, especially those in the most underserved communities, and prioritize their input and needs along with data gained from multiple sources. Include recommendations that any alternative services are accessible to all passengers including wheelchair users.

Why: Improvements are needed to increase mobility for all users; AI can be used to better plan and optimize transit services more frequently and nimbly, and in a way that prioritizes rider access and workforce needs while addressing system costs. For many, public transportation may be their only source of mobility, but too often is unavailable or infrequent and very inconvenient. For example, when paratransit provides shared rides, passengers often have to wait hours to get to their destination. They may also experience long wait times for pick-up and departure.

Risks: Using AI, agencies might make certain changes that are not in the best interest of the riders, including replacing accessible transit with options that are not accessible. For example, relying on data produced from smartphones can lead to underrepresentation of riders who don't use smartphones. Automated determination of planning use cases may lack critical consideration for discrimination against certain demographics or, for example, low-income neighborhoods.

Benefits: System improvements could lead to reduced travel times, increased ridership and revenues, greater access to mobility, a higher-quality customer experience, a better integrated multimodal journey, paratransit cross jurisdictional services, stops on paratransit rides such as to a pharmacy, an energy-efficient mix of fixed route and on-demand transportation, and improved safety and accessibility for bus riders who rely on accessible transit stops. Transit providers could utilize AI to provide information on the availability of wheelchair accessible vehicles (WAVs), and better track the number of requests, denials, wait times, and common routes to identify how many WAVs are needed and where.

4.5.5.2 Safety and Accessibility

Facilitating safe onboarding and alighting, wayfinding, and the safer and more sustainable operation of buses and shuttles.

USDOT Action: Consider whether and how AI standards can ensure equity in data sets and scenarios in the FMVSS or FTA Bus Testing Program, or other modal standards. Include the US Access Board, disability, and other transit rider communities in discussions and convenings regarding transit adoption of AI, including in FTA Strategic Transit Automation

Research Plan projects. Provide guidance and Technical Assistance (TA) to entities on compliance with the Americans with Disabilities Act (ADA) and other civil rights laws for AI use in transit, on plans for emergencies when the AI system is not available, and with respect to passengers who do not use a smartphone.

Why: Barriers to safe, accessible transportation include entering and exiting a bus or shuttle due to inaccessible bus stops or curbs, snow, and dangerous gaps between a rail car and the platform, as well as wayfinding or confusing directions within transit facilities or to a next transit stop or a destination. Technology will likely make jobs easier to perform which would reduce the workload on transit operators.

Risks: ADA noncompliance and lack of an attendant to assist with onboarding and alighting, wheelchair securement, fare payment or other assistance for all riders including people with sensory, physical, or developmental disabilities. Inequitable data sets that underrepresent groups based on race, gender, or disability could result in missed automated braking events for certain populations (e.g., wheelchair users) or inequitable scheduling/offering of transit vehicles. Liability and overreliance on AI can lead to fewer staff available for riders in call centers.

Benefits: AI could be used to provide real-time transit and paratransit vehicle information, including arrival, departure, and upcoming stops for riders with sensory and cognitive disabilities. AI might also provide improved in-vehicle communication to riders with sensory and cognitive disabilities. Transit vehicles including rail, fixed route buses, shuttles and on demand vehicles without drivers could allow on board attendants to focus on customer service and other non-driving tasks in service to riders. Onboard attendants are especially important for some paratransit and transit riders who are otherwise isolated in their daily lives and rely on the relationships they develop, and time spent with transit staff.

4.5.5.3 Paratransit and Fare Eligibility

Optimizing resources by supporting eligibility determinations.

USDOT Action: Provide guidance and consider standards on the need for transparency of data sets and scenarios and the use of AI in any paratransit or fare eligibility process. Riders must be made aware of AI's use, and plain language must be used.

Why: Some transit agencies are using generative AI to streamline the application process for paratransit eligibility required under the ADA. Agencies may use AI for eligibility processes to develop more productive workflows, digitize paperwork, detect fraud, cut down on staff time for assessments or intake or replace staff altogether. Algorithmic bias has been shown to be prevalent when applied to benefit programs leading to denial of critical access to housing, healthcare, child welfare and other services based on race, disability, delivery of other services, past denials, or convictions.

Risks: Inequity, lack of accountability for denial appeals, fewer staff available for riders who may still need to submit their application over the phone or in person. Inaccessibility of mobile or web-based apps leading to missed updates and notices sent to applicants.

Benefits: Streamlined process with faster response times for initial applications, eligibility renewal and appeals. Reduced paperwork for medical professionals submitting verifications.

4.5.5.4 Operations Support

Enhancing paratransit efficacy.

USDOT Action: USDOT should engage disability, civil rights and transit rider communities in addition to transit and AI industry stakeholders on the use of AI to improve operations support, including: the safety of facilities; fare capping; predictive maintenance for vehicles, tracks, elevators, escalators, lifts, and transit facilities; predicting impacts of the AI on the electric grid; automated bus lane enforcement; and use of surveillance for transit station and vehicle safety.

Why: Maintenance of vehicles, track and facility, and features such as elevators are costly. Preventive maintenance can save time and money and increase access for transit riders. Elevator and escalator outages can create barriers to service.

Risks: Safety and privacy concerns regarding use of surveillance technologies that disproportionately impacts people of color and disabled travelers. Accuracy of outputs will be critical to ensure required maintenance as well as health and safety risks are identified appropriately.

Benefits: AI can provide real-time information on elevator and escalator outages, critical infrastructure for disabled passengers. Passengers could be alerted in real-time so that they have time to find alternative transportation or routes if possible.

4.5.6 Taxis and Rideshare

4.5.6.1 Operations

Encouraging equity in operations.

USDOT Action: Assess impact of and encourage the development of best practices for routing, passenger and driver scoring, and other operational aspects to ensure overall approaches that balance risk mitigation, equitable access, and integration with other travel modes.

Why: Taxi and rideshare services use AI for routing optimization and navigation support. In each case routes are optimized to best meet some codified policy (e.g., minimum time, distance, population served).

Risks: Routing decisions can disproportionately affect specific populations (e.g., bias against a select passenger profile type) and lead to unjust distribution of trips. Systems may create overreliance on AI routing at the expense of routing skills of human operators, requiring drivers to take routes which are not ideal in real-world conditions and potentially increase congestion or environmental impact.

Benefits: Improved operational effectiveness of the transportation system, minimizing costs, reducing environmental impact, reducing time in transportation, ensuring equitable options, and improving safety.

4.5.7 Freight (Trains and Trucks)

4.5.7.1 Safety and Fraud Detection

Improving safety and reducing losses.

USDOT Action: Increase monitoring of the use of transaction data for safety and fraud detection. Evaluate approaches in which federal involvement (e.g., data exchange) can enhance safety, reporting, and coordination of fraudulent activity with law enforcement.

Why: AI models, specifically Large Language Models (LLMs), can sift through transactions to identify underlying characteristics that could lead to potential crashes. FMCSA could be doing this now. Also, LLMs are being used by shippers and brokers to detect fraud in brokers and carriers.

Risks: Safety and fraud detection systems require access to and processing of vast amounts of transaction data. Algorithmic biases and data security may pose a national security risk. These systems also require access to and processing of personal data, presenting a risk to personal privacy.

Benefits: Proactive efforts to leverage transaction data can improve safety, decrease fraud, and protect national interests.

4.5.8 Other Applications

4.5.8.1 Routing Optimization

Improving productivity of passenger and freight services.

USDOT Action: Support research on tools that determine routes, timing, and travel speed to encourage overall approaches that balance mitigating risks with saving users or providers time or money.

Why: Individuals use AI for navigation support, and shippers and carriers use AI to develop multi-stop milk runs and point-to-point vehicle tours. In each case routes are optimized to best meet some codified policy (e.g., minimum time, distance, etc.). This may also include decisions about timing (e.g., just-in-time delivery) and travel speed.

Risks: Routing decisions can disproportionately affect specific populations and lead to unjust distribution of trips or goods. Systems may create overreliance on AI routing at the expense of routing skills of human operators, requiring drivers to take routes which are not ideal in real world conditions.

Benefits: Improved productivity of the transportation system, minimizing costs, reducing environmental impact, reducing time to destination or delivery, and improving safety.

4.5.8.2 Predictive Maintenance

Anticipating and recognizing maintenance needs.

USDOT Action: Encourage the use of AI tools for predictive maintenance through competitive grant programs (including FTA for transit fleets). Include AI for predictive maintenance as priorities under ARPA-I and other research efforts. Provide technical assistance for agencies looking to procure and use software-enabled tools for maintenance purposes.

Why: AI can be used to identify maintenance issues in both vehicles and fleets, as well as our nation's infrastructure. With machine learning capabilities and digital twinning technology, we can now identify and predict vehicle and fleet maintenance with precision, improving not only vehicle performance but also maintenance operations and costs. Agencies are currently predicting public bus fleet breakdowns and maintenance needs early using AI, resulting in increased productivity and lowered strain on resources.

Risks: AI systems that support infrastructure and fleet maintenance have some of the same general risks as any other system that relies on artificial intelligence, including risks around cybersecurity and privacy. Data quality and availability are also issues for using AI for predictive maintenance. AI depends on the quality and accuracy of the data it is trained on, and it will only produce an analysis according to that data.

Benefits: AI systems can analyze data from maintenance records, sensors, and telematics to predict potential equipment failures and optimize maintenance schedules. When fleets and personal vehicles are better maintained, there is greater safety and cost-effectiveness on the road. Additionally, public fleet operators may see lowered costs and more effective use of resources—allowing workers to spend more time on higher priority, safety-critical projects.

4.5.8.3 Chatbots and Document Processing

Improving administrative flows and functions.

USDOT Action: Increased monitoring of chatbots and associated document processing systems to ensure a balance between risk and benefits.

Why: Like other firms, freight transportation firms deploy innovative chatbots to handle customer inquiries, track shipments, and provide updates, pursuing provider productivity or enhancing customer service without human intervention. They are also being used to automate the processing of invoices, bills of lading, and other documents using Natural Language Processing (NLP) capabilities.

Risks: Automated processes leveraging NLP and LLMs have been shown to hallucinate and overlook critical context. Such hallucinations and other unknown effects of model bias may lack the robustness and repeatability of more deterministic data systems, creating unintended harms and system vulnerabilities, including documentation of regulated processes. Users of chatbots may also unwittingly input sensitive personal information or trade information that could compromise privacy, cybersecurity, or transportation security.

Benefits: The flexibility and robustness of chatbots and voice-enabled technologies can lead to better system performance (e.g., increased speed and reduced cost).

5 Automated Driving

5.1 Table of Contents

5.2 Preface

5.2.1 Overview

This Automated Driving chapter of TTAC's report has three primary sections:

- The **Data** section advises USDOT to take specific steps to facilitate appropriate and effective collection, protection, analysis, and dissemination of data related to automated driving systems (ADS).
- The **First Responders** section advises USDOT to work with stakeholders, including local officials with on-the-ground experience, to develop a workplan for facilitating safe interactions between first responders and ADS-enabled vehicles.
- The **Workforce** section advises USDOT to build a comprehensive transportation workforce development initiative on a foundation of stakeholder engagement, focused and timely research, regulatory coordination, and interagency cooperation.

5.2.2 Defining Automated Driving

Automated driving is when a combination of sensors, computing hardware, software, and actuators performs the entire dynamic driving task (DDT)—including steering, braking, accelerating, signaling, and paying attention—*so that a human does not need to do so*. This combination of hardware and software is called an automated driving system (ADS).[47]

If a human user needs to pay attention to the road, then they are not using an ADS. They might instead be using an advanced driver assistance system (ADAS). An ADAS might also steer, brake, accelerate, signal, and pay attention—but it relies on a human driver who is also paying attention. For this reason, an ADAS is not an ADS.

[47] SAE International, SAE J3016, Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (2021), https://www.sae.org/standards/content/j3016_202104. USDOT has long used SAE J3016's definitions. See USDOT Automated Vehicles Activities, https://www.transportation.gov/AV (including plans released in 2021, 2020, 2018, 2017, and 2016).

As its name indicates, this chapter focuses on automated driving. Nonetheless, the text occasionally refers to driver assistance systems when they are relevant to the discussion. Both ADAS and ADS can together be referred to as "driving automation systems."[48]

Automated driving potentially encompasses a wide range of technologies, applications, and business cases. For example, a vehicle capable of automated operation *may or may not*:

- Be designed for all roads, communities, and travel conditions;
- Be capable of automated operation for an entire trip;
- Include a traditional steering wheel, throttle, and brake pedal;
- Need a human who can resume driving when requested to do so; need this human to be physically present in the vehicle; or rely on a human located far from the vehicle to provide instructions and information;
- Use specific sensor technologies, including camera, radar, lidar, sonar, inertial motion, and GNSS;
- Use highly detailed maps that are created in advance;
- Communicate electronically with other vehicles and/or with roadway infrastructure;
- Be originally manufactured as an automated vehicle; be retrofitted by a developer other than the vehicle manufacturer; or be modified by third parties without the involvement of that developer;
- Be sold to individual consumers; or be deployed as part of a fleet;
- Carry passengers, deliver goods, provide services, or perform novel functions;

and so on.[49]

5.2.3 Scope of Work

The Secretary of Transportation gave the Committee a long list of tasks and questions related to automated driving. To ensure it could provide substantive recommendations in 2024, the Committee triaged this list to focus on ADS-related data needs, ADS interactions with first responders, and ADS implications for the workforce.

For future reference, this section includes USDOT's initial instructions in their entirety. The first part relates to "state and local ADS deployment policy needs," and the second part relates to "anticipating and addressing workforce impacts of ADS." These instructions follow:

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[48] SAE International, SAE J3016, Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (2021), https://www.sae.org/standards/content/j3016_202104

[49] This list was adapted (with slight modifications) from Uniform Law Commission, Uniform Automated Operation of Vehicles Act (2019) (Prefatory Note), https://www.uniformlaws.org/viewdocument/final-act-29 (citing Bryant Walker Smith, How Governments Can Promote Automated Driving (2017), https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=1411&context=nmlr).

State and Local Automated Driving System (ADS) Deployment Policy Needs: *Provide recommendations to the Department on how USDOT can further support state and local governments as ADS transitions from testing to deployment. Key tasks:*

1. *Develop a prioritized list of opportunities for how USDOT can further support state and local governments as ADS transitions from testing to deployment. Additional questions/issues to consider:*
    a. *Are there needs for new research, guidance or stakeholder engagement?*
    b. *What processes or best practices/recommendations should USDOT consider, including for: data gathering, record keeping, tracking, and reporting; and permitting ADS testing and operations? What approaches at the state/local level, or internationally, have been successful?*
    c. *How are needs different based on land use/built environment and agency size/resources?*
2. *Identify and provide recommendations on data and information-sharing arrangements that can be used to understand and manage the deployment of ADS-equipped vehicles operating in mixed traffic. Additional questions/issues to consider:*
    a. *What are the specific data and metrics? Are these defined in existing standards or elsewhere? Are they currently collected by any actors, or are new data collections needed?*
    b. *How can data sharing balance the information needs of the public sector vs. competitive concerns of the private sector?*
    c. *What does a mutual sharing environment look like?*
    d. *What successful models exist in adjacent domains?*
    e. *Where are the risks (e.g., privacy, proprietary considerations) and what oversight is needed (e.g., different levels of certification to access data at various levels of aggregation)?*
    f. *Are there new tools and technologies to improve data collection or data sharing?*
    g. *Are frameworks needed to support key decisions with respect to data collection and sharing (e.g., identifying user inputs, calculations and background data)?*
    h. *What key performance indicators (KPIs) can be used to measure the safety, security, equity, accessibility, and sustainability of a given automated driving deployment?*

Anticipating and Addressing Workforce Impacts of ADS: *Provide recommendations to the Department on steps it can take and the role it can play to anticipate and support the transportation workforce for potential disruptions from the expanded* *deployment of driving automation broadly, and ADS specifically, including steps that USDOT can take in partnership with Federal partners. Key tasks:*

1. *Identify the impact of driving automation on:*
   a. *Job quality and functions that may be significantly altered or eliminated;*
   b. *The skills and training needs of the existing workforce; and*
   c. *Current conditions with respect to recruiting drivers in the near-term.*
2. *What can USDOT do, in partnership with Federal partners, to prepare the transportation workforce of the future?*
3. *Additional questions/issues to consider:*
   a. *When is the right time to begin developing future workforce training for operating and maintaining new technologies? How stable and mature should those technologies be?*
   b. *How might workforce needs change over time as new technologies are adopted?*
   c. *How might impacts differ by geography (e.g., urban vs. suburban vs. rural)?*
   d. *How should USDOT appropriately consider job displacement and other labor impacts when making decisions about new transportation technologies?*
   e. *What should USDOT do to promote good quality jobs as new transportation modes and technologies emerge?*
   f. *What should USDOT do to help manage risks and uncertainty?*

5.3 Automated Driving and Data

5.3.1 Background Points

5.3.1.1 ADS Safety Expectations

Industry and government have set high expectations for the safety of ADS driving. Some ADS testing and deployment appears to show high levels of driving competency and safety, but the range of ADS safety performance across the industry is neither well established nor uniform. Therefore, it is not currently possible to generalize from any specific existing deployment to represent the performance of the entire industry.

5.3.1.2 Quantity and Breadth of Public ADS Data

Historically, USDOT has relied heavily on nationwide datasets of police-reported crashes to inform its rulemaking, enforcement, and other regulatory actions. These datasets, which are the foundation for independent safety research efforts, are based on very high volumes of both crashes in numerators and driving (Vehicle Miles Traveled (VMT) or Exposure) in denominators. ADS are in the early stages of deployment and have driven a minuscule fraction of the miles that support many USDOT and other public agency judgments. ADS driving to date has occurred in limited markets, with limited vehicle types and under conditions that are not necessarily representative of national or even statewide road networks in terms of road types, traffic conditions, time of day, weather, and other factors that may affect safety outcomes.

5.3.2 Problem Statements

5.3.2.1 Federal Collaboration to Support State and Local Agencies (P1)

Automated driving may affect virtually every component of the national road transportation system, and it thus calls for analysis and/or action by myriad state and local agencies as well as the USDOT. These agencies include, for example, regulators who have permitting authority over automated driving, researchers who study safety outcomes, engineers who design roads, and public safety officials who interact with vehicle occupants and other road users. Requirements for ADS operations on public roads have been developed and adopted by some state and local governments, but there is no national consensus about how to define a clear set of minimum ADS performance expectations that can be systematically measured and enforced. Further, USDOT has no explicit workplan to collaborate with state and local agencies to support development of consistent expectations and/or measurement approaches that would inform identification of data needs.

5.3.2.2 New Analysis Methods (P2)

The impacts of ADS on the transportation system cannot be evaluated with high dependability using existing analysis methods that were developed based on assumptions of human drivers performing the dynamic driving task. Stakeholders representing diverse interests are likely to have diverse perspectives about the most appropriate new analysis methods and/or new combinations of existing methods to apply to support consistent regulatory decisions and outreach to the public.

5.3.2.3 Existing Human Driving Data (P3)

The data that are currently collected and reported about the road transportation system (based on human drivers performing the dynamic driving task (DDT) in a wide variety of vehicles) are not well suited for direct comparisons with the performance of ADS nor for supporting predictions of transportation system performance when substantial fractions of the vehicles will be driven by ADS. For example, the existing human driving VMT data are generally too highly aggregated to provide a basis for comparisons with ADS that currently operate in a narrower range of conditions in vehicles of the latest model.

5.3.2.4 ADS Data Collection (P4)

In order to support publicly accessible analyses of the positive and negative transportation system impacts of ADS operations in real-world traffic conditions, additional collection of publicly accessible data about ADS operations will be needed. Analyses of such data will be needed to support regulatory decisions by public agencies and to inform the general public.

5.3.2.5 Personal Privacy Protections (P5)

ADS may enable companies to generate, collect, and process data about individuals in a way that may implicate personal privacy interests. Regulators and law enforcement may request or require companies to disclose these data in a way that may implicate personal privacy interests. It is important to define the appropriate levels of protection of data that are reported to regulatory agencies, researchers, and the general public to balance the needs of all relevant stakeholders.

5.3.2.6 Intellectual Property Protections (P6)

Regulators and law enforcement may request or require companies to disclose data that may implicate intellectual property interests. It is important to define the appropriate levels of protection of data that are reported by companies to regulatory agencies, researchers, and the general public to balance the needs of all relevant stakeholders.

5.3.2.7 Burdens Associated with ADS Data (P7)

Data collection, reporting, and analysis to produce measures of performance are complicated and resource-intensive processes. These processes need to be appropriately simple, practicable, and affordable, while ensuring quality, objectivity and utility. Deliberate efforts are needed to minimize potential duplications of effort among public agencies who are seeking data and by ADS developers and fleet operators who are reporting data.

5.3.2.8 Government Resources for Data Analysis (P8)

USDOT and state and local agencies need additional staffing, skills, technology, and funding to facilitate thorough and timely analyses of data.

5.3.2.9 Ensuring Retention and Integrity of Data (P9)

Reliable and trustworthy data are essential for AV performance evaluation, defect investigations, and crash investigations. Those data are generated, processed, stored, and extracted by private-sector entities that may have different data needs from public-sector entities. At the same time, ADS generate a tremendous amount of data, all of which cannot and likely should not be stored. As of now, there are no detailed guidelines about what data are necessary to be retained to support the absence of unreasonable risk. Over time, the development of FMVSS and other regulations that directly address automation capabilities can help distinguish what data should and should not be retained.

5.3.3 Recommendations

5.3.3.1 Early Learning

To address problems P1, P2, and P4.

USDOT should facilitate consistent and comprehensive documentation of the impacts of early ADS deployments on the transportation system, using data from both industry and government sources, as well as public feedback. USDOT should facilitate sharing of data, analysis and lessons learned by all stakeholders to provide a foundation for development of best practices, standards, and regulations. This information should include a combination of quantitative measured data (recognizing the limitations of small sample sizes), case study evaluations of successful ADS deployments and particular incidents, and qualitative experiential data from people and agencies that have interacted with the ADS on public roads.

5.3.3.2 Public Agency Training and Professional Capacity Building

To address problem P1.

USDOT should support training and professional capacity building for state and local agency regulators so that they can more effectively perform their regulatory functions for ADS.

5.3.3.3 Technical Assistance for State and Local Agencies

To address problems P1 and P8.

USDOT should establish an assistance program for state and local government agencies to help them understand the currently available ADS performance assessment findings and how to interpret the applicability of those findings to their specific local circumstances; and to assist them in assessing potential local ADS deployments.

5.3.3.4 State and Local Stakeholder Participation

To address problems P1, P4, P7, and P8.

USDOT should allocate resources to convene stakeholders and support state and local stakeholder participation in definition of the analytical approaches and ADS data collection that will be necessary to effectively support them. (The efforts to develop the analysis and data collection requirements are covered below in *Analysis Methods Development (5.3.3.5), ADS Impact Research and Analysis (5.3.3.6),* and *ADS Data Collection and Dissemination (5.3.3.7).*) USDOT should reach beyond state and local permitting authorities to include a wider range of stakeholder organizations representing consumers, traffic engineers, safety analysts, environmental analysts, and others to identify data collection needs. These resources should focus on early learning based on the operating conditions encountered in early deployments (urban roads and interstate freeways).

5.3.3.5 Analysis Methods Development

To address problems P3, P4, and P7.

Given the current lack of consensus on the most appropriate analysis methods to apply to ADS impact assessments, the early analyses should devote significant attention and resources to the selection of methods and/or development of new methods. In order to promote impartiality, independence, and public credibility of the analyses, USDOT should ensure that these projects are advised in a timely manner, such as by expert panels or working groups representing a diverse range of stakeholders and perspectives, including local and state public agencies, transportation interest groups, labor organizations representing transportation workers, researchers, consumers, and the ADS industry.

5.3.3.6 ADS Impact Research and Analysis

To address problem P4.

USDOT should fund and conduct comprehensive analyses and research studies, including by independent expert organizations, with the goal of producing transparent, valid, and fair analysis results describing the transportation system impacts of ADS deployments, to guide future policy development, such as:

1. Assessing the early deployment use cases of urban ride-hailing, local package delivery, and long-haul trucking;
2. Ensuring that ADS assessments are based on valid comparisons with conventional operations under comparable conditions;
3. Assessing broader system-level safety impacts of ADS deployment, including:
    a. The potential for shifts in mode use patterns relative to other transportation modes (e.g., human-driven private personal vehicles and trucks, short-haul commercial aviation, public bus and rail transit, and active modes such as walking and cycling);
    b. Potential changes in the population of human drivers;
    c. Behavioral changes of other road users;
    d. Possible changes to VMT affecting exposure; and
    e. Differential safety impacts on different populations (e.g., based on age, gender, race, disability status, rural/urban and/or socio-economic status).

5.3.3.7 ADS Data Collection and Dissemination

To address problems P4, P8, and P9.

DOT should provide financial and technical support for collection and dissemination of data, according to the principles defined below in *Data Collection, Analysis and Dissemination Principles (5.3.3.10)*, to represent the full breadth of impacts of ADS on the transportation system, addressing topics such as:

1. Transportation system energy use, congestion, satisfaction of travel needs, goods movement, etc.;
2. Equity and disability access;
3. Modal shifts;
4. Community and neighborhood livability;
5. Environmental and health impacts (GHG production, criteria emissions, noise, etc.); and
6. New opportunities to use ADS data collection to provide more comprehensive baseline information about the operation of the transportation system.

5.3.3.8 Baseline Data Collection

To address problem P3.

USDOT should collect and report baseline (human-driven) transportation system performance data at more disaggregated levels (e.g., county level, class of roadway and class of vehicle) so that they can support direct comparisons with targeted ADS deployments. Crash data collection should be improved to be more consistent across states and more accurate and complete, especially with respect to data about crashes involving vulnerable road users. This could be achieved by more robust training on incident reporting and improvement of state crash data reporting systems.

5.3.3.9 Seeking Applicable Lessons from Other Modes

To address problem P2.

USDOT should expand on existing cross-modal coordination activities to maximize the opportunities to learn from other transportation modes that have much better safety records than light duty motor vehicle travel (such as commercial aviation and public transit) when considering ADS safety. Tools and analyses that have been used to improve the safety of commercial aviation, public transit, commercial trucking, and other modes, especially through data and information sharing, may offer useful insights for developing methods for improving the safety of ADS operations. TTAC encourages USDOT to fully leverage its existing cross-modal initiatives to identify applicable lessons that could inform work on ADS.

5.3.3.10 Data Collection, Analysis and Dissemination Principles

To address problems P3, P4, P5, P6, P7, and P9.

USDOT should reexamine historic data collection and disclosure practices developed in the context of human drivers to update them as needed to fulfill the principles below for automated driving. The behavior of vehicles in the pre-existing transportation modes has been based on human operator performance capabilities and limitations, but driving automation systems introduce a new element with software determining that behavior. State and local agencies and the general public need access to data to be able to understand what effects that transition from human to software behavior has on the road transportation system.

1. **Appropriate to support analyses defined above in *Analysis Methods Development (5.3.3.5)* and *ADS Impact Research and Analysis (5.3.3.6)*:** Ensure that data on ADS testing and public operations are of an adequate level of detail to support (i.e., provide input to) and independently conduct and verify analyses of positive and potential negative ADS impacts with respect to safety, climate, transportation network, equity, and disability access goals, and should allow key stakeholders and the general public to draw informed conclusions about ADS safety and performance.
2. **Privacy:** Appropriately address the personal privacy of passengers, other road users, and residents.
3. **Advancing innovation:** Protect ADS developer trade secrets and intellectual property in order to encourage innovation.
4. **Burden:** Minimize burden and cost on industry and government agencies while achieving the intended purpose.
5. **Useful:** The data should be useful. The need for the data should be clear and defensible and tailored to meet clearly stated objectives, with clear protections for confidentiality when appropriate.

6. **Consistent and unambiguous:** Public agencies, in consultation with experts and industry, should define the data reporting requirements precisely, unambiguously, and comprehensively to ensure that all reporting is done consistently across all reporting entities.

5.3.3.11 Data Dissemination

To address problems P5 and P6.

USDOT should create more easily accessible platforms for stakeholders, including the public, to access comprehensive transportation system and ADS performance data (for example, by providing more user-friendly interfaces for people to use to access the data).

5.3.3.12 Accelerating NHTSA Information Sharing

The Office of the Secretary of Transportation (OST) should work with NHTSA, FMCSA, FHWA, FTA, and other operating administrations that conduct research related to ADS to identify and remove the impediments to rapid public dissemination of the findings from their research programs and investigations of crashes that involve driving automation systems. ADS technology is changing at such a rapid pace that research findings should be disseminated as quickly as possible, including through pre-publication or other means faster than report publication, to ensure that benefits are gained from the investment of public resources in this work and that the findings can be used by industry and the broader stakeholder community promptly.

NHTSA should seek synergies with other resources that may be available within NHTSA or elsewhere (such as NTSB or other experts) to aid in accelerating progress on its special crash investigations of driving automation systems. It is important that the findings from these investigations be disclosed more promptly so that interested stakeholders can learn the relevant lessons about safety of the affected systems and the implications for other driving automation systems as quickly as possible.

5.3.3.13 Standing General Order

To address problems P4, P5, and P6.

NHTSA established the Standing General Order (SGO) as a way for the agency to gain early insight into potential safety issues involving driving automation systems of Level 2 and above. The SGO reporting requirements for industry self-reporting of crashes provide some insight into ADS and Level 2 ADAS operations. However, TTAC members have raised diverse concerns about the scope of SGO data collection and about public access to key elements of SGO crash data. As such, TTAC recommends that NHTSA continue the SGO and enhance its value by taking the following actions:

1. **Stakeholder input via RFI:** Given that more than three years have passed since the initiation of the SGO, NHTSA should formally seek broad stakeholder input to update, as quickly as possible, the SGO data reporting requirements and public access practices. Such an activity would support NHTSA in engaging all stakeholders (state and local governments, transportation and insurance industries, traffic safety advocates and consumers) in its data collection efforts.

2. **ADS vs. ADAS:** Based on the recognition of the differences between Level 2 ADAS and ADS there is a need to identify the unique data reporting elements and requirements that may be different between Level 2 ADAS and ADS.

3. **Scope of data collection:** NHTSA should evaluate the crash data collected to date under the SGO and confer with the relevant public and private stakeholders regarding whether data reporting elements should be added and/or removed to support well-informed decisionmaking about driving automation system safety. The SGO requires reports for a broader range of ADS-involved crashes than are typically covered by police crash reports; it does not include exposure data (mileage) nor any information about non-crash events. The lack of exposure data makes it impossible to estimate the rate of occurrence of crashes. Exposure data is most valuable for assessing ADS and Level 2 ADAS safety when it is disaggregated, for example, by county and road classification.

4. **Public access to data:** NHTSA should evaluate the process for redacting data elements in crash reports filed under the SGO and solicit stakeholder input in determining whether the public would benefit from fewer redactions. Such an activity would ensure that SGO reports are serving their general safety purpose and that the public has access to the data necessary to understand the safety of ADS and Level 2 ADAS. Location, combined with day/time, is particularly important to support analysis of infrastructure-related crash factors in aggregate or applied to a specific location.

5. **Analysis of SGO data:** NHTSA should help the public to understand the meaning of the SGO crash data by publishing timely summaries and analyses on a routine cadence that provide insights into what the Agency has gleaned from the data collection. Such an activity would support NHTSA in educating the public about ADS and Level 2 ADAS safety and actual real-world performance in the context of the crash statistics for conventional driving.

5.4 Automated Driving and First Responders

5.4.1 Background Points

5.4.1.1 Scope of this Section

This section primarily addresses interactions between:

1. Firefighters, police officers, and other first responders and
2. Fleet-deployed driverless automated vehicles (AVs).

TTAC also recognizes there is a much broader range of safety-critical interactions between public-safety workers generally and AVs generally.

5.4.1.2 Public-Safety Workers

Public-safety workers include not only firefighters and police officers but also other public-safety officials, other emergency medical personnel, traffic control workers, tow operators, road construction workers, crossing guards, and others. These workers may have different training, resources, responsibilities, and authorities. It is important to carefully consider similarities and differences in interactions between AVs and these various workers.

5.4.1.3 Automated Vehicles (AVs)

This section uses the term "driverless" to describe an AV conducting a trip that does not involve a human driver in the vehicle, and it uses the term "fleet-deployed" to describe an AV that is part of a centrally managed fleet. To date, every driverless AV that has interacted with a first responder has been part of such a fleet. In the future, however, a wide variety of AV deployment scenarios are at least conceivable. These could include centralized or individual ownership of the vehicles themselves as well as centralized or individual management of the ADS on those vehicles.

5.4.1.4 Existing Research and Best Practices

Industry and government have long recognized the importance of appropriate interactions between ADS and public-safety workers. Research and best practice efforts have focused on describing the types of scenarios the ADS should be able to handle. These include situations in which public-safety workers:

1. Are serving people who face life-or-death consequences;
2. Are enforcing rules of the road or investigating crimes;
3. Must quickly close roads to reduce the risk to health and safety of the public, to ensure the security of high level public officials and dignitaries, to facilitate special events that support local economic and cultural life, and to respond to natural disasters; and
4. Seek to manage continued flow of traffic on roads where traffic signals are not operational or public infrastructure is damaged.

5.4.1.5 AV Interaction Guides

Research and best practice efforts have also identified information that ADS developers should provide to first responders prior to deployment. Developers often present this information in the form of interaction guides. However, increases in the number of ADS developers and in the number of ADS and AV types could lead to many company- or vehicle-specific interaction guides that vary in both substance and format. By analogy: One organization maintains a directory of 76 different emergency response guides from manufacturers of electric vehicles (EVs) and other alternative-fuel vehicles.[50]

5.4.2 Problem Statements

5.4.2.1 ADS Interference with First Responder Operations

Fleet-operated driverless AVs in early testing and deployment on city streets necessarily involve routine interaction with first responders, and the majority of these interactions have proceeded without incident. These positive interactions can be attributed to cooperation between companies operating these fleets and local first responders in understanding expected driving behavior and in training personnel.

[50] NFPA, Emergency Response Guides, https://www.nfpa.org/education-and-research/emergency-response/emergency-response-guides

Nevertheless, first responders in some early testing and service areas have reported instances in which fleet-operated light-duty driverless AVs operating on city streets interfered with first responder operations. These included reports of driverless AVs:

1. Blocking emergency vehicles traveling with lights and sirens and obstructing their path from a fire station or to an emergency scene;
2. Coming too close to emergency scenes and emergency personnel or intruding into emergency scenes;
3. Driving over loaded hoses and damaging fire suppression equipment;
4. Failing to respond appropriately to cones, hazard tape, flares, and other equipment;
5. Failing to yield to emergency vehicles (including events resulting in collisions);
6. Failing to take direction from public-safety workers on a timely basis;
7. Making repeated efforts to proceed into areas occupied by first responders or temporarily closed to motor vehicle traffic;
8. Making unpredictable maneuvers that require first responders to divert resources and attention from emergency-response duties to preventing or responding to interference by AVs in driverless operation; and
9. Failing to navigate intersections effectively where traffic signals are not functioning properly and making unexpected stops in hazardous locations where a power outage or high cellular demand has slowed communications between driverless AVs and human advisors.

Other road workers, including utility and construction workers and transit operators, have reported similar kinds of fleet-operated driverless AV interference with their work on urban roads, and travelers have reported similar kinds of interference with their use of public roads. Scenarios have been studied and published. However, USDOT does not collect data on most of these incidents, and USDOT has no explicit workplan to collaborate with state and local first responders, other public-safety workers, and industry to support development of expectations for these scenarios.

5.4.2.2 ADS Interactions with Human Traffic Control and Traffic Control Equipment

During active emergency operations, special events, and routine management of congestion, first responders and other public-safety workers use lights and sirens, eye contact, hand signals, cones, batons, caution tape, flares, whistles, and voice commands (among other tools) to maintain a safe perimeter around emergency scenes and to direct traffic. A driverless AV and its support services should be able to interpret those signals and devices, and the vehicle should generally respond as if it were being driven by an attentive unimpaired human driver.[51] While there are standards and training around hand signals for

[51] Although predictability is important, there might nonetheless be situations in which the safest response might differ from that which would be expected from an attentive unimpaired human driver.

directing traffic, their implementation can vary across jurisdictions and even within jurisdictions.

5.4.2.3 *Communication Challenges*

Rapid two-way communication between road users and public-safety workers is essential. First responders and traffic control officials have reported slow and otherwise inadequate communication with driverless AVs. These reports have included incidents in which:

1. Public officials are unable to quickly determine the status of a driverless AV and reliably predict whether it will remain stationary, move, or follow their instructions;
2. Public officials have to stand immediately adjacent to a driverless AV or enter its interior to establish voice communication with a responsible human advisor; and
3. Public officials cannot hear or be heard by a responsible human advisor who can take actions requested by public officials.

SAE adopted an ADS Marker Lamp Standard (J3134),[52] but this document was issued before significant volume of driverless operation on roads. While there are aspects of this broad topic of communication in existing standards and research, there is not clear alignment among key stakeholders on a standardization strategy nor any one organization that is bringing together all of the stakeholders across the variety of ADS operations and different operational design domains.

5.4.2.4 *Resource Constraints and Challenges*

Even if it has immense benefits, automated driving may still impose burdens on public safety officials, including the time and expense required to identify operational issues, train for new systems, and manage inconsistencies across multiple companies or vehicle types.

5.4.3 Recommended Workplan on AV Interactions

TTAC advises USDOT to work with stakeholders to develop a workplan to evaluate efforts to date and to identify research priorities, best practices, industry standards, and regulations to support and ensure effective interactions between driverless AVs and public-safety workers.

The workplan should consider the needs of first responders and other public-safety workers. It should also account for differences between vehicle operations (e.g., passenger, freight), vehicle types (e.g., light, heavy), operational design domains (e.g., urban, highway), and ADS management approaches (e.g., centralized, decentralized).

The workplan should explore:

[52] SAE International, SAE J3134: Automated Driving System (ADS) Marker Lamp (2019), https://www.sae.org/standards/content/j3134_201905/. This topic is also regularly discussed at the Global Forum for Road Traffic Safety and the World Forum for Harmonization of Vehicle Regulations. See, e.g., UN Working Party on Lighting and Light Signalling (2024), https://unece.org/transport/events/wp29gre-working-party-lighting-and-light-signalling-90th-session; UN Global Forum for Road Traffic Safety (2024) https://unece.org/info/Transport/Global-Forum-for-Road-Traffic-Safety/events/386808

1. **Data collection and measurement** of AV interactions with first responders, including comprehension of and timely response to lights, sirens, and human traffic control and operations when public infrastructure or provider communications are damaged or degraded;
2. **Equipment and procedures** necessary for timely and effective communication between AVs and public-safety workers, including:
    a. The ability of first responders and other public-safety workers to immediately assess the operational status of a vehicle (e.g., engaged, disengaged, yielding, ready to go, etc.) from distances relevant to them;
    b. The ability of first responders to distinguish among AVs operated by different entities;
    c. Voice-to-voice two-way communication between first responders and responsible staff who have situational awareness of and ability to direct driverless AVs; and
    d. The ability of an automated-driving company or a driverless AV to:
        i. timely recognize public-safety workers; and
        ii. timely verify that a communication is actually coming from an authorized public-safety worker;
    e. Tools to support geofencing by public agencies to facilitate driverless AV avoidance of emergency scenes and temporary road closures; and
    f. V2X applications and other digital infrastructure that can improve interactions among driverless AVs, first responders, and state/local transportation agencies;
3. **Training and performance standards** for industry staff who have responsibilities related to facilitating interactions between driverless AVs and public-safety workers; and
4. **Ongoing forums** where first responders who are interacting with actual deployments and the developers operating or planning to operate in those jurisdictions routinely discuss challenges encountered by first responders and other public-safety workers so that scenarios are quickly updated to facilitate industry and public agency learning.

As part of these topics, USDOT should consider assessing:

1. How public-safety workers' interactions with automated vehicles compare to their interactions with conventional vehicles operated by human drivers (recognizing that similarities and differences may inform but do not dictate policy outcomes);[53]
2. How lessons learned from managing first responder interactions with electric vehicles (EVs) might inform approaches to managing first responder interactions with AVs;

[53] See, e.g., Bryant Walker Smith, Ethics of Artificial Intelligence in Transportation (2020), https://ssrn.com/abstract=3463827 (discussing expectations for automated driving vis-à-vis expectations for conventional driving).

3. Implications for public-safety workers of policy approaches that seek to identify a responsible, accessible, and responsive entity for every AV or at least for every AV without an adult inside;[54]
4. Issues related to requests by automated-driving companies to first responders (e.g., to respond to a passenger who appears to be unconscious); and
5. Risks and opportunities related to sharing data between automated-driving companies and public-safety agencies (including first responders).

This workplan should be integrated into USDOT's National Roadway Safety Strategy (NRSS) and the Federal Highway Administration (FHWA)'s Strategic Highway Safety Plan (SHSP).

5.5 Automated Driving and the Workforce

5.5.1 Identifying Stakeholders

Problem statement: *In considering workforce and economic impacts of automated driving systems (ADS), the US Department of Transportation (USDOT) may not always be aware of specific equities and expertise.*

Recommendations:

1. As USDOT (including its modal agencies) considers the workforce and economic impacts of ADS, it should prioritize the identification of relevant stakeholders in both formal and informal proceedings. USDOT should be aware that employee representatives, manufacturers, and developers may have specific expertise in transportation sectors and subsectors (such as transit vs. trucking vs. light-duty passenger vehicles and truckload (TL) vs. less-than-truckload (LTL) trucking) and should make efforts to identify and engage these stakeholders as appropriate.
2. Once identified, USDOT should hold sector-specific convenings and listening sessions with these stakeholders to understand the unique impacts on and concerns of each sector.
3. To ensure timely data about impending and ongoing changes in relevant workforces. USDOT should prioritize creating and maintaining early-warning systems and feedback loops that involve these diverse stakeholders, state governments, other federal agencies, and other potential sources of near-real-time workforce information.

[54] See, e.g., Uniform Law Commission, Automated Operation of Vehicles Act (2019), https://www.uniformlaws.org/viewdocument/final-act-29; UK Automated Vehicles Bill (2023), https://www.gov.uk/government/publications/automated-vehicles-bill-2023

5.5.2 USDOT Research and Data Needs

Problem statement: *Substantial research exists and is continuing to be conducted on the impacts of ADS deployment on the transportation workforce.*

Recommendations:

1. USDOT should conduct and share its own research on workforce issues and should actively monitor, analyze, and share external research on workforce issues.
2. USDOT should consider updating its 2021 report on Driving Automation Systems in Long Haul Trucking and Bus Transit: Preliminary Analysis of Potential Workforce Impacts[55] to incorporate specific policy questions that are relevant to stakeholders or that have become relevant since the last publication.
    a. This update may include deeper analyses of: deployment timeframes across different sub-modes (e.g., long haul vs. local delivery); job creation, displacement, retention, and quality, including impacts on wages and equity;[56] changes in manufacturing demands; skills gaps; macroeconomic impacts beyond commercial motor vehicle (CMV) drivers; and other issues as appropriate.
    b. For example, USDOT in conjunction with the US Department of Labor (DOL) might consider whether ADS-relevant jobs are being offshored, whether tasks are being shifted from trained workers to untrained individual users, and whether human employees are being directed to train automated systems that are intended to replace them in whole or in part.
3. USDOT should conduct a gap analysis to determine where it is lacking economic and workforce impact data that may assist the Department in policymaking and should determine the best methods to gather such data, including via stakeholder participation.
4. DOT should conduct an analysis of the resilience of relevant transport systems, including the implications of potential skill or labor loss for evacuations and other emergency situations.

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[55] USDOT, Driving Automation Systems in Long-Haul Trucking and Bus Transit, Preliminary Analysis of Potential Workforce Impacts Report (2021), https://www.transportation.gov/av/workforce/report

[56] Equity should be understood at least as broadly as in the Executive Order on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government (EO 13985), https://www.federalregister.gov/documents/2021/01/25/2021-01753/advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government ("the consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment, such as Black, Latino, and Indigenous and Native American persons, Asian Americans and Pacific Islanders and other persons of color; members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality.").

5.5.3 Existing USDOT Tools

Problem statement: *What tools does USDOT currently possess to address workforce impacts of the deployment of ADS, and how should these tools be deployed?*

Recommendations:

1. USDOT should exercise its authority to create non-statutory preferences in grantmaking—as it does through USDOT Innovation Principles,[57] the Executive Order on Worker Organizing and Empowerment (EO 14025),[58] and other initiatives—to prioritize relevant grant applications that explicitly consider workforce and worker impacts, that expand access to skills, training, and the choice of a union, and that involve the impacted workforce in shaping innovation.
2. For relevant grant programs with potential ADS eligibility, including multimodal programs, USDOT should require applicants to submit workforce data such as Workforce Impact Assessments (WIAs). USDOT should provide additional consideration for applications that demonstrate positive workforce impacts.
3. If USDOT develops specific preferences or requirements for its grantmaking activities, these items should be standardized to the extent possible and clearly communicated to applicants.
4. USDOT and its modal administrations should report on their capacity to address issues of workforce impacts, economic impacts, and worker readiness as new technologies are deployed. Reporting should assess existing staffing and expertise, external capacity building, and whether the Office of the Secretary of Transportation (OST) needs enhanced internal structures (such as new offices or bureaus) to better coordinate workforce efforts across modal agencies.
5. USDOT's Federal Motor Carrier Safety Administration (FMCSA) should examine whether its Entry Level Driver Training Rule requires updated curriculum or training to account for new skills and technical knowledge required for vehicles where the operation involves both an ADS and one or more humans.

5.5.4 Interagency Cooperation

Problem statement: *Relevant authorities and expertise on addressing different elements of workforce and economic impacts are spread among multiple federal agencies as well as within individual agencies.*

Recommendations:

1. USDOT should consider the establishment of a multiagency working group to address workforce needs and impacts associated with the increased deployment of automation

[57] USDOT, Innovation Principles, https://www.transportation.gov/priorities/transformation/us-dot-innovation-principles

[58] Executive Order 14025 on Worker Organizing and Empowerment (April 26, 2021), https://www.federalregister.gov/documents/2021/04/29/2021-09213/worker-organizing-and-empowerment/

technologies and determine how federal agencies can use their respective authorities cooperatively. This task force should include USDOT, DOL, Department of Energy, US Department of Education, US Federal Trade Commission (FTC), Department of Justice (DOJ), and others if deemed appropriate. The task force should consider:

   a. Skills gaps that exist or may exist as ADS technologies are deployed, including consideration for deployment timelines and the needs of entities deploying these technologies.

   b. Changing skills needs associated with ADS technologies—such as skillsets required in vehicle and equipment manufacturing as well as in vehicle maintenance—and how the agencies can leverage existing programs to address these needs. For example, how will traditional vehicle mechanics obtain the skills and support necessary to maintain and repair ADS components?

   c. Strategies for ensuring that opportunities created by reskilling, upskilling, and new occupational needs are developed with consideration for promoting worker organizing and collective bargaining as required by the Executive Order on Worker Organizing and Empowerment (EO 14025) and the USDOT Innovation Principles.

   d. The workforce implications of employee models vs. independent-contractor models.

   e. The workforce implications of closed systems vs. open systems—and especially right-to-repair mandates.

   f. The potential for pinch points, choke points, and emerging monopolies in relevant industries.

   g. The advantages, disadvantages, and potential contours of industrial policy focused on transportation automation.

2. In addition to the working group, USDOT should also consider establishing individual interagency partnerships to leverage specific policy objectives.

   a. USDOT and DOL should consider best practices to provide impacted workers access to Employment and Training Administration (ETA) displacement programs and to advance new DOL Registered Apprenticeship programs where innovative technologies are altering the transportation employment landscape.

   b. USDOT and the US Department of Education should consider engaging on retraining initiatives via higher education.

   c. USDOT and the US Department of Education should consider developing outreach programs to high schools, elementary schools, and vocational schools to educate students on careers in science, technology, engineering, and math (STEM) and other fields as they relate to ADS development, manufacturing, maintenance, and operations.

3. USDOT should also perform an analysis of input data it receives from other agency partners, including DOL's Bureau of Labor Statistics (BLS), to determine if the scope of

data collection, methods of data collection, and frequency of analysis require modification to better inform USDOT policymaking with respect to ADS deployments that potentially impact the workforce.

4. USDOT should also survey and analyze efforts undertaken by state and local governments—including cities, employment and training agencies, state departments of transportation, and others—to understand initiatives, pilot programs, and research being conducted at the subnational level on topics of workforce impacts, skills gaps, and retraining.

5.5.5 Other Technologies

Problem statement: *Technologies other than automated driving systems may also have significant implications for the workforce.*

Recommendations:

1. USDOT should closely consider the ongoing and potential impacts of advanced driver assistance systems (ADAS), vehicle electrification, and other vehicle technologies both in their own right and as case studies to better understand potential implications of and strategies for ADS.
2. USDOT should closely evaluate the potential impacts of a range of other existing and emerging technologies, especially artificial intelligence, on the broader transportation workforce.

5.5.6 Comprehensive Initiative

USDOT, in conjunction with stakeholders and other agencies, should use the information generated from the previous five recommendations to inform and produce a comprehensive workforce development initiative to support the transportation workforce of the future. This initiative should recognize that disruptive technologies will not be limited to ADS and that workforce implications will not be limited to professional drivers.

6 Project Delivery

6.1 Table of Contents

6.2 Preface

6.2.1 Overview

The US Department of Transportation (USDOT) defines excellence in project delivery as *completing high-quality projects that are well-intentioned, on time, on task, and on budget.*

USDOT instructed TTAC to advise on "how USDOT and its partners can leverage emerging technologies to help improve the delivery of safe, equitable, efficient, and affordable transportation projects." What follows is an abbreviated list of recommendations[59] that identify perceived challenges in the project delivery process that should be prioritized by USDOT in the future for potential technology solutions, as well as specific technological recommendations that can be pursued now.

The goal of this chapter is to identify and address the current challenges and bottlenecks in Project Delivery (PD) at the Federal level while empowering those closest to the community to successfully complete projects. Challenges to excellent project delivery vary by context, and there are many points in each stage of project delivery that contribute to increased delays and costs. These recommendations should not be considered exhaustive; rather, they were the ones that rose to the top in discussions with a small but diverse group of transportation professionals. Some recommendations are only appropriate for discretionary funding programs, while others are relevant to the delivery of any USDOT-funded project. It should be noted that there are different procedures based on individual funding types and the administrations through which the funding flows at USDOT, and the following recommendations should be applied as relevant.

TTAC is composed of thirty members, and about eight members participated in the Project Delivery Subcommittee at various points. Several additional stakeholders who work within and adjacent to government project deliverers contributed to these recommendations either in weekly engagements or as part of guided discussions with regular attendees of the subcommittee's weekly meetings.

Through subcommittee discussions and initial stakeholder engagements, several key themes emerged:

1. **Improve communication about resources**: USDOT has many resources to aid in project delivery, but those charged with delivering projects are not familiar with them.
2. **Remove barriers**: There are financial and knowledge-based barriers that hinder project progress.
3. **Streamline processes**: There is ample opportunity and desire to simplify workflows by eliminating unnecessary steps and reducing complexity.
4. **Increase opportunities for feedback**: Improving the feedback loop between project deliverers and USDOT would foster continuous improvement and responsiveness.

[59] The Committee's vote to adopt this chapter included an abstention from Tekedra Mawakana.

5. **Improve consistency:** There is a need to improve consistency of project delivery for stakeholders regardless of their locality, project type, or type of USDOT funding.

6.2.2 Scope of Work

In June 2024, USDOT instructed TTAC to advise on the "**Role of Emerging Technology in Improving Transportation Project Delivery**":

> ***Key Task:*** *Provide recommendations on how USDOT can leverage and promote the appropriate use of emerging technology—both within USDOT and by Federal grantees—in the delivery of Federally-funded transportation projects and in the ongoing maintenance of transportation infrastructure. USDOT views excellence in project delivery as delivering "good projects well—meaning on time, on task, and on budget."*
>
> 1. *Identify the components of transportation project delivery and maintenance that hold the greatest potential to be improved using emerging technology.*
> 2. *Identify tools that are already in use, are in development, or could be adapted from other application areas to help improve transportation project delivery and maintenance.*
> 3. *Provide recommendations on best practices for applying emerging technologies appropriately to improve the delivery of transportation projects and maintenance of transportation infrastructure.*
> 4. *Issues to consider:*
>   a. *Risks and risk mitigation approaches related to identified tools and use cases.*
>   b. *Potential impacts to the safety or rights of the public and how negative impacts in these areas can be mitigated.*
>   c. *Needs for guidance in the use of such tools and practices that USDOT should consider providing to agencies responsible for Federally-funded infrastructure projects.*
> 5. *Provide recommendations on how USDOT can best promote the responsible and appropriate use of emerging technologies to improve transportation project delivery and the ongoing maintenance of transportation infrastructure.*
> 6. *Document other issues and recommendations regarding innovation in project delivery identified in the course of examining the role of emerging technologies.*

6.2.3 Methodology

6.2.3.1 Subcommittee Group Inception

Between June 2024 and November 2024, the Project Delivery Subcommittee met virtually as often as weekly. The subcommittee engaged in a broad discussion about their lived experiences of PD and proposed concepts and ideas for how PD could be improved.

Specific choke points in PD that they had experienced consistently were identified. Meeting notes were shared in a Google Drive folder limited to subcommittee participants.

6.2.3.2 Identified Pillars of Improvement

In September 2024, the subcommittee conducted an initial thematic analysis of the discussion notes and identified six specific themes in the discussion: grant administration,[60] environmental and right-of-way review process, procurement, communication between USDOT and project delivery team, workforce development, and technology support. In October 2024, the subcommittee presented its initial recommendations and progress report to TTAC.

6.2.3.3 Community Feedback

To gather insights from stakeholders in the broader transportation industry, the subcommittee developed and distributed a Discussion Guide to investigate if the identified Pillars of Improvement were viewed as accurate and important within national stakeholder organizations as well as gather further insights into any other missed themes for PD improvement that our initial discussions may have overlooked.

Stakeholder Organization	Abbreviation	Role (as described by the organization)[61]
Association of Metropolitan Planning Organizations	AMPO	AMPO is a nonprofit organization founded in 1994 to support metropolitan planning organizations (MPOs) across the country. With over 170 MPO members, AMPO is member-led and focused on empowering communities. The mission is to strengthen MPOs as they plan safe, reliable, and equitable transportation networks that work for everyone.
National Association of City Transportation Officials	NACTO	An association of 100 major North American cities and transit agencies formed to exchange transportation ideas, insights, and practices and cooperatively approach national transportation issues.
National League of Cities	NLC	An organization comprised of over 2,725 city, town, and village leaders who are focused on improving the quality of life for their current and future constituents.

[60] USDOT supports federally funded projects through a variety of funding mechanisms. This Project Delivery chapter generally uses the term "grant" as shorthand for all these funding mechanisms.

[61] TTAC does not necessarily endorse each organization's characterization of its role.

Stakeholder Organization	Abbreviation	Role (as described by the organization)[61]
American Council of Engineering Companies	ACEC	ACEC is a federation consisting of 51 state and regional Member Organizations, advocating for policies at the federal, state, and local levels that promote economic growth and improve the quality of life for every American.
American Road and Transportation Builders Association	ARTBA	ARTBA brings together all facets of the transportation construction industry to responsibly advocate for infrastructure investment and policy that meet the nation's need for the safe and efficient movement of people and goods.
Associated General Contractors of America	AGC	The leading association for the construction industry with over 27,000 member firms, providing a full range of services satisfying the needs and concerns of its members, thereby improving the quality of construction and protecting the public interest.
The American Association of State Highway and Transportation Officials	AASHTO	A nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all transportation modes, including air, highways, public transportation, active transportation, rail, and water.
The Transportation Research Board	TRB	The Transportation Research Board provides leadership in transportation innovation and progress through research and information exchange. TRB is one of six divisions within the National Research Council, the primary operating agency of the National Academies of Science.
Volpe National Transportation Systems Center (USDOT Volpe Center)	Volpe	The USDOT Volpe Center serves as a federal resource positioned to provide world-renowned, multidisciplinary, multimodal transportation expertise on behalf of USDOT's operating administrations, the Office of the Secretary, other federal agencies, state and local governments, academia, and industry.

6.2.3.4 Analysis

A qualitative thematic analysis was conducted to draw out key recommendations related to each Pillar of Improvement to determine which—if any—pillars stood out as most critical to PD improvement. The thematic analysis also drew out recommendations for future research from gaps in themes that did not fit into the identified six Pillars.

6.2.3.5 Report

This chapter on Project Delivery is organized by its six Pillars of Improvement:

1. Grant administration;
2. Environmental and right-of-way review process;
3. Procurement;
4. Communication between USDOT and Project Delivery team;
5. Workforce development; and
6. Technology support.

Each section corresponding to a Pillar of Improvement provides (where applicable):

1. A problem statement;
2. Key findings;
3. Standout quotes and key messages; and
4. Recommended actions for USDOT.

6.3 Grant Administration

6.3.1 Problem Statement

1. To improve the number and quality of equitable transportation projects delivered, funding must first reach the communities that need it. Grants can be difficult to apply for, and many communities lack the staff resources to strategically identify opportunities, partners, and appropriate projects.
2. The match requirement for most grants is an additional barrier to application.
3. Significant time can lapse between the application deadline, award notification, and grant agreement finalizing. Including the time to prepare the application, it can take 16 to 18 months before work can begin.

6.3.2 Key Findings

1. Respondents supported a uniform grant application process across USDOT programs to minimize redundancy and reduce administrative costs.

2. Matching funds were flagged as a barrier, particularly for high-need and high-impact projects, with recommendations for reduced or eliminated requirements to promote equity.

3. Respondents highlighted delays in the reimbursement process as a significant issue, stressing the need for streamlined systems. The slow-moving nature of reimbursement often creates financial strain for local agencies.

6.3.3 Standout Quotes and Key Messages

1. *"Create a master agreement for direct recipients that covers terms and conditions for all grant awards; then, for each new grant award, only an authorization pursuant to that agreement must be approved. This will substantially reduce the contractual documents that need to be approved for each successive grant award. Alternatively, if one already has a grant contract in place that covers all the standard terms and conditions, allow that to be extended to cover future grant awards, again so only the scope of work needs to be agreed on."*

2. *"Federal staff have been very helpful."*

3. *"...Process improvements will not reduce the need for staff, but it will enable them to respond more quickly."*

6.3.4 Recommended Actions for USDOT

1. **Develop a common application for grants that is handheld device-enabled:** A common application is one where potential grantees can enter their relevant demographic, administrative, and other legal information into one platform that can be utilized for multiple grant applications. This would reduce the need for redundant administrative work, which would strain small governments and other entities. In addition, making this platform accessible via handheld devices would streamline the grant application process by allowing users to easily search for relevant funding opportunities, submit applications, and track progress in real time. The portal would feature user-friendly interfaces, automatic document uploads, and notifications to ensure applicants stay informed and on top of deadlines.

2. **Develop a master agreement for grant recipients:** This should cover terms and conditions for all grant awards; then, for each new grant award, only an authorization pursuant to that agreement must be approved. This will substantially reduce the contractual documents that need to be approved for each successive grant award. Alternatively, if one already has a grant contract in place that covers all the standard terms and conditions, allow that to be extended to cover future grant awards, again so only the scope of work needs to be agreed on allowing grant recipients to immediately proceed to the executed grant agreement upon award. This will ensure that critical projects get underway without unnecessary waiting. This recommendation should not be construed as calling for the elimination of specific and unique grant requirements and conditions such as labor conditions.

3. **Provide proactive support:** Identify underrepresented communities and build capacity at the federal level to support them either directly or through funding programs that

support local agencies in doing so. Prioritize outreach to communities who have not received a federal grant award or who have not received the expected amount of federal discretionary grants based on their relative size and other demographics.

4. **Build staffing capacity for grant administration:** Provide direct funding support to communities to increase their ability to recruit and train a team of skilled professionals to manage the full lifecycle of grants, from research and application to compliance and reporting. USDOT should develop a "train the trainer" model with an internal team equipped to educate these local teams with the tools and knowledge to streamline workflows, ensure timely submissions, and maintain strong communication with funders, ultimately improving productivity and maximizing grant success.
5. **Continue to reevaluate match requirements:** Many communities do not apply for grants due to the lack of match funding available. Continue to reevaluate match requirements by regularly reviewing the alignment between grant objectives and the available funding, and remove a matching requirement whenever possible. Providing clear examples and assisting communities in identifying match solutions that do not involve local cash (partnerships, state funding, in-kind contributions, etc.) would increase the number of communities able to access USDOT grants.

6.4 Environmental and Right-of-Way Review Process

6.4.1 Problem Statement

Many of the required environmental, right-of-way (ROW), and other review processes require significant financial and time resources but may not yield improved outcomes. This is a phase of federal project delivery where there is an opportunity to improve the required processes and identify tools to assist in delivering under current requirements.

6.4.2 Key Findings

1. Respondents advocated for preemptive Categorical Exclusion (CE) or NEPA approvals to streamline reviews.
2. Tools like One Federal Decision and eNEPA were recommended for wider adoption.
3. There is interest in AI-based solutions to enhance environmental and impact assessments.

6.4.3 Standout Quotes and Key Messages

1. *"The new rule to complete NEPA in two years is proving very difficult. This goes along with several items above, but streamlining the environmental process is imperative."*
2. *"Address the shortage of assessors who are qualified to assess ROW."*
3. *"Use the MPO long-range plan process to create an EIS [environmental impact statement], and other projects would fall under that for purposes of clearance and mitigation. It would require mitigation to be as deliberate as transportation projects."*

4. *"Once a project is funded, the environmental process is the biggest obstacle. Especially on smaller projects such as sidewalks and pathways. We have several projects that are bogged down and have been delayed multiple times because of difficulties with the environmental process."*

6.4.4 Recommended Actions for USDOT

1. **Streamline environmental review:** Over time, USDOT and other agencies have developed comprehensive project delivery frameworks designed to assess the potential impacts of federally funded infrastructure projects, particularly under the National Environmental Policy Act (NEPA). These processes aim to safeguard the environment and surrounding communities, and their importance has only grown in the face of modern challenges.

   Fortunately, recent advancements in impact assessment methodologies—particularly in identifying and mitigating negative effects—have significantly strengthened the ability to measure potential risks. USDOT should continue to seek new, less labor-intensive, and more effective ways to conduct these reviews of environmental and property impacts.

   It is also important to understand that these review processes and the federal funding tied to them were originally crafted for large-scale, new infrastructure projects, such as the construction of roads through previously undeveloped areas. However, the bulk of current federal funding is directed toward rehabilitating and upgrading existing infrastructure.

   In this context, we recommend reassessing projects delivered through emergency procedures to identify elements that could be incorporated into regular project delivery. This would apply specifically to projects where the project typology and other variables suggest that such a shift would not result in negative environmental or community impacts. By adapting these emergency protocols for more routine use, it may be possible to streamline the delivery of certain projects, reducing project cost and time while maintaining the integrity of environmental and community protections.

2. **Develop a new model of Programmatic Agreement and Programmatic Categorical Exclusion:** Developing a new model of Programmatic Agreement (PA) and Programmatic Categorical Exclusion (PCE) involves creating standardized frameworks that streamline environmental review processes while ensuring compliance with regulatory requirements. The new model would provide clear guidelines for project eligibility, reduce administrative burdens, and facilitate faster decision-making by categorizing certain activities for expedited approval, thereby supporting project implementation without compromising environmental protections.

3. **Develop Programmatic Categorical Exclusion agreements for adoption by state and municipal DOTs:** Creating Programmatic Categorical Exclusion (PCE) agreements for adoption by state and municipal Departments of Transportation would standardize and simplify the environmental review process across various jurisdictions, ensuring consistent and timely application of categorical exclusions. These agreements would outline specific criteria and procedures for identifying projects that qualify for expedited

review, enabling DOTs to streamline their workflows, reduce delays, and maintain compliance with federal and state environmental regulations.

4. **Develop a program to provide preemptive Categorical Exclusion or National Environmental Policy Act approval at the time of grant award:** Developing a program to provide preemptive Categorical Exclusion (CE) or National Environmental Policy Act (NEPA) approval at the time of grant award would expedite the environmental review process by granting early clearance for projects that meet established criteria. This proactive approach would reduce project delays, minimize bureaucratic hurdles, and allow grant recipients to move forward with implementation more quickly while still ensuring compliance with environmental laws and regulations.
5. **Consider expanding partnerships with private-sector companies:** Particularly in areas such as digital construction technologies (e.g., building information modeling (BIM), AI, and machine learning), which could help the Every Day Counts program (EDC) leverage cutting-edge advancements.

6.5 Procurement

6.5.1 Problem Statement

Procurement processes vary from government to government but universally take a long time and a lot of effort. There are barriers to getting disadvantaged business enterprises (DBE) into the pipeline for Federally funded projects, which limits the marketplace and impedes the ability to deliver projects. Long lead times and certain requirements significantly delay project delivery.

6.5.2 Key Findings

Master agreements were highlighted as an impactful way to standardize processes, reduce administrative costs, and streamline project authorizations.

6.5.3 Standout Quotes and Key Messages

1. *"...With so many projects underway, in a small market, there are not a lot of options to get bids."*
2. *"Potential for widespread Buy American Waivers for specific items/products."*
3. *"Procurement needs to be risk-based. The costs of the oversight on small items are probably greater than the potential financial risks."*
4. *"...[F]ocus where the greatest risks are."*

6.5.4 Recommended Actions for USDOT

1. **Improve procurement consistency, cost efficiency, and time efficiency:**
   a. Implement open standards for a universal procurement software to streamline the purchasing process across all projects and ensure consistency in compliance.

b. The adoption of master agreements with boilerplate language would help standardize project contracts and reduce the time needed to finalize individual agreements.

c. Advanced procurement strategies should be employed for all grant types, for materials with long lead times, allowing procurement to begin immediately upon grant award to avoid delays.

2. **Increase shared knowledge:** Implement a fast, real-time system to connect local teams with others who have executed similar projects, fostering innovation and productivity.

3. **Increase local governments' ability to be direct recipients:**

   a. USDOT can enhance local governments' capacity to act as direct recipients of federal funds by providing targeted technical support, such as training workshops and resources on federal funding requirements, financial management best practices, and compliance processes.

   b. Specifically, USDOT could offer tailored guidance on navigating federal procurement rules, establishing transparent reporting systems, and using federal funds effectively while maintaining compliance with regulations.

   c. Additionally, creating dedicated support teams or "on-call" financial advisors within USDOT to assist municipal finance teams throughout the grant lifecycle would help reduce apprehension around managing large federal funds.

   d. To further build confidence, USDOT could also develop a series of clear, user-friendly templates and tools for budgeting, cost tracking, and reporting, ensuring that local governments have the right tools and support to manage federal funds without fear of audit failures or penalties.

   e. Establishing a reimbursement policy that requires timely use of awarded funds (within a defined period) would incentivize timely spending and accountability.

6.6 Communication Between USDOT and Project Delivery Team

6.6.1 Problem Statement

1. Project deliverers and regional coordinators face challenges navigating the Federal project delivery process due to inconsistent communication on procedures, updates, and resources.

2. The absence of a structured feedback system within USDOT may lead to ongoing inefficiencies, particularly for those less familiar with Federal requirements, potentially impacting project execution and overall success.

6.6.2 Key Findings

1. Real-time communication platforms and dynamic feedback mechanisms were highlighted as key to resolving bottlenecks early.
2. Respondents emphasized the need for Federal Highway Administration (FHWA) Division Office training to reduce discrepancies in guidance between USDOT, division offices, and state DOTs.
3. Respondents also highlighted opportunities to utilize existing Local Technical Assistance Program (LTAP) office resources.
4. Assigning a single point of contact for each program was noted as helpful for clarity and efficiency.

6.6.3 Recommended Actions for USDOT

1. **Increase communication with project deliverers:**
   a. *Enable structured feedback:* Conduct listening sessions and surveys to leverage real-time feedback platforms to capture insights from a wide and representative group of stakeholders.
   b. *Create a centralized communication hub:* Facilitate seamless communication among division offices, state DOTs, and project directors through a unified platform.
   c. *Identify program liaisons:* Assign dedicated contacts for each program to ensure continuity and personalized support.
2. **Ensure consistency in guidance and communication:**
   a. *FHWA Division Office training:* Provide ongoing, standardized training to ensure consistent guidance across all division offices.
   b. *Inconsistent-guidance alerts:* Implement a system for flagging discrepancies in guidance across division offices and state DOTs to ensure alignment.
   c. *Third-party advisory services:* Consider the role of external private-sector consultants (who may be able to clarify and ensure compliance with complex federal regulations but who may not necessarily build organizational capacity).
   d. *Clear responses:* Designate specialists who can deliver clear, actionable answers to program-related questions that are standardized.
   e. *Living FAQ repository:* Maintain a centralized, user-friendly Frequently Asked Questions (FAQ) portal with up-to-date, standardized responses to common queries.
   f. *Support for standards changes:* Provide clear explanations on the trade-offs between new and old standards, helping stakeholders navigate transitions.
3. **Enhance technical assistance and education:**

a. *Strengthen LTAP offices:* Enhance the effectiveness of Local Technical Assistance Program (LTAP) offices through standardized training and tailored regional resources.

b. *Peer learning opportunities:* Expand peer exchange programs to facilitate knowledge sharing, particularly for smaller localities and less-experienced Project Directors.

c. *Build capacity:* Formalize knowledge transfer through targeted training programs, offering specialized support for under-resourced regions and first-time Project Directors.

d. *Educational outreach:* Provide webinars, town halls, and project summaries to keep project sponsors informed and engaged throughout the lifecycle.

4. **Optimize web search for USDOT support:** A targeted search-engine optimization strategy would focus on refining content, keywords, and backlinks to position USDOT's Project Delivery Center of Excellence[62] as the top search result for project delivery-related searches. This would involve using high-quality, relevant content, optimizing metadata, and leveraging local and industry-specific search trends to improve visibility and drive traffic to the Center's resources and services.

6.7 Workforce Development

6.7.1 Problem Statement

In some places, there are not enough people to manage or construct projects. Retention is an issue. Knowledge leaves when individuals leave. Reliance on consultants does not build organizational capacity.

6.7.2 Key Findings

1. Respondents highlighted uncertainty about how Metropolitan Planning Organizations (MPOs) fit into workforce programs but expressed general agreement on the need for localized training.
2. Workforce development programs were highlighted as critical to addressing labor shortages industry-wide.
3. Respondents emphasized the need for regional, context-specific programs.

6.7.3 Recommended Actions for USDOT

1. **Enhance workforce capacity:** Address skills gaps by increasing funding for specialized training and hiring programs. Provide sustained funding for staff that are not tied to specific projects (i.e., build out project management capacities).

[62] USDOT Project Delivery Center of Excellence, https://www.volpe.dot.gov/project-delivery

2. **Develop train-the-trainer programs:** Recognize the importance of cross-training local staff, utilizing mobile training camps, and developing flexible workforce solutions (i.e., similar to the Civilian Conservation Corps established as part of the New Deal).[63]
3. **Develop a universal Disadvantaged Business Enterprise (DBE) program:** To reduce the burden on DBEs from having to get certified in multiple places, and offer incentives to encourage the use of certified businesses in all relevant projects.
4. **Create a centralized vendor database:** This should be created to track vendors with a proven track record of successfully utilizing federal funding, making it easier for state and local teams working on USDOT projects to identify reliable partners.
5. **Develop open standards and technical assistance to increase the use of technology:** There is potential for advanced technologies like automation, artificial intelligence, and project management software to improve forecasting and monitoring, project planning and management, and productivity and risk management and to identify training needs.
6. **Develop centralized job descriptions:** To increase shared knowledge and provide structure for curriculum and professional development for new workers.
7. **Expand funding for workforce development as part of all grant opportunities.**

6.8 Technology Support

6.8.1 Problem Statement

What technology is available or could be made available to improve the project delivery process?

6.8.2 Key Findings

1. **A Need for open standards:** Open standards for digital project delivery are essential for ensuring that data can be easily shared, interpreted, and acted upon across different platforms and stakeholders. For our work, open standards are:

   voluntary, consensus-based, and open: voluntary, meaning their use is not mandated by law; consensus-based, meaning that a published standard has attained general agreement through cooperation and compromise in a process that is inclusive of all interested parties; open, meaning that they are not proprietary and are available for anyone to use.

   The use of standards encourages industry growth by minimizing development costs, increasing compatibility and interoperability, and increasing buyer and seller confidence in products.[64]

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[63] Congressional Research Service, Federal Conservation Corps Programs: Options for Congress in Response to COVID-19 (2020), https://crsreports.congress.gov/product/pdf/R/R46513

[64] USDOT, About ITS Standards, https://www.standards.its.dot.gov/LearnAboutStandards/ITSStandardsBackground

Lack of standardization currently impedes interoperability, complicates collaboration, and limits innovation.

American Council of Engineering Companies (ACEC), American Road and Transportation Builders Association (ARTBA), and Associated General Contractors of America (AGC) have all highlighted the importance of open standards to unlock efficiencies and create a more cohesive and scalable digital infrastructure ecosystem.

Expected impact: By promoting open standards, USDOT would lay the groundwork for an interoperable ecosystem that fosters innovation, reduces project delays, and lowers costs across the project lifecycle. Such standards would allow different software platforms to "talk" to each other, facilitating smoother collaboration between project stakeholders and enabling the private sector to develop new digital tools without fear of compatibility issues.

2. **Accelerating digital transformation through Federal initiatives**: Federal support is important for digital transformation. State DOTs and smaller contractors often face barriers to digital transformation due to resource constraints, lack of technical expertise, and resistance to change. Programs like the Advanced Digital Construction Management Systems (ADCMS) initiative offer a model for how Federal support can drive the adoption of digital tools.

   Expected impact: With enhanced support from ADCMS and similar Federal initiatives, state DOTs and other stakeholders would be better positioned to adopt digital tools quickly. This would result in a faster transition to modernized project delivery practices, leading to reduced project timelines, lower costs, and improved safety and sustainability outcomes.

3. **Opportunities for AI in project delivery:** AI is already reshaping digital project delivery and has significant potential to optimize various stages of the project delivery process. By analyzing large datasets, AI can potentially enhance decision-making, identify inefficiencies, and automate repetitive tasks. When using AI technologies and applications, it is important to consider risks as well as opportunities.

   Expected impact: Carefully integrating AI into digital project delivery could improve project execution, reduce delays, and improve the quality of transportation infrastructure. It could also create new opportunities for innovation as private-sector firms develop AI-driven solutions tailored to the needs of state DOTs and contractors.

4. **The need for collaborative research in digital and AI-driven project delivery:** Digital transformation in project delivery requires sustained investment in research, innovation, and workforce development. Key organizations like AASHTO, ARPA-I, TRB, Volpe, ARTBA, AGC, and private sector firms play crucial roles in advancing the state of practice.

   Expected impact: Through collaborative research and targeted investment in workforce development, USDOT can help overcome the barriers to digital transformation and AI integration. Long-term collaboration with public- and private-sector organizations would foster innovation, ensure the security and interoperability of digital tools, and support the industry-wide shift toward modernized project delivery.

6.8.3 Recommended Actions for USDOT

1. **Collaborative standards development funding:** USDOT should provide effective levels of funding in partnership with non-government partners to accelerate the development of open standards including representation from industry leaders, software vendors, state DOTs, and academia.
2. **Pilot programs and testbeds:** USDOT should establish pilot programs that test the application of open standards in real-world projects.
3. **Create a digital Project Delivery standards repository:** A centralized online repository managed by USDOT could house all national open standards, protocols, and guidelines for digital project delivery. This repository would act as a reference point for State and local agencies and private-sector entities, ensuring easy access to the most up-to-date standards and supporting materials.
4. **Expand ADCMS funding and scope:** USDOT should consider expanding the ADCMS program to increase funding and include more comprehensive support for the adoption of digital project delivery tools.
5. **Provide technical workforce development and training programs:** Many state agencies lack the in-house expertise to implement digital project delivery tools effectively. USDOT should coordinate funding for a federal/state/local training partnership with the private sector including AGC and ARTBA, to provide hands-on support to state DOTs and contractors.
6. **Publicize success stories and best practices:** USDOT should showcase successful implementations of digital project delivery by innovative project delivery entities (including public and private initiatives) that have benefited from ADCMS. Sharing case studies can help build momentum and inspire other state DOTs to follow suit.
7. **Include digital delivery in Every Day Counts:** FHWA should include a digital project delivery initiative in every round of its Every Day Counts partnership with States. Digital Transformation throughout the administration of the Federal Aid Highway Program should be a high-level strategic goal of USDOT.
8. **Automate environmental and right-of-way reviews:** When used carefully, AI can potentially streamline environmental reviews by analyzing vast amounts of data (e.g., historical environmental data and geospatial information) to quickly assess potential impacts.
9. **Optimize resource allocation and scheduling:** AI-driven predictive models can analyze past project data to forecast material needs, labor requirements, and equipment usage (e.g., helping project managers optimize resource allocation and avoid common scheduling issues through dynamic adjustments to schedules based on real-time data).
10. **Predictive maintenance and asset management:** AI can help manage infrastructure assets by predicting when maintenance is required based on real-time sensor data.

11. **Establish a National Research Consortium on Digital and AI-Driven Project Delivery:** USDOT should facilitate and fund the creation of a national research consortium, bringing together stakeholders from academia, industry, and government.
12. **Prioritize research on interoperability and cybersecurity:** USDOT should allocate funding to research in these areas to ensure that digital tools remain secure and compatible across platforms.
13. **Create a centralized research innovation fund for emerging transportation technology in project delivery:** This fund should provide grants to companies, researchers, and state agencies experimenting with new technologies related to project delivery, helping them bring these solutions to market more quickly.

7 Innovation for Safety

7.1 Table of Contents

7.2 Preface

7.2.1 Overview

This chapter advises USDOT to take four steps to increase roadway safety for everyone:

1. Align with the Canadian and European approach to adaptive driving beams (ADB);
2. Update the New Car Assessment Program (NCAP) at least every five years to account for new safety technologies (including V2x);
3. Integrate smart and digital infrastructure elements into the Department's Complete Streets Guidance; and
4. Build on the Department's existing work on the use of high-visibility enforcement to deter especially dangerous driving behaviors, including by updating and disseminating research on the appropriate and effective use of technology tools.

It is important to note that by no means are these four steps exhaustive or sufficient; USDOT is and should be pursuing many other solutions to our country's immense traffic safety problem. However, TTAC chose to highlight these four solutions because they:

1. Potentially have broad support;
2. Can be implemented quickly;
3. Represent innovations that are emerging, overlooked, or underleveraged; and
4. Demonstrate the importance of innovating with respect to vehicles, infrastructure, policy, and education.

7.2.2 Scope of Work

At its first meeting in January 2024, TTAC welcomed USDOT's National Roadway Safety Strategy[65] and accordingly advised USDOT to explicitly include the topic of "**Emerging, Overlooked, and Underleveraged Innovation for Safety**" within the Committee's ambit. Accordingly, in June 2024 the Department identified this as TTAC's fourth topic:

> ***Key task:*** *Describe how USDOT can transform transportation by improving safety through innovations that could be imminently available (**emerging**), that do not receive sufficient attention (**overlooked**), or that are not being used to their full potential (**underleveraged**).*
>
> ***Questions/issues to consider:***
>
> 1. *Why does this topic matter?*
> 2. *What are the most promising tools for improving road safety? (These could potentially include, among many others, concepts such as the Safe System Approach, vehicle technologies such as intelligent speed control, infrastructure treatments such as roadside communications, and device features such as smartphone crash detection.)*
> 3. *With respect to these tools: What resources, activities, and voices outside USDOT are especially helpful? What examples and analogies within USDOT are especially promising, concerning, or instructive?*
> 4. *What steps should USDOT take to facilitate the development, deployment, and use of these tools in a way that is effective and equitable? What should USDOT not do?*
> 5. *Where is consensus possible? Where consensus is not possible, what are the key issues?*

7.3 Problem Statements

TTAC recognizes significant safety challenges and hence opportunities in connection with vehicles, infrastructure, policy, and education:

1. **Vehicles:** Vehicle-based technology is capable of protecting vehicle occupants and other roadway users by preventing or mitigating crashes and by enabling safer driving behaviors. Given the timeframe necessary for vehicle development, it is urgent to identify the overlooked and underused technologies that are technically ready for implementation in a timely fashion. There is currently an imbalance in focus on vehicle occupant safety rather than safety for those outside the vehicle.
2. **Infrastructure:** Vulnerable road user (VRU) fatalities have risen at alarming rates. Under the Safe System Approach, fatalities are unacceptable. Currently there are underleveraged and overlooked innovations that can be used to improve safety and

[65] USDOT, National Roadway Safety Strategy, https://www.transportation.gov/NRSS

mobility. Infrastructure needs to be modernized to implement known solutions and enable new technologies that can improve safety.

3. **Policy and education:** There is a need to change the culture of transportation safety to encourage long-term, sustained solutions. There are underleveraged resources and tools that need to be researched and disseminated to determine if solutions could be applied more broadly.

7.4 Adaptive Driving Beams (Vehicle Solution)

NHTSA should revise the Adaptive Driving Beams (ADB) rule and align itself with the European and Canadian approach to ADB. NHTSA could accomplish this by adopting the SAE J3069 recommended practice for ADB systems.[66] By doing so, NHTSA would strike a balance that permits wider and faster adoption of advanced safety headlight systems that can immediately improve visibility and associated driver behaviors on America's roads.

ADB systems seamlessly illuminate the road for a driver and may also be helpful in lighting the road for trailing vehicles that have older lighting technology. The system automatically adjusts the lighting position when facing oncoming or preceding vehicles. The system also adjusts the pattern of light emanating from the vehicle to both reduce glare for oncoming drivers and maintain a high level of lighting on the roadway.

These systems have been available in Europe and Canada for many years. However, NHTSA's 2022 rulemaking reduces flexibility for automakers to install technologies that can protect consumers at a reasonable cost. While admirable in its intent, this rule made the perfect the enemy of the good by forcing a choice between forgoing an ADB system altogether and pursuing a system that meets requirements far more demanding than those in Canada and Europe. In addition, aspects of the rule are inconsistent with other NHTSA regulations. If not adjusted, parts of this rule stand as an obstacle to the deployment of this important safety technology in the US market.

With increases in pedestrian fatalities coming primarily at night,[67] this technology could help to protect vulnerable road users. But under current NHTSA regulations, ADB systems that are allowed in Europe and Canada are not allowed in the United States.

[66] SAE International, SAE J3069: Adaptive Driving Beam System (2021), https://www.sae.org/standards/content/j3069_202103/

[67] See, e.g., Nicholas N. Ferenchak and Masoud Ghodrat Abadi, Nighttime Pedestrian Fatalities: A Comprehensive Examination of Infrastructure, User, Vehicle, and Situational Factors (2021), https://www.sciencedirect.com/science/article/abs/pii/S002243752100092X; Emily Badger, Ben Blatt, and Josh Katz, Why Are So Many American Pedestrians Dying at Night? (2023), https://www.nytimes.com/interactive/2023/12/11/upshot/nighttime-deaths.html

7.5 New Car Assessment Program (NCAP) (Vehicle Solution)

Given the pace of technology development, NHTSA should commit to updating NCAP every five years to assess and include technologies that advance safety. As part of this update, NHTSA should add V2X technologies to the NCAP roadmap.

TTAC welcomes the New Car Assessment Program (NCAP) final decision announced on November 18, 2024, which includes a new roadmap.[68] This is the first time NHTSA finalized an NCAP roadmap in more than 15 years.

NCAP must align with the pace of innovation, technology development, product cycles, and other global NCAP efforts.[69] Technologies that are ready for deployment must be assessed and analyzed. NCAP should be a means by which information drives consumer demand for innovative safety technologies. It must balance keeping up with the pace of technological innovation and providing enough lead time so that automakers can innovate and adapt.

An effective and consistently maintained NCAP roadmap can help accelerate the development and deployment of advanced safety technologies and can provide greater consumer awareness on key aspects of vehicle safety performance. At the same time, NCAP must provide ongoing and updated certainty to the auto industry for product planning purposes. NCAP should challenge automakers to innovate around safety technologies. While NCAP can drive consumer demand, it also plays an important role in motivating technology deployment from which NHTSA can glean data that ultimately informs future rulemakings.

TTAC notes that NHTSA's final decision does not include integration of vehicle-to-everything communication (V2X) technologies into any part of the ten-year NCAP roadmap. V2X remains an underutilized safety technology that would be buoyed by inclusion in NCAP.

Given the slow turnover in the vehicle fleet (the average age in 2024 rose to 12.6 years overall and 14 years for passenger cars), NHTSA might also consider ways that NCAP could encourage safety improvements over the life of a vehicle. For example, research into updating a vehicle's safety systems after its manufacture could potentially support assessing forward-compatibility as part of NCAP. Similarly, research into aftermarket safety devices could potentially support an NCAP-like evaluation of these devices.

7.6 Digital Infrastructure (Infrastructure Solution)

USDOT should update its Complete Streets guidance. USDOT should consider incorporating smart and digital infrastructure elements in its definition of and guidance for

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[68] NHTSA, With Focus on Reducing Roadway Deaths, NHTSA Finalizes Significant Updates to 5-Star Safety Rating Program (2024), https://www.nhtsa.gov/press-releases/5-star-safety-ratings-program-updates; NHTSA, New Car Assessment Program Final Decision Notice—Crashworthiness Pedestrian Protection (2024), https://www.federalregister.gov/documents/2024/11/25/2024-27446/new-car-assessment-program-final-decision-notice-crashworthiness-pedestrian-protection

[69] Global NCAP, https://www.globalncap.org/

complete streets, as these technologies could improve safety and facilitate multimodal mobility. USDOT should also revisit non-technological solutions and address barriers to adoption, including funding, procurement, and project delivery barriers.

The Federal Highway Administration (FHWA)'s Complete Streets guidance[70] influences federal, state, and local plans and policies. Related efforts to increase safety and accessibility for vulnerable road users (VRUs) should consider both non-technological solutions (including curb cuts, sidewalks, and lighting, among others) and technological solutions (including leading pedestrian intervals (LPI), digital curbs,[71] and intelligent traffic management systems, among the others discussed below). Many of these solutions are both overlooked and underleveraged.

Basic improvements to physical infrastructure, including curb cuts and sidewalks, can significantly enhance safety and mobility for a wide variety of travelers, connecting them more seamlessly to other modes and ensuring that the system is accessible to all. Funding should therefore continue for these important infrastructure elements.

A "complete streets digital layer" encompassing technological solutions can increase safety for pedestrians and other VRUs. V2X and LPI can make pedestrians more visible to motorists. Adaptive traffic signals can give people, especially those with mobility challenges, more time to cross intersections. Timely access to data, including from embedded sensors, can help identify safety hotspots for pedestrians and cyclists, both in real time and in the planning processes of transportation agencies. Accurate and complete digital mapping can enhance these agencies' ability to better plan for and target infrastructure investments that support all users and increase safe mobility.

USDOT should reduce barriers to technological innovations and foster partnerships that allow for pilot programs and the testing of emerging, overlooked, and underutilized technologies. USDOT could ensure that street design guidelines cover the installation and maintenance of these technologies. USDOT could also support efforts to create a uniform digital standard for communicating roadway speed limits.

USDOT's updated guidance could emphasize the use of data in transportation planning and design, allowing for more data-driven decision-making. With the rise of shared mobility services such as ride-hailing, car-sharing, and bike-sharing, Complete Streets could use technological tools to dynamically manage infrastructure and curb space in real-time. This might include dedicated pick-up and drop-off zones, digital curb management, designated parking spots for shared vehicles, or bike-sharing stations. AI tools can give agencies information they may not be aware of and identify issues not seen previously in a way that helps them properly plan for infrastructure investments and safety countermeasures.

Protection of personal privacy and robust cybersecurity protocols are essential components of deploying connected infrastructure, at both the planning and the implementation stages.

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[70] See FHWA, Complete Streets in FHWA, https://highways.dot.gov/complete-streets; see also FHWA, Moving to a Complete Streets Design Model (2022), https://highways.dot.gov/complete-streets/moving-complete-streets-design-model-report-congress-opportunities-and-challenges

[71] See, e.g., The Digital Curb Program: Revolutionizing Curb Management in San Francisco (2024), https://www.transportation.gov/sites/dot.gov/files/2024-09/SFMTA.pdf

Data generated by connected infrastructure should not generally be provided to law enforcement agencies unless subject to proper legal process.[72]

7.7 High-Visibility Enforcement (Policy Solution)

USDOT should build on its work on high-visibility enforcement to help communities reduce especially dangerous driving involving impairment, speeding, and inattention.

TTAC recognizes NHTSA's high-visibility enforcement toolkit,[73] its emerging Community Enhanced Traffic Enforcement model (CENTRE), and its other important work to empower communities to deter especially dangerous driving behaviors.[74]

USDOT as a whole should amplify this work and disseminate its research-based conclusions. As part of this, USDOT should:

1. Review, update, and publicize its research[75] on enforcement, including with respect to what technology tools such as automated enforcement have been shown to successfully support enforcement efforts and how communities can benefit from responsibly implementing these tools;
2. Undertake comprehensive research into the factors influencing the efficacy of high-visibility enforcement and the specific features and circumstances that can make such deployments more successful and accepted;[76]
3. Publish best practices regarding mitigation strategies for chronic offenders such as increased penalties and/or targeted education;
4. Ensure that civil rights, equity, and fairness are foundational to the design, deployment, and evaluation of enforcement efforts;
5. Emphasize that efforts to improve the safety of vulnerable road users should focus the bulk of enforcement activities on motor vehicle operators (given that motor vehicles are far heavier and faster than people);
6. Support increased education on the safe use of all mobility devices (including motor vehicles, bicycles, e-bikes, e-scooters, and others); and
7. Situate enforcement within the Safe System Approach's broader context.

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[72] For more discussion of privacy and cybersecurity, see the Artificial Intelligence chapter.

[73] NHTSA, High Visibility Enforcement (HVE) Toolkit, https://www.nhtsa.gov/enforcement-justice-services/high-visibility-enforcement-hve-toolkit

[74] USDOT, Advancing Roadway Safety with the Assistance of Law Enforcement Partners (2024), https://www.transportation.gov/nrss/roadway-safety-and-law-enforcement-fact-sheet

[75] Research includes, but is not limited to, past, present, and future studies, findings, and programs.

[76] See, e.g., Bryant Walker Smith, Jeffrey Michael, and Johnathon Ehsani, Ideal Enforcement (2023), https://repository.law.umich.edu/cgi/viewcontent.cgi?article=1064&context=mtlr

8 Member Comments

Under TTAC's rules, every appointed member is invited, upon the Committee's disposition of a substantive chapter of this report, to submit a Member Comment of no more than 200 words pertaining to that chapter. These individual statements constitute part of this report.

8.1 Comments on the Introduction

8.1.1 Mark Chung

The U.S. Department of Transportation's creation of the Transforming Transportation Advisory Committee (TTAC) represents a significant stride toward a safer and more innovative transportation future for America. I deeply appreciate Secretary Pete Buttigieg and the dedicated USDOT team for uniting diverse stakeholders to steer this progress.

While transportation technologies offer incredible opportunities, advancing these innovations requires a balanced approach with safety as the top priority. Technology has the ability to reshape transportation—reducing crashes, improving efficiency, and increasing accessibility. However, implementing these changes demands thoughtful planning, rigorous testing, and an unwavering commitment to safeguarding lives on our roads.

The choices we make today will influence the safety and fairness of our transportation system for generations. TTAC's mission to provide thoughtful leadership is a hopeful reminder that while technology propels change, it is human care and accountability that ensure its success.

Thank you to Secretary Buttigieg and the USDOT leadership for your forward-thinking leadership, guidance and for championing a vision of progress that values both innovation and the preservation of life.

8.1.2 Kate Gallego

It was an honor to Chair Secretary Buttigieg's TTAC over the last year alongside a diverse group of experts, advocates, and local leaders. Throughout our time together, we discussed difficult topics ranging from privacy to workforce automation impacts to national security implications of technology.

As you read this report, you will notice it was a broad team effort that no one person on the Committee could have accomplished alone. Each of us brought unique expertise and backgrounds to our convenings, and our compromises are presented in the report.

As a local government representative on the Committee, I was pleased our final report provided actionable deliverables. In my community, where autonomous vehicles are plentiful and popular, we have learned so much about how autonomous technology interacts with first responders and how powerful it can be in our collective efforts to reduce accidents on our streets. These lessons and more are reflected in the report.

I hope recommendations from the TTAC's work will be implemented across the country in years to come. Together, we can ensure the United States continues its leading role in transportation innovation while prioritizing the safety and well-being of our residents.

Thank you for reading this important report.

8.1.3 Bryan Reimer

TTAC's report is a collaborative product that encompasses the work of several subcommittees. As with any report of this nature, it reflects the efforts of countless volunteers who are willing to listen to one another, make compromises, and work collectively toward a common goal. I applaud my colleagues for their collective investments in developing these recommendations for USDOT, and I am hopeful that they will help shape future directions within the department and its modal administrations. The leadership of TTAC and TTAC's subcommittees is commendable.

There is, however, one important standout through TTAC's initiatives: Bryant Walker Smith's enthusiasm, effort, and encouragement of others has significantly enriched the substance of this effort. He deserves commendation for his contributions and exemplifies the type of leadership that is critically needed within USDOT during this transformative time.

8.1.4 Bryant Walker Smith

I am grateful to our dedicated USDOT colleagues for conceiving, creating, and facilitating TTAC; to the outstanding leaders of our subcommittees for spending their weekends, late nights, and early mornings weaving strands of insight into tapestries of advice; and to all our active participants for sharing not only their expertise but also their humanity.

I highlight humanity because TTAC is a group of individuals. For multiple reasons, the topics in this report are deeply personal to many of the participants—and, in the case of our stakeholder members, to many others whose interests they specifically represent. Committee members who were expressly appointed to give advice could have simply done so and been done with it. But I observed at least as much genuine listening as talking. Participants with diverse backgrounds and divergent views sought to understand and help each other. Even when I perceived a tactical advantage to one or another, the members worked in good faith so TTAC could collectively deliver its very best advice to USDOT.

This report is that advice—the writing that followed the listening and talking. That now leaves the doing, and I am hopeful our transportation community will meet the challenge.

8.2 Comments on Artificial Intelligence

8.2.1 Carol Flannagan

For many or all of the technologies and approaches listed, AI can be used for good or can be used in a way that is detrimental to specific groups of people over others. Automated enforcement, for example, has been shown to be effective (especially for speeding and red-light running), but has also been used in ways that created significant burden for certain groups or generated revenue without clear benefit to safety. For example, license plate readers result in punishment (i.e., fines) with limited safety benefit. When placed near lowsocioeconomic-status neighborhoods, this type of automated enforcement results in disparate negative consequences without associated positive consequences (as might happen if the enforcement were for speeding). While we advise to use the word "monitoring" or "surveillance" when appropriate and not when not, to avoid the charged nature of those words, the way in which a monitoring technology is used is at least as important if not more important than whether it is monitoring. For automated speed enforcement, privacy impacts may be *de minimis*, but other impacts may be significant to some groups (but not others). It may be best to use "monitoring" when anyone considers it so and focus on implementation practice.

8.2.2 Tekedra Mawakana

I want to thank the members of the AI subcommittee who put great effort into tackling such a broad and complex topic. There are a number of good ideas and discussions in the AI chapter that are worthy of USDOT's consideration. However, I could not support the totality of the AI chapter as there are many items with which I do not fully agree. I understand the committee's time constraints, but the report notes these sections are a "work in progress" and "incomplete," and the AI sections perhaps could have benefited from additional time and discussion. For instance, the AI used in AVs should not be prejudged as higher risk, especially when automated driving is robustly regulated by USDOT and when the data to date suggests Waymo's technology is already improving road safety in the areas where we currently operate.

Waymo's approach to product safety is built on 15 years of researching, developing, and commercially launching a product already regulated for safety. We continue to responsibly iterate our AI-powered technology, including exploring specialized applications of foundation models that can improve the safety and performance of the Waymo Driver.

8.2.3 Bryan Reimer

The impact of AI on society is broad, evolving, and potentially ever-changing. It presents opportunities and challenges to governments, businesses, individuals, and other stakeholders. Embracing much—though not all—of what AI enables is critical to our nation's global economic competitiveness. Maximizing the utility of AI enabled technologies will require openness, collaboration, and consensus for the greater good. The TTAC's work on AI embodies this approach: a consensus-driven effort aimed to help USDOT refine its and its modal administrations' strategies to maximize the utility of AI in our transportation system.

As the world adapts to the far-reaching impact of AI, regulatory support may at times be needed. I encourage USDOT where possible to take a risk / benefit view in assessing directions. Nimble, adaptable approaches to guidance should, where possible, be prioritized over more traditional, less flexible methods. Solutions that are optimal today may not be optimal tomorrow. I am hopeful that USDOT can leverage the outcomes of TTAC's work to accelerate the changes necessary for the safe, responsible, and appropriate development and use of AI in our transportation system.

8.2.4 Bryant Walker Smith

I support TTAC's AI recommendations *because* I support AI's immense promise.[77]

An 1838 court opinion emphasized how railroads had "become of great and growing importance; they afford high-ways of incalculable value to commerce, and the ever ready means of social intercourse between distant communities … but for such noble ends, we must ingraft the railroad system in the affections, as well as the interests of the people; and the parents of so much enterprize, wealth, and national good, must not be justified when wrong, else they might become the tyrants of the day."[78]

AI will become an instrument of tremendous power for countries, governments, companies, collectives, and individuals—and Spider-Man (among others) reminds us that "with great power comes great responsibility."

Given this, many policy discussions should shift from whether technologies are trusted to whether the entities commanding those technologies are trustworthy.[79] USDOT should consider how to recognize and incentivize the trustworthiness of the companies it regulates, including through lessons from FMCSA's BASICs and other modal efforts. USDOT should also demonstrate its own trustworthiness by voluntarily and openly sharing its AI-related successes and failures.

8.3 Comments on Automated Driving

8.3.1 Carol Flannagan

1. While voluntary data collection may seem like an industry-friendly compromise, mandated data collection is equitable across companies, rewards the good actors (because they can be compared accurately), and provides the greatest benefit to the public. If data elements are selected carefully with broad stakeholder input, mandated data collection will not be overly burdensome and will provide much broader benefit than voluntary data collection, which leads to poor-quality analyses and understanding of the safety landscape.
2. Not mentioned, but needed, are approaches to appropriately understand and mitigate potential public concerns about the use of automated vehicles in law enforcement, especially the relationship between fleet ADS and law enforcement. For example, do rideshare ADSs have an obligation to report illegal passenger behavior to law enforcement? As with automated enforcement (e.g., speed or red-light cameras), the implementation matters a lot, and transparency with the public is critically important. USDOT needs to tackle these kinds of questions long before there is an actual case of abuse.

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77 https://newlypossible.org/files/presentations/2023-12-16_AcademicVisionforAI.pdf

78 State v. Tupper (S.C. App. 1838)

79 https://newlypossible.org/files/presentations/2019-11-14_TrustworthyCompany.pdf

8.3.2 Tekedra Mawakana

My team and I focused our participation in TTAC on this chapter, and I am proud of the many important recommendations the committee has made. These include: ensuring that ADS assessments are based on valid comparisons with conventional operations under comparable conditions; stating that the need for ADS data should be clear and defensible and tailored to meet clearly stated objectives, with clear protections for confidentiality; suggesting that NHTSA consider including mileage in its SGO reporting; and USDOT developing a workplan to explore important topics relating to the interactions between AVs and first responders. While TTAC members do not agree on all matters related to automated driving, the content of this chapter is worthwhile because it reflects the areas where our diverse perspectives are in alignment.

An important note: a diverse and global group of safety researchers, insurance experts, and AV developers recently published a set of best practices for Retrospective Automated Vehicle Evaluation (https://arxiv.org/abs/2408.07758). Waymo and I believe this goes a long way toward building "consensus on the most appropriate analysis methods to apply to ADS impact assessments," which, in 5.3.3.5, the report states is currently lacking.

8.3.3 Bryan Reimer

The future of ADS has never been brighter. Advancements in AI may lead to a future where the need for human drivers is virtually or entirely eliminated. However, society is far from this utopia, and the evolution of ADS has been marred by overhype, false premises, mishaps, a lack of transparency, and other challenges. This situation has placed unacceptable burdens on states, local communities, first responders, and others. Road users have been—and may still be—subjected to increased risks as tele-operated robots exhibit non-human-like behaviors.

The development of this potentially impactful technology needs to be encouraged through responsible, flexible, and data-driven policies that balance the interests of all stakeholders through a FAA style safety culture. Testing and deployment decisions may look to the FDA's processes designed to balance benefits with risks as a framework for the future.

If the U.S. is to maintain its leadership in the development of ADS and ADAS technology, it is imperative that the federal government take on an increased leadership role. Efforts to convene all stakeholders, both public and private, to collaborate on solutions that extend beyond TTAC's focus—such as establishing a national framework for ADS, performance standards for ADAS, etc.—are essential.

8.3.4 Bryant Walker Smith

USDOT solicited advice on a limited set of topics related to automated driving, and I support TTAC's resulting recommendations.

I write to highlight a key tension that TTAC has navigated and that policymakers face: How should expectations for automated driving compare to expectations for conventional driving?

I start from three irreconcilable premises:

1. We should hold automated driving and conventional driving to equivalent standards for safety, health, equity, sustainability, financial responsibility, and incident reporting.
2. Those standards should be higher than they are today.
3. It is easier to raise those standards for automated driving than for conventional driving.

(There is a similar tension for fleet-owned vs. individually-owned vehicles.)

In my view: USDOT should collect information on every vehicle crash; prices at pumps and chargers should reflect associated environmental externalities; and everyone should have the millions of dollars of automotive insurance required in Europe.

Because these and other policy outcomes are unlikely for conventional driving, I am reluctantly inclined to seek some through automated driving alone. And yet this uniquely burdens automated driving in a way that risks slowing its potentially immense benefits.

I say more in *Ethics of Artificial Intelligence in Transport*.[80]

8.4 Comments on Project Delivery

8.4.1 Tekedra Mawakana

I abstained from voting on this chapter because I am not an expert on federal transportation project delivery mechanisms or obstacles, nor is Waymo active on this topic. We and our riders do, however, benefit from the fast and efficient completion of road infrastructure improvements, as do all Americans. Insofar as the recommendations in this chapter could improve the safety, maintenance, capacity, equity, efficiency, or accessibility of America's roads, I hope USDOT will act swiftly to adopt them.

8.4.2 Bryant Walker Smith

I support TTAC's recommendations for improving project delivery. Reducing the time and cost of societally beneficial projects can advance important goals such as safety, mobility, opportunity, equity, sustainability, and community.

I write separately only to emphasize that a holistic analysis of "efficiency" must account for *all* these goals (among many others). If not properly defined and qualified, the term "efficiency" at best is a platitude and at worst distorts important public values.

Measures of transportation system performance often compare specific numerators and denominators: people transported per hour, lane-miles built per dollar spent, economic outputs per economic inputs, and so forth.

We must always be clear and careful about what is—and is not—being measured. Too often we risk implicitly defining our goals too narrowly (e.g., moving motor vehicles), overlooking externalities (e.g., costs to neighborhoods of motorists speeding down local streets to bypass congestion), excluding intangibles (e.g., the value of civic engagement and human

[80] https://ssrn.com/abstract=3463827

connection), and zeroing unknowns (e.g., the long-term impacts of climate change or the long-tail risks of systemic disruptions).

Ultimately, we cannot credibly measure efficiency unless we ask the fundamental question invoked in this report's Introduction: Are we making life better for people today and tomorrow?

8.5 Comments on Innovation for Safety

8.5.1 Bryan Reimer

Countless innovations can aid in democratizing safety technologies to mitigate the undertreated health crisis on our nation's roads. However, due to the limited time and scope of TTAC's efforts in this area, our recommendations cover only a small segment of the technologies that deserve prioritization. Crucially, technological innovation cannot be encouraged or harmonized through regulatory actions alone. USDOT and its modal administrations need to support or develop collaborative efforts with car makers and safety suppliers that enable technologies to be more swiftly conceived, tested, proven, brought to market, and benchmarked.

NHTSA should identify and implement strategies that explicitly encourage data-driven improvements to safety systems throughout a product's lifecycle. Encouragement of real-world naturalistic driving data and synergistic testing approaches is important for establishing safety benefits and understanding the impact of various convenience systems on drivers. As the integration of driver behavior, vehicle technology, and environmental context is multifaceted, these real-world data driven approaches are essential.

Finally, by embracing USDOT's safe-systems approach, there is a need to focus on attention-centric design, adaptable systems, and robust driver support. This is particularly essential given the rapid influx of new interface technologies and automation into vehicles.

8.5.2 Bryant Walker Smith

1. Road deaths per billion vehicle-miles traveled (per NHTSA and OECD):

   2000: 15 (US), 15 (Canada), 16 (Australia), 12 (UK), 8 (Massachusetts), 24 (South Carolina)
   2021: 13 (US), 7 (Canada), 7 (Australia), 5 (UK), 7 (Massachusetts), 21 (South Carolina)

   Per capita, the contrast is even starker.

2. I support TTAC's important recommendations on Innovation for Safety. Because retrofitting the roads and vehicles of today is as important as planning for those of tomorrow, USDOT should also prioritize:

   a. Responsible use of automated enforcement for speed limits and other safety-critical driving rules.

   b. Interim measures to make existing roads safer when reconstruction is not imminent, including narrowing driving lanes, tightening turn radii, enhancing crosswalk conspicuity, and fostering a sense of place. To this end, USDOT should support NACTO in further developing and sharing its Interim Design Strategies.

c. An MUTCD that fully values pedestrians, bicyclists, and communities.

d. Installation of alcohol ignition interlock devices and other safety support systems on existing vehicles, including through cooperation with states, fleet operators, insurers, and parents.

e. Research into the opportunities and risks of aftermarket and phone-based safety support systems.

Where USDOT cannot act, I urge Congress to do so.

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USDOT Staff framed key questions, offered technical feedback, and provided essential support. They are not responsible for the substance of the Committee's recommendations.