Summary of RFI Responses - Opportunities and Challenges of Artificial Intelligence (AI) in Transportation

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Notice

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Executive Summary

Artificial Intelligence (AI) applications, from machine learning to generative AI, are currently being deployed in domains across the nation's transportation system. A Request for Information (RFI) published by the U.S. Department of Transportation's (DOT) Advanced Research Projects Agency – Infrastructure (ARPA-I) in May 2024 as directed by presidential Executive Order (E.O.) 14110 on *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*, sought input on these current AI applications, as well as future opportunities, challenges, and related issues in transportation. The 95 unique responses summarized in this RFI report were received from public agencies, industry, labor, and nonprofit organizations. They provide the DOT and ARPA-I with a wealth of information on what AI-enabled technologies are operating in the field, as well as how new and emerging AI applications and methods may potentially further enhance the nation's transportation system.

Current applications of AI described by respondents are transforming traffic operations and logistics through advanced data analytics and real-time monitoring, with applications in asset management, planning, analysis, and interfacing with the public. Automated vehicle (AV) deployment was a large focus of respondents, with additional current applications noted in drone delivery systems and pedestrian detection, which enhance safety and efficiency in urban environments. Respondents described how airlines and airports are using AI for scheduling, traffic flow optimization, and energy price prediction, while digital twins and predictive asset management tools are in use across the modes. Additionally, AI-driven analytics are improving traffic flow and safety in both surface and air transportation, with tangible improvements in decision-making and reductions in human error. Overall, respondents described AI usage as paving the way for future advancements that may improve efficiency, safety, and operations management across the transportation network.

Opportunities for AI in transportation were recommended in a wide variety of areas broadly defined as asset management with computer vision, AI assurance, logistics, planning, project delivery, safety, accessibility, automated vehicles, as well as potential cybersecurity advancements. Improvements in aviation safety and efficiency were two other areas of possible progress mentioned by respondents. Many respondents also recommended an increase in the use of digital twins to simulate various aspects of transportation such as traffic, roadway structures, pedestrians, and human behaviors.
Digital twins allow for testing new technology and ideas without putting humans at risk. Respondents noted that increasing the efficiency of large data storage collation to accurately predict and understand near-miss incidents may lead to important safety developments across several modes of transportation. Recommendations for future exploration that ARPA-I could support included the utilization of AI to better predict and understand traffic flows to better optimize traffic on our roads.

The challenges of AI in transportation were noted by nearly all respondents, particularly as AI models become more embedded in the operation of transportation systems. Lack of trust and understanding of AI, how data are used, potential bias, legal concerns, workforce displacement, regulatory considerations, integration with legacy systems, explainable AI, and cybersecurity challenges were frequently noted.

Many respondents urged caution as AI becomes more advanced and increasingly utilized in safety-critical transportation applications. Respondents stated that a significant amount of attention to these challenges will help smooth the integration of AI into transportation. Workforce training and public education on AI models were emphasized throughout the responses, with a focus on balancing system improvements with safety and privacy.

Autonomous mobility ecosystems, including increasing deployment of AVs, may provide additional opportunities and challenges, with respondents noting the potential benefits of optimization of routing across multimodal transportation systems. Respondents described mobility ecosystems powered by AI models that have the potential to improve accessibility for those who may not be able to operate a vehicle due to physical limitations or age, and with multimodal infrastructure management providing additional opportunities.

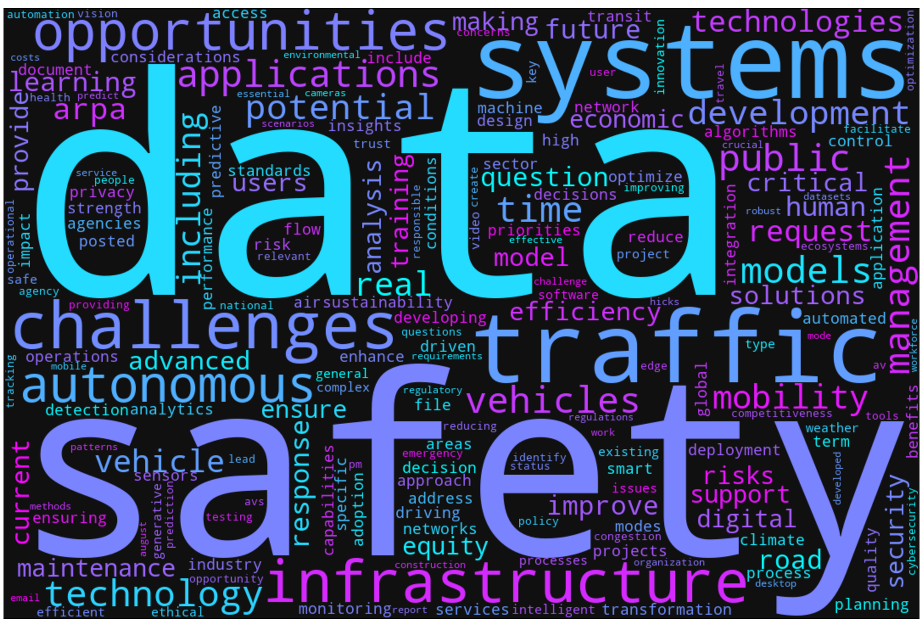

Figure 1. Most frequent relevant phrases from the corpus of text generated by the AI RFI responses.

Overall, the responses to this RFI highlight the substantial benefits of current AI applications in transportation, as well as its potential additional opportunities and challenges including risks. Respondents largely agree that significant regulatory and cybersecurity challenges lie ahead. There was an emphasis on the need for unified and sensible regulatory approaches that DOT could help inform. Numerous innovative uses of AI are already being utilized and tested in areas such as safety, asset management, traffic optimization, and parking management. Cautious optimism was expressed in many responses that AI use cases will continue to increase and create more opportunities in transportation. Respondents recommended that ARPA-I and the DOT remain proactive and maintain open communication regarding safety and AI innovation, underscoring the substantial potential opportunities for AI applications and innovation. Recommendations for ARPA-I involvement include investment in external innovative research that develops AI technologies, systems, and capabilities to improve transportation infrastructure in the US; investment in AI applications in transportation, prioritizing funding for cross-modal projects in DOT; investing in a framework for explainable AI; and recommendations that ARPA-I support investment in AI assessment and assurance tools in addition to the AI technologies themselves. The responses to this RFI will help shape future investments by ARPA-I and the DOT in AI solutions that could transform the nation's transportation system utilizing approaches that emphasize safety and trustworthiness, balancing cybersecurity, sustainability, equity, and efficiency.

1. Introduction

1.1 Background and Overview of the AI RFI

In May 2024, the U.S. Department of Transportation's (DOT) Advanced Research Projects Agency – Infrastructure (ARPA-I) published a Request for Information (RFI) to obtain input on artificial intelligence (AI) opportunities, challenges, and related issues in transportation. The RFI was issued in response to the emerging capabilities and implications of AI across the transportation sector, and more broadly across society, as directed by presidential Executive Order (E.O.) 14110 on *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*[1] released on October 30, 2023. In section 8, "Protecting Consumers, Patients, Passengers, and Students", under Sub-section (c), the E.O. directs the DOT to "promote the safe and responsible development and use of AI in the transportation sector, in consultation with relevant agencies". Paragraph (iii) under sub-section (c) further requires that ARPA-I "explore the transportation-related opportunities and challenges of AI—including regarding software-defined AI enhancements impacting autonomous mobility ecosystems".
The AI RFI responses received will assist ARPA-I and the U.S. Department of Transportation in carrying out its responsibilities under section 8 (c)(iii) of E.O. 14110, as noted above.

[1] https://www.whitehouse.gov/briefing-room/presidential-actions/2023/10/30/executive-order-on-the-safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence/

1.2 Purpose and Organization of the Report

This report summarizes insights from the 95 unique, responsive comments[2] to the AI RFI, which will help inform potential areas for future innovative advanced research and development programs to be funded and managed by ARPA–I.

This report is organized into the following sections:

- Section 2. Summary Data on the RFI Responses
- Section 3. Current AI Applications in Transportation
- Section 4. Opportunities of AI in Transportation
- Section 5. Challenges of AI in Transportation
- Section 6. Autonomous Mobility Ecosystems
- Section 7. Other Considerations in the Development of AI Applications in Transportation
- Section 8. Key Takeaways
- Appendix A. List of RFI Respondents
- Appendix B. Published RFI Text

Virtually all aspects of transportation and mobility—from the design, construction, operation, and maintenance of physical infrastructure systems to the emerging digital infrastructure that underpins and enables the movement of people and goods—will likely be impacted by the deployment of AI tools and applications. These changes will bring new benefits and risks with deep implications for the safety, accessibility, equity and resiliency of our mobility systems. Furthermore, it is difficult to anticipate the myriad ways that these AI-driven changes will reshape the ways individual users of the transportation system, communities, the private sector, and the public sector interact to shape mobility decisions. The diverse stakeholders who responded to the AI RFI gave ARPA-I a preview of the future AI may enable in the transportation system. This Report represents a synopsis of comments from the responses received and does not reflect DOT policy or opinions.

1.2.1 Cross-cutting Themes

Safety

Emerging AI-enhanced systems have the potential to improve transportation safety across modes, with implications for DOT's commitment to reaching its ambitious goal of achieving zero roadway fatalities within the next 30 years. Hardware advances in sensing, including Light Detection and Ranging (LiDAR) and improved visual range cameras, are likely to be coupled with improvements in data gathering and processing using AI to better understand the "why" of incidents and near-misses. This may also allow for active intervention to improve safety. From the potential to decrease human error-related incidents and near-misses in aviation, to the ability to place sensors in or near heavy use roadways to gather safety data, the possibilities to increase safety in transportation with AI are substantial.

[2] This number includes submissions directly received by ARPA-I and omits duplicative and non-responsive submissions.

While improving safety is a major goal of increasing the use of AI in transportation, it is worth noting that some concerns exist. The Air Line Pilots Association, International urges caution in the development and implementation of AI for aviation, recommending that any AI use in aviation be a supplement for human operators as opposed to a replacement. They urge particular caution for AI use cases that are in the passenger aviation sector. Safety is the top priority of the DOT and remains the priority for the DOT's focus on the development and deployment of AI in transportation.

Transit and Traffic Operations

Across the themes of current transportation applications, opportunities, and challenges, numerous respondents noted applications for AI in roadway and transit operations. These range from current applications such as computer vision technologies being employed in automated enforcement of vehicles impeding transit right-of-way (ROW), such as in bus-only lanes or at bus stops, to opportunities in AI for optimizing routing in urban areas. The use of AI in transit operations also addresses accessibility issues, another cross-cutting theme, for example in AI-powered technologies that detect if a rider may need enhanced access to board or disembark a transit vehicle. Challenges of AI applications in transit and traffic operations were also noted, including economic and workforce implications of AI-enabled automation in traffic operations, and in managing how probabilistic models may interact in unpredictable ways.

Accessibility

AI technologies have the promise to benefit people living with disabilities who may require assistive devices such as wheelchairs. Respondents referenced accessibility of the transportation system in particular regarding challenges and opportunities for AI. Namely, AI offers the opportunity to create enhanced trip planning tools that can make transportation more accessible. Using AI to inform users of arrival times, accessibility options, alternative routes, heavy use times, and person recognition in crosswalks were all touted as potential benefits. Challenges to effective deployment of AI in transportation were noted by some respondents, for example in preserving the equitable access to AI benefits and prioritizing safety of all road users (Advocates for Highway and Auto Safety). Additional challenges may arise from accessibility of AI-enabled technologies in transportation in rural and underserved areas (Ankura), emphasize the need for the DOT to consider accessibility from multiple perspectives.

Automated Vehicles

Respondents frequently cited automated vehicles (AVs) as the most prominent current use of AI in transportation. AV technologies were frequently noted in the opportunities as well. For instance, the Autonomous Vehicle Industry Association (AVIA) emphasized the economic opportunities of reduced congestion and increased safety which could reduce the number of insurance claims for AVs compared to human-driven vehicles. Challenges facing broader AV deployment were noted by several respondents, including the need for a comprehensive national roadway AV policy framework. The Association for Uncrewed Vehicle Systems International (AUVSI) additionally noted the need for aviation system of verification, validation, and certification to be made applicable to AI-enabled functionalities, and for a separate regulatory framework for automated vehicles in the maritime sector.

2. Summary Data on the RFI Responses

Of the 112 responses received, 95 were considered responsive to the RFI. These responses were from academic entities, Federally-funded research and development centers (FFRDCs), individuals, industry, labor, nonprofit, and public sector organizations, with the majority of responses from industry. The origin of each of the responses is summarized below:

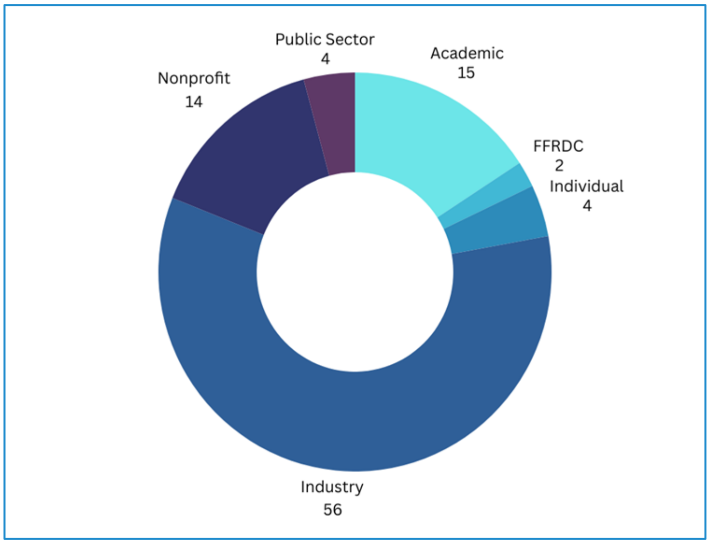

Figure 2. Count of the 95 AI RFI respondents by organization type.

The responses typically provided feedback closely tied to the respondent's area of expertise. ARPA-I identified several themes of interest to frame the responses. Based on the themes of interest, most responses discussed safety in at least one of the RFI question areas. Digital infrastructure and climate and resilience were the next most discussed themes. Fewer respondents noted AI information related to construction or advanced materials.

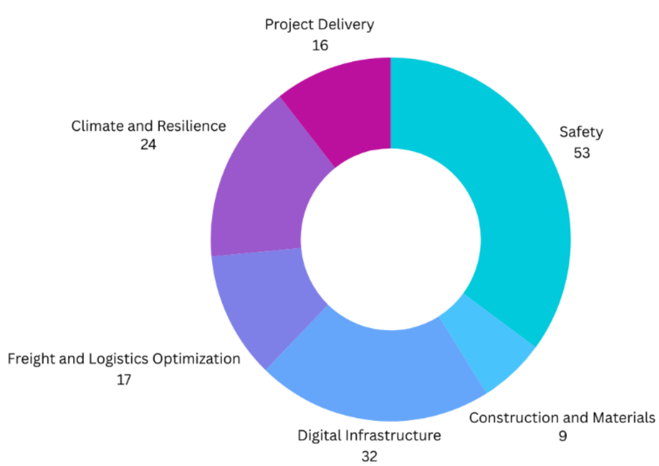

Figure 3. Count of respondents focused on key cross-cutting themes.

The majority of respondents did not respond to all focal questions in the RFI. Most respondents discussed the focal questions related to Current AI Applications, Opportunities of AI, and Challenges of AI in transportation. Approximately half the respondents addressed the penultimate question, regarding Autonomous Mobility Ecosystems.

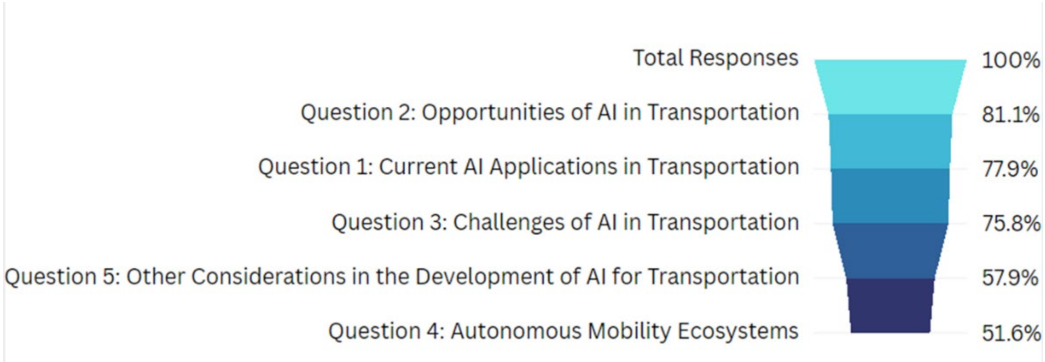

Figure 4. Percent of responses addressing each of the focal questions of the RFI.

3. Current AI Applications in Transportation

The RFI asked respondents to provide their identification of relevant, current, or near-term applications of AI in transportation, across the DOT priorities areas of safety, climate and sustainability, equity, economic strength and global competitiveness, and transformation. Of the wide range of responses, a set of emerging themes are summarized below, with a focus on roadway and transit operational applications.

3.1 Automated Vehicles

The most common response regarding current applications of AI in transportation focused on connected and automated vehicles (CAVs), as well as how AI models are currently supporting a wide range of technologies from Automated Driver Assistance Systems (ADAS) to full vehicle automation. Current vehicle automation applications mostly focus on steering, parking, and acceleration monitoring automations, which can optimize driving and contribute to safer vehicle operation. Respondents noted the current research by industry and academic institutions to raise the level of automation in passenger and commercial vehicles (University of Denver). One respondent (Virginia Tech Transportation Institute) suggested that automated driving systems (ADS) and traffic infrastructure in smart cities can use advanced sensors and computer vision methods to attempt to better understand driving behaviors.

Example responses: University of Denver; Cyber Florida; MITRE Corporation; Dell Technologies.

3.2 Transit Operations

Private companies are using computer vision for automated enforcement of vehicles impeding transit right-of-way (ROW), such as in bus-only lanes or at bus stops. Blocked bus stops present an accessibility problem for many riders who require directly boarding or exiting a bus onto a sidewalk, rather than into an active travel lane. This same style of automated enforcement can be used for any vehicle parking in bike lanes, blocking intersections, or other impediments. Another use of such technology is through vehicle type and volume estimation. This can be used for planning and roadway project impact evaluations.

The Institute of Transportation Engineers note from their member survey that red light running prediction, detection devices for traffic mobility, predicting mechanical failure, and object detection to help with identifying near-misses and predicting roadway vehicle usage are all currently utilized functions of AI in transportation. Generally, for transit and roadway operations, multimodal generative AI models are an upcoming technological innovation that adds new capabilities, such as the ability to perform rich image and video analysis or vehicle sensor data processing. Respondents noted that large language models (LLMs) are currently in use to enhance operational efficiency by improving scheduling systems and enabling predictive maintenance for rail and transit systems.

Example responses: Hayden; MetroLab Network; ENSCO.

3.3 Roadway Traffic Operations and Safety

Respondents discussed use of predictive analytics for roadway traffic operations, to reduce congestion-related crashes, optimize for reduced greenhouse gas (GHG) emissions from idling vehicles, and improve efficient movement of people to their places of work. These type of analytics approaches currently use AI methods such as deep neural networks (DNN) and reinforcement learning. For example, DelDOT and Missouri DOT use AI to support traffic management and detect incidents on their major highways (Noblis).

In addition to optimizing for traffic operations, numerous agencies use computer vision from video feed images for real-time traffic congestion and traffic volume estimation, and to detect hazards on the roadway, erratic driver behavior, or traffic violations. One such AI implementation is through the use of convolutional neural networks (CNNs) that help retrieve data from video to give information about stop lines, traffic signals, and other traffic-related information. This, in turn, allows for better understanding of near-miss information and allows officials to make decisions about particular aspects of traffic management and safety devices (Viva). These applications of AI can be effective for reducing the human toll of crashes and align with the primary U.S. DOT mission of ensuring safety of the transportation system. Sensor-based technology is in use to help with understanding the flow of traffic and helping with real time decision making related to ramp metering. The ability to route not only fleets of trucks, buses, rideshares, or other vehicles, but also route individually based on real-time conditions for drivers could improve roadway management and congestion, and in turn, lead to fewer accidents (MITRE Corporation).

Weather can create challenges that impact travel conditions and safety. The Artificial Intelligence for Traffic and Weather program that US Ignite is running in coordination with the US Army Corps of Engineers at Fort Carson, CO, seeks to better respond to such safety concerns. Through the use of weather data inputs and AI methods, they are able to make real-time decisions on travel recommendations for service members traveling to and from the military installation without having to rely on potentially variable local reports on conditions.

Example responses: Cambridge Consultants, referencing Clearway; MetroLab Network; Noblis.

3.4 Parking Management

Respondents noted the current use of parking management systems and smart parking technology that allows users to have real-time information about the status of parking availability. Not only does this save time and effort, but it lowers emissions by reducing idling and time spent searching for parking. Ankura Consulting Group, LLC also points out that parking in some cities is managed by AI systems using sensors and computer vision which helps reduce congestion and improve traffic flow.

Example responses: Cambridge Consultants, referencing Parquey; Ankura Consulting Group, LLC.

3.5 Roadway Asset Monitoring

Companies and public sector roadway infrastructure owners-operators (IOOs) have been using AI to detect and monitor the condition of roadway assets for several years. Examples include detection of potholes and pavement condition monitoring using either dedicated vehicles with specially calibrated camera instruments or by using crowdsourced computer vision data from cameras (Noblis). The ability to process large amounts of information with multimodal large language models and natural language processing to get construction history data from text documents could help with infrastructure maintenance and improvements (Callentis Consulting Group). Many other respondents noted that the ability to use tools such as computer vision, sensors, and video with AI allow for more efficient monitoring of roadway assets compared to manual monitoring.

Example responses: Cambridge Consultants, referencing RouteReports; xWeather; MetroLab Network, Institute of Transportation Engineers; Bentley Systems, Inc.

3.6 Air Travel and Airport Uses

Numerous respondents noted applications of AI in air travel, from computer vision applications on drones to optimizing airline schedule planning. The use of AI with video allows airports to detect drones in the area and can differentiate between birds to allow for a potential response (Axon Enterprise, Inc.), and for drone delivery to take advantage of machine learning approaches for detecting safe landing sites (Microsoft). AI can also help with aircraft and vehicle movement within the airport to ensure near misses are avoided and better understood when they occur. Notably, the Small UAV Coalition offered that highly-automated commercial drone operations currently do not require AI/ML applications to be operated safely.

Identification of risk is a major aspect of aviation and current use of rule-based algorithms have been transformative in the aviation safety industry. Booz Allen Hamilton proposed improving that process with machine learning applications similar to the use of deep learning in Safety Management System programs. Deep learning is applied to transcribe pilot-controller voice transmission to text and an effort is being made to detect long landing events. Finding ways to merge current technology to future advancements could lead to prevention of incidents and understanding them more thoroughly when they occur. The Air Line Pilots Association, International note that while such applications are currently being employed, integration of AI into aviation systems will require a cautious approach for pilots, air traffic controllers, and passengers to achieve the maximum benefit from these technologies.

4. Opportunities of AI in Transportation

4.1 Automated Vehicles

Many of the respondents referenced the likely increase in both partially and fully automated vehicles in the future of transportation. The University of Denver response suggests that future advancements in automated vehicles will lead to fewer crashes, more efficient use of the roadways, and less traffic congestion, and vulnerable road user safety. Such advances in AVs were referenced by several respondents to potentially have transformative benefits to the transportation sector. Dell noted that automated freight systems could streamline logistics and supply chain operations. At least one respondent noted the potential for automated vehicles to transform the safety and efficiency of the transportation industry (including Institute of Transportation Engineers). CCD Transportation Task Force highlighted how automated vehicles could improve access for those using a wheelchair if they are designed with those users in mind. MITRE Corporation gave the example of uncrewed shipping as a way that automated vehicle technologies could enhance shipping and transportation.

Cyber Florida discussed the opportunities associated with combining driving automation with Vehicle to Vehicle (V2V) communications. As more vehicles on the road become automated, vehicles may be able to communicate their future movements with other automated vehicles, allowing for an opportunity to platoon vehicles.

National simulation frameworks were also proposed by several respondents, to assess AV technology impacts at a large scale. For example, Cambridge Consultants proposed the use of three open-source modeling frameworks, MATSIM, POLARIS, and BEAM, to assess impacts of AV technology on roadway safety in a transparent, explainable, and reproducible way.

4.2 Computer Vision and Asset Management

AI offers the opportunity to automate video analysis, which can lead to much more periodic and precise tracking of transportation assets. Currently, this data collection can be expensive and infrequent or can rely on citizen reporting. Future opportunities include using computer vision AI models to collect high-frequency reporting on inventory and condition on a city-wide scale for all transportation assets (Hayden AI). Missing signage or safety-critical infrastructure, such as bollards, can lead to dangerous conditions, so near-real-time data on assets from computer vision can allow for fast response when assets are damaged or go missing. Respondents also noted the potential for a system that can predict infrastructure and vehicle maintenance needs.

The use of LiDAR to monitor assets, such as airport runway conditions, could improve the efficiency of maintenance to ensure that human effort is spent in the most pressing places (Coalition for Safe and Secure Technology). Adding in the ability to assess concrete and pipes in a more streamlined way could also be beneficial, according to Gecko Robotics. Gecko Robotics and Huntridge Labs, LLC (SDVOSB) both mention the use of AI to manage the country's aging bridge infrastructure for potential issues in need of repair or replacement. Advancements in aircraft routing and efficiency of the use of National Air Space as well as the use of AI to improve landings is another recommendation (The Port Authority of New York and New Jersey). The creation of an integrated freight and logistics system that includes automated trucks, drones, sidewalk robots, and utility vehicles was recommended by Leidos. Roadway user predictive analytics and AI powered inspections were also discussed as potential improvements to asset management as AI technology continues to evolve.

4.3 Logistics, Planning, and Project Delivery

Accurate estimation of the time and cost of a project is difficult and often elusive. The utilization of massive amounts of historical project planning data can be processed with AI and delivered back to project managers to improve time and cost estimations. Through the use of AI, nPlan stated that they are able to improve project delivery timeliness through a more data-driven approach to potential pitfalls, delays, or risks that may arise. The use of LiDAR before digging in construction sites is a way that the American Road & Transportation Builders Association is improving safety and cost for projects. They have an AI-based system that is able to determine where the underground areas that need to be avoided might exist. Planning for transportation often must consider how a new roadway or other transportation entity will impact the environment. Stephanie Vail-Muse proposed that AI could be leveraged in the future to more thoroughly understand these challenges and create plans to adequately address such concerns.

4.4 Safety Improvements

Making use of generative AI to interpret data for engineers, giving them the "why" of a near-miss in plain language may increase their ability to act quickly for a solution, assuming the advancements in generative AI are such that trust is high (ITS America). Tools such as incident detection, simulations of attacks and failures, and improvement of infrastructure readiness can all lead to an increase in safety for all types of road users (Virginia Tech Transportation Institute). The ability for emergency response teams to optimize their routes through communication between connected vehicles and emergency vehicles could improve outcomes in emergencies (U.S. DOT UTC CYBER-CARE Center). Crews could also have access to patient data in real time that might help improve care through quicker understanding of the patient's unique medical conditions (Joshua Legler).

The Texas Department of Transportation stated, "With pattern recognition, AI holds promise in finding connections hidden in voluminous data. Rather than being a solution in search of a problem, AI could be the solution to problems across various transportation sectors that we do not currently recognize." The recognition of such patterns could lead to safety solutions that have not yet been considered. Similarly, applying predictive models to traffic patterns and infrastructure to prevent accidents and near misses was proposed by MetroLab Networks as a way to work towards Vision Zero.

One proposal, by Cambridge Consultants, outlined a transformational concept ("moonshot" idea) that they refer to as a 'Safety Overseer'. Such a system could integrate multiple modes of transportation with multiple technologies to monitor the safety of the transportation system and recommend safety interventions. This system could be developed with the intention of achieving the Vision Zero goals of the National Roadway Safety Strategy.

AI-enabled design, construction, and operation processes of transportation infrastructure was noted by several respondents, as well as considering infrastructure performance prediction to improve safety (Alliance for Automotive Innovation; Callentis Consulting Group).

4.5 Accessibility

Both The Consortium for Constituents with Disabilities Transportation Task Force and The Patient Helpline provided perspectives of those living with disabilities, noting that public transportation can be particularly difficult to navigate for those living with a disability. The use of machine learning, deep learning for computer vision, perception, sensor fusion, and real-time decision-making tools were noted to be potentially helpful for accessibility, safety, and optimization features. Using AI to inform users of arrival times, accessibility options, alternative routes, heavy use times, and person recognition in crosswalks were all touted as potential benefits. The American Council of the Blind also recommends specific improvements to transportation using AI that can improve the accessibility of transportation for those with vision impairment and blindness. A related, but relatively unique look at improving transportation for wheelchair users, was offered by the United Spinal Association. Their recommendation to use AI as a staff training tool to help the transportation industry offer better services to wheelchair users was a novel idea for improving accessibility for a group of vulnerable road users.

4.6 Cybersecurity Opportunities

While most respondents cited cybersecurity concerns as potential drawbacks to the use of AI, some respondents described an opportunity to leverage the technology to improve cybersecurity operations. One such measure was noted by Cambridge Consultants which would allow for autonomous cyber defense for connected vehicles and their infrastructure through either roadside units or a connected system of intrusion detection. Leidos mentioned the possibility of improving cybersecurity by focusing on V2X, connected vehicles and applications, as well as digital infrastructure.

In general, respondents focused on the cybersecurity posture of transportation AI systems themselves, for example the Florida Center for Cybersecurity called for a program to audit AI models. Respondents did not focus on the use of AI for anomaly detection, either in-vehicle or on collected data, or the use of AI to perform cybersecurity assessments on transportation systems.

4.7 Air Traffic Applications

AI applications have the opportunity to benefit air traffic, with applications in air traffic flow management. For example, the MITRE Corporation noted the opportunities with mitigating the workload of air traffic controllers, as a collaborative tool to support aviation Traffic Flow Management. This concept is related to comments from the Air Line Pilots Association, International, who noted the potential for AI applications in information management and safety monitoring in aviation systems, while also cautioning that AI technology integration must be vetted through traditional risk management practices.

Advanced Air Mobility (AAM) was noted by some respondents, including one respondent (Dell Federal Systems) proposing "autonomous flying cars" as a way to bolster safety in transportation, and with a mixed environment of autonomous and piloted vehicles envisioned by another (Association for Uncrewed Vehicle Systems International; AUVSI) for a future Urban Air Mobility (UAM) system where AI-enhanced Air Traffic Management is envisioned.

5. Challenges of AI in Transportation

5.1 Keeping Data Private and Unbiased

In addition to the numerous opportunities AI applications in transportation offer, respondents noted several challenges that need to be addressed. Nearly all respondents mentioned data, in terms of the volume, variety, and governance of the data used to underpin AI applications in transportation. Both the creation and the management of data bring significant challenges from a data infrastructure perspective as well as the computation requirements that would be necessary.

Respondents (including NJ Transit, Callentis Consulting Group, and The Future of Privacy Forum, and Exodigo) mentioned the importance of ensuring that data adheres to privacy laws in place as well as keeping data as free from bias as possible. A number of respondents noted that as the volume of data collected from vehicles and the operators of those vehicles, coupled with V2V and V2X communication, the privacy of data itself will be a key challenge in managing AI applications (Cyber Florida).

Real concept drift was mentioned (Metron) as a potential concern with machine learning models in transportation. Namely, this issue can arise as traffic patterns change due to policy or weather-related events, and the need to frequently update machine learning data is paramount to reducing drift.

5.2 Regulatory Considerations

Respondents recommended that balancing innovation with safety requires regulatory oversight to ensure that innovation is not stymied, and that public interest is kept in the forefront of any AI implementation in transportation. As the growth of AI continues, so too will the need to adjust existing regulations and adopt new ones to handle new concerns. Respondents (including Microsoft, Small UAV

Coalition, Association for Uncrewed Vehicle Systems) called for a balance of sensible regulations to keep from negating growth. At least one other respondent mentioned the need to ensure "competitive balance" as the technology continues to grow (Cambridge Consultants).

5.3 Cybersecurity Challenges

Cybersecurity was mentioned by most respondents as a potential challenge related to the implementation of AI in transportation. Several respondents (including Leidos) shared the sentiment that security will need to be a vital component of such advancements in transportation, particularly with the use of public data. Deloitte considered the importance of a robust cybersecurity program; one that focuses on the specific needs and vulnerabilities related to AI and data, to be of the utmost importance as AI is further integrated into transportation. Many respondents (including Deloitte, MetroLab, ITS, TCG, American Road & Transportation Builders Association, American Society of Civil Engineers, Cambridge Consultants, DiploAI, New York State MTA, The Port Authority of NY and NJ, U.S. DOT UTC Cyber-Care Center, and Southwest Research Institute) shared concerns related to keeping data secure. Respondents also stressed the importance of developing new ways to manage the cybersecurity challenges that lie ahead with increases in the use of AI in transportation. In general, respondents focused on both traditional cybersecurity concerns, as well as the cybersecurity risks associated with the AI software stack and models themselves, such as cybersecurity challenges due to the complexity of AI algorithms.

5.4 AI Assurance

AI assurance refers to the techniques, activities, and processes used to evaluate and assure expected properties of AI components or AI-enabled systems throughout the lifecycle of these components or systems[3]. Numerous respondents noted the need to reconsider how AI technologies are managed and deployed, to move from specifying standards for specific applications of AI towards a more general trust framework. Such an effort is paramount to ensuring a balance between innovation and safety. As AI continues to enter the public space and the ubiquitous transportation sector, improving the general public's understanding and trust of AI will be necessary for the integration of such technology. Software companies, such as Bentley Systems, are working to develop large language model (LLM)-based assistants that are able to summarize design standards and assist with compliance.

Trust frameworks are an important aspect of AI assurance. Booz Allen Hamilton noted in their response that trustworthy AI models are those which can be explainable (XAI) and have formal tests and verification; autonomous mobility systems will need to have trustable models as a foundation. Cambridge Consultants proposed a human-centric trust frameworks in transportation, emphasizing the need for AI assurance, noting that 'ensuring trust is paramount for effective adoption and growth' of AI

[3] https://www.transportation.gov/hasscoe/highlights/AI-assurance

solutions in transportation. The Air Line Pilots Association, International, built on this need for trustable AI by emphasizing that trust needs to extend to the data underlying the models, as well as the goals of the AI solutions to improve safety to the highest degree possible, not simply to automate tasks done currently by humans. In general, AI assurance a rich topic with opportunities for improvement across modes of transportation.

5.5 Integration with Legacy Systems

Current transportation infrastructure was not designed with AI in mind, which could make a seamless integration difficult, according to MetroLab Network. Much of the data that is gathered in public spaces is currently from cameras. One respondent (Viva) noted the difficulty of using AI models with those cameras because of the relatively poor video quality leading to inaccurate data. The improvement of digital infrastructure, and the data that is used to implement AI systems, is a huge task that the American Society of Civil Engineers called upon ARPA-I to oversee as AI becomes more ubiquitous in transportation. In order for AI to be realized to its fullest potential, infrastructure modifications will have to be made, according to many respondents.

5.6 Public Perception of AI and Trust

With the many recent advancements in AI, the general public may be relatively unfamiliar with how the technology works. Companies that may have an interest in protecting their investments are not as likely to share information about how their technology works "under the hood". This has led to what is sometimes referred to as the AI black box problem. MetroLab Network pointed out that local governments may be hesitant to adopt such technologies due to this concern. Likewise, Dell Technologies shared that trust may be low due to public concern about reliability and safety of AI-related technology. The general public is also likely to be skeptical of AI due to the potential for future job displacement.

5.7 Workforce Displacement and Evolution

Respondents commented that the automation of many tasks currently done by humans could cause workers to lose jobs or need to be re-trained. Such concerns were highlighted by the responses from several of the respondents. Another area of concern is the possibility of technical errors in safety critical-settings such as truck driving or piloting an airplane (Air Line Pilots Association, International, Owner-Operators Independent Drivers Association). Those respondents noted that the possibility of loss of jobs and loss of life in those settings demands caution. Microsoft noted their partnership with AFL-CIO to discuss and anticipate needs of labor as AI technologies are increasingly deployed.

5.8 Explainability, Interpretability and Evaluation of AI Models

As noted, AI technology is a difficult concept to understand, and an even more difficult concept to explain. There has been a push for something termed 'explainable AI' (XAI) but there is no single approach or framework that gives consistent interpretations of how models work and interact with data. Respondents consistently touched upon the lack of explainability as a concern (including the Air Line Pilots Association, International, and MetroLab Network). Given the overall lack of transparency related to AI, it is difficult to evaluate models and test them. This leads to even less ability to explain the technology and may lead to more skepticism.

5.9 Legal Issues

The transportation and public legislative landscapes are complex and ubiquitous. Implementing AI into that complex network of regulations and legality will require careful consideration to ensure a smooth implementation (Dell Technologies). At least one respondent (NJ Transit) referenced the currently unresolved legal considerations that may present as AI becomes more integrated into transportation. Regulating and governing change is always difficult and MetroLab Network reports that "preemption is top of mind for many state, regional, and local governments". They note that government entities want to know how to handle potential errors or AI-related accidents that could impact their constituents. Respondents call on the DOT to help shape these impending regulations.

5.10 Bias and Equity Issues

Data, particularly historical data, have inherent bias. Respondents (including University of Minnesota and Cambridge Consultants) discussed the challenges that are presented from using such data and urged caution to ensure that any efforts to use data do not reinforce such societal biases. As the Patient Helpline noted, facial recognition, for example, is much less accurate at recognizing people of color or those that require assistive devices such as canes, walkers, or wheelchairs. At least one respondent (NJ Transit) recommended that AI cater to a diverse population which includes vulnerable road users.

6. Autonomous Mobility Ecosystems

The E.O. specifically requested that DOT ask stakeholders about AI's potential impacts on "autonomous mobility ecosystems", which can include the development and integration of multiple technologies from driving automation, mapping, machine vision, Vehicle-to-Everything (V2X) connectivity, and more to create safe and efficient self-driving transportation system.

6.1 Opportunities

Many of the previously discussed topics such as assurance, computer vision, and operations clearly play a role in creating autonomous mobility ecosystems. However, MetroLab Networks identified key opportunities for AI to respond to enhance safety by responding to hazards faster than humans and reducing human error, creating optimized routing to enhance driving efficiency, and leveraging autonomy to increase accessibility options for disabled, elderly, and younger populations. The American Society of Civil Engineers extended the concept to include the use of sensing on autonomous vehicles to help identify emerging maintenance issues and to inform road system enhancements.

6.2 Challenges

Stakeholders identified a number of barriers to creating an autonomous mobility ecosystem, primarily in policy and regulatory challenges, not the underlying technologies. MetroLab Networks cited data and privacy concerns, as well as the lack of federal guidance on AV systems. The Autonomous Vehicle Industry Association echoed these concerns by noting that AV specific regulation is likely necessary, which could be integrated with existing National Highway Traffic Safety Administration (NHTSA) and Federal Motor Carrier Safety Administration (FMCSA) policies. Both MITRE Corporation and Noblis noted the need for more data and transparency in understanding and contextualizing the risks associated with autonomy for both individuals and regulators.

6.3 Risks

Respondents grouped risks into three primary categories: cybersecurity, job displacement, and safety. The risk of systems being hacked by malicious actors was flagged by multiple groups, with particularly emphasis from the U.S. DOT UTC CYBER-CARE Center. Both MetroLab Networks and the Owner-Operators Independent Drivers Association (OOIDA) potential impacts on the individuals, companies, and communities that may be disrupted by automation. Finally, both OOIDA and Advocates for Highway and Auto Safety cautioned against rapid deployment of autonomy without fully vetting the systems to ensure their transparency, safety, and reliability.

7. Other Considerations in the Development of AI for Transportation

In addition to the above areas covered in this RFI, respondents also proposed a variety of advances related to testing, governance, budgetary concerns, and research and development. Some respondents (including Cambridge Consultants, Callentis Consulting Group and MEMA) made recommendations to either use AI as a tool for training or to increase training related to AI for employees. Education and training are bound to be vital with such impactful changes in technology.

AI-enabled design of sustainable and resilient infrastructure materials and structures, using physics-informed AI/ML models, as well as AI-enabled smart materials were as an opportunity by Callentis Consulting Group. Advanced construction methods and materials for infrastructure were noted by additional respondents, although this was not a large focus for most responses.

The UCLA Mobility Lab offered the potential to improve simulations with The Mobility System Digital Twin framework that they state offers the ability to improve the simulations of AI networks and AI agents. Their proposal would be used in concert with Connected and Automated Vehicles (CAV) to allow for a better understanding of traffic patterns without the risks of involving humans. Twinning could be beneficial for impact assessments, policy support, mobility solutions, and integration between humans and AI, according to the UCLA Mobility Lab.

At least one other respondent (including Cambridge Consultants) discussed testing and testbeds and brought up the importance of having firewalled development on high-performance computing clusters. They offer that this could allow for more robust red team cybersecurity operations.

Several more respondents reported the need for more investment into research and development and urged ARPA-I and DOT consider holding competitions for innovation in the realm of AI in transportation (Exodigo, Humatics Corporation, MEMA, DiploAI, Subhadip Kumar, Southwest Research Institute, Alliance for Automotive Innovation).

8. Key Takeaways

The AI RFI responses provide ARPA-I with a snapshot of the AI enabled technologies that will power the future of the transportation system, as well as their associated opportunities, challenges, and risks that may present to users.

Respondents provided numerous current transportation-focused uses of AI across all modes. These use cases support agency functions in operations, asset management, planning, analysis, and interfacing with the public. Current trends in AI are transforming traffic operations and logistics through advanced data analytics and real-time monitoring. Recent innovations include automated vehicles, drone delivery systems, and pedestrian detection, which enhance safety and efficiency in urban environments. Respondents noted that AI is leveraged for airline scheduling, traffic flow optimization, and energy price prediction, while technologies like digital twins and asset condition monitoring enable proactive asset management. Additionally, AI-driven safety analytics improve risk assessment of aviation operations and road traffic. This leads to more efficient decision-making and a reduction in human error, according to respondents. Overall, AI usage is paving the way for future advancements that may improve efficiency, safety, and operations management in transportation.

Future considerations for AI in transportation were recommended in a wide variety of areas broadly defined as asset management with computer vision, AI assurance, logistics, planning, project delivery, safety, accessibility, automated vehicles, as well as potential cybersecurity advancements. Improvements in aviation safety and efficiency were two other areas of possible progress mentioned by respondents. Many respondents also recommended an increase in the use of digital twins to simulate various aspects of transportation such as traffic, roadway structures, pedestrians, and human behaviors. This allows for testing new technology and ideas without putting humans at risk. Respondents point out that increasing the efficiency of collating vast stores of data to accurately predict and understand near-miss incidents may lead to important safety developments across several modes of transportation. Recommendations for future exploration that ARPA-I could support included the utilization of AI to better predict and understand traffic flows to better optimize traffic efficiency. Excitement for the future of transportation is palpable. That said, respondents point out that key challenges should be resolved before AI is fully integrated into transportation.

Respondents noted several areas that will present challenges as transportation moves towards integrating AI into regular operation. Those challenges were related to public perception and trust of AI, use of data, potential bias, legal concerns, workforce displacement, regulatory considerations, integration with legacy systems, difficulty explaining AI, and cybersecurity challenges. Many respondents urged caution as AI becomes more advanced and increasingly utilized in transportation. Respondents stated a significant amount of attention on these challenges will help create a smoother integration of AI in transportation. They noted the importance of training for the workforce and education for the public as key areas to improve public trust in AI. Any advancements made to the transportation industry have to be balanced with the safety and privacy in mind.

There were other areas mentioned by respondents that were not as closely tied to the broad categories described above. One response included the proposal to use AI to train transportation employees on best practices for working with travelers with disabilities and assistive devices. Other responses mentioned digital twinning and creating testbeds for validating AI. Several respondents also felt that ARPA-I can lead the way by creating opportunities for more research and development to better understand the implications of AI in transportation. DOT support for industry innovation with ideas such as competitions and incentives were cited by some respondents as ways to increase creativity and foster innovation. Responses related to vulnerable road users cited that as technology continues to increase in the public transportation sector, so too does the need to consider those with assistive devices such as wheelchairs or walkers. Vulnerable road users (VRUs) having access to real-time information on accessible seating availability was also mentioned as an area AI may be able to improve. Using AI technology to improve overall access for VRUs is yet another area several respondents discussed.

An area of much discussion was automated vehicles (AVs). Respondents discussed the potential for autonomous mobility ecosystems and what opportunities, challenges, and risks lie ahead. Aspects of transportation respondents thought may improve with autonomous mobility ecosystems varied. Responses broached an array of topics such as routing optimization and reduction in human error (MetroLab Network). Improved accessibility for those who may not be able to operate a vehicle due to physical limitations or age was another consideration. Some respondents touted the faster responses of AI compared to humans as a potential safety improvement AVs could offer over their human counterparts. Infrastructure management through the use of automated scanning using AVs (American Society of Civil Engineers) was also noted as a significant opportunity.

The challenges and risks described were similar to responses related to AI in transportation, in general, with some specific differences related to AVs. Concerns raised were generally related to safety, infrastructure inadequacies for AVs, potential incompatibility with human drivers, regulation deficits, cybersecurity concerns and vocational displacement. The Owner-Operators Independent Drivers Association expressed concerns over the livelihood and well-being of independent truck drivers as Advocates for Highway and Auto Safety urged caution and recommended proper safeguards be put into place before implementation of AVs is widely adopted.

The responses to this RFI highlight the enormous challenges and opportunities for AI in transportation. Building on efforts across the federal government, such as the NIST AI Risk Management Framework, and the National AI Advisory Committee (NAIAC), will support the work of DOT and ARPA-I in facilitating the development of AI in transportation. Respondents largely agreed that significant regulatory and cybersecurity challenges lie ahead. There was an emphasis on the need for unified and sensible regulatory approaches, and ARPA-I investment in emerging AI technologies could support the development of these frameworks. Numerous innovative uses of AI are already being utilized and tested in areas such as safety, asset management, traffic optimization, and parking management. The cautious optimism that AI use cases will continue to increase and create more opportunities in transportation was evident by the majority of responses.

There were several recommendations for ARPA-I and DOT to remain proactive and maintain open communication regarding safety and AI innovation, which underscores the opportunities for exploration and innovation as AI becomes more prevalent in the discussion of transportation. Numerous respondents expressed support for ARPA-I's mission to fund transformative new technologies, systems, and capabilities to improve transportation infrastructure in the United States. Specific recommendations for ARPA-I involvement include Microsoft's recommended use of ARPA-I to facilitate research and pilot AI applications in transportation, prioritizing funding for pilot projects which can lead to shared learning across the DOT, and promoting AI trustworthiness incorporation into standard approaches. Deloitte recommended ARPA-I promote a framework for explainable AI to increase transparency and the rate of adoption of AI solutions. The American Society of Civil Engineers recommended ARPA-I support investment in AI assessment and assurance tools. These recommendations highlight the overall themes of transparency, AI assurance, and safety that the many thoughtful responses provided.

Appendix A: List of RFI Respondents

A total of 95 unique, responsive comments to the RFI were received and assessed by U.S. DOT. Thak you to all RFI respondents for their time and effort in responding to the Request for Information.

Number	Respondent	Type of Respondent
1	New Jersey Transit Corporation ("NJ TRANSIT")	Public Sector
2	New York State Metropolitan Transportation Authority (MTA)	Public Sector
3	Texas Department of Transportation	Public Sector
4	The Port Authority of New York & New Jersey	Public Sector
5	Advocates for Highway and Auto Safety	Nonprofit
6	American Council of the Blind	Nonprofit
7	American Road & Transportation Builders Association	Nonprofit
8	American Society of Civil Engineers	Nonprofit
9	Association for Uncrewed Vehicle Systems International (AUVSI)	Nonprofit
10	Autonomous Vehicle Industry Association	Nonprofit
11	Consortium for Constituents with Disabilities (CCD) Transportation Task Force	Nonprofit
12	Fiber Optic Sensing Association (FOSA)	Nonprofit
13	Richard Govada Joshua / IEEE	Nonprofit
14	The Future of Privacy Forum	Nonprofit
15	The Patient Helpline	Nonprofit
16	United Spinal Association	Nonprofit
17	MetroLab Network	Nonprofit
18	International Brotherhood of Teamsters	Labor
19	Air Line Pilots Association, Int'l	Labor
20	AISP	Industry
21	Alliance for Automotive Innovation	Industry
22	Ankura Consulting Group, LLC	Industry
23	Applied Intuition, Inc.	Industry
24	Arcadis	Industry
25	Axon Enterprise, Inc.	Industry
26	Bentley Systems	Industry
27	Booz Allen Hamilton Inc.	Industry
28	Booz Allen Hamilton Inc.	Industry
29	Callentis Consulting Group	Industry
30	Coalition for Safe and Secure Technology	Industry
31	Cyber Florida: The Florida Center for Cybersecurity	Industry
32	Dell Federal Systems L.P. ("Dell")	Industry
33	Deloitte Consulting LLP	Industry
34	ENSCO, Inc	Industry

35	Ensense AI	Industry
36	Exodigo	Industry
37	GE Aerospace	Industry
38	Gecko Robotics	Industry
39	Geographic Paradigm Computing, Inc.	Industry
40	Google Public Sector	Industry
41	GridMatrix	Industry
42	HAAS Alert	Industry
43	Hayden AI	Industry
44	Humatics Corporation	Industry
45	Huntridge Labs, LLC (SDVOSB)	Industry
46	Illinois Hispanic Chamber of Commerce	Industry
47	Institute of Transportation Engineers	Industry
48	Intel Corporation	Industry
49	Ito World	Industry
50	ITS America	Industry
51	Kyle Visner	Industry
52	Leidos	Industry
53	MEMA	Industry
54	Merlin Labs, Inc.	Industry
55	Metron, Inc.	Industry
56	Michelin Mobility Intelligence	Industry
57	Microsoft	Industry
58	Noblis	Industry
59	nPlan ltd	Industry
60	Owner-Operator Independent Drivers Association (OOIDA)	Industry
61	RTX Technology Research Center	Industry
62	Samsara Inc.	Industry
63	SAS Institute Inc.	Industry
64	Small UAV Coalition	Industry
65	SONDA USA INC	Industry
66	Supernal LLC	Industry
67	TCG Inc.	Industry
68	TechFocus LLC	Industry
69	Trenchant Analytics LLC	Industry
70	Trimble Inc	Industry
71	US Ignite	Industry
72	Viva	Industry
73	Cambridge Consultants Inc.	Industry
74	DiploAI	Industry
75	Bob Fix	Individual

76	Joshua Legler	Individual
77	Shyla Patera	Individual
78	Stephanie Vail-Muse	Individual
79	MITRE Corporation	FFRDC
80	Southwest Research Institute	FFRDC
81	Afolabi Adeniyi	Academic
82	Consortium of three universities (UC Irvine, U. of Arizona, U. at Albany)	Academic
83	Jeff Ban	Academic
84	Pacific Northwest Transportation Consortium (PacTrans), U.S. DOT University Transportation Center for Federal Region 10	Academic
85	Subhadip Kumar	Academic
86	The Ohio State University	Academic
87	The U.S. DOT UTC CYBER-CARE Center	Academic
88	UCLA Mobility Lab - Mobility Systems Team	Academic
89	University of Arizona	Academic
90	University of California, Davis	Academic
91	University of California, Los Angeles (UCLA)	Academic
92	University of Denver	Academic
93	University of Minnesota, Twin Cities	Academic
94	Virginia Tech Transportation Institute	Academic
95	Yasamin Moghaddas	Academic

Appendix B: Published AI RFI Text (May 2024)

Text available at https://www.federalregister.gov/documents/2024/05/03/2024-09645/opportunities-and-challenges-of-artificial-intelligence-ai-in-transportation-request-for-information.

SUMMARY

The U.S. Department of Transportation's Advanced Research Projects Agency—Infrastructure (ARPA-I) is seeking input from interested parties on the potential applications of artificial intelligence (AI) in transportation, as well as emerging challenges and opportunities in creating and deploying AI technologies in applications across all modes of transportation. The purpose of this Request for Information (RFI) is to obtain input from a broad array of stakeholders on AI opportunities, challenges and related issues in transportation pursuant to Executive Order (E.O.) 14110 of October 30, 2023 entitled "Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence".

SUPPLEMENTARY INFORMATION

Advances in artificial intelligence (AI) bring significant potential benefits and risks, and they have the potential to transform American society with deep implications for safety, access, equity and resilience in the transportation sector. Virtually all aspects of transportation and mobility—from the design, construction, operation, and maintenance of physical infrastructure systems to the operation of the digital infrastructure that underpins and enables the movement of people and goods—will likely be impacted by the deployment of AI tools and applications. Beyond the direct impact of the technology itself, AI has the potential to reshape how individuals, communities, corporations, governments, and other users interact with the transportation network in ways that are difficult to anticipate. In recognition of AI's rapidly evolving capabilities and implications across all facets of government, society and our economy, the Biden Administration issued Executive Order (E.O.) 14110 on *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence* on October 30, 2023. In section 8, "Protecting Consumers, Patients, Passengers, and Students", under Sub-section (c), the E.O. directs the U.S. Department of Transportation to "promote the safe and responsible development and use of AI in the transportation sector, in consultation with relevant agencies". Paragraph (iii) under sub-section (c) further requires that ARPA-I "explore the transportation-related opportunities and challenges of AI—including regarding software-defined AI enhancements impacting autonomous mobility ecosystems". This RFI seeks information that will assist ARPA-I and the U.S. Department of Transportation (DOT) in carrying out their responsibilities under section 8 (c)(iii) of E.O. 14110 noted above.

About ARPA-I

The *Advanced Research Projects Agency—Infrastructure (ARPA-I)* is an agency within DOT (see *https://www.transportation.gov/arpa-i*) that Congress established "to support the development of science and technology solutions that overcomes long-term challenges and advances the state of the art for United States transportation infrastructure." (Pub. L. 117-58, section 25012, November 15, 2021; 49

U.S.C. 119). ARPA-I is modeled after the Defense Advanced Research Projects Agency (DARPA) within the U.S. Department of Defense and the Advanced Research Projects Agency-Energy (ARPA-E) within the U.S. Department of Energy. ARPA-I offers a once-in-a-generation opportunity to improve our nation's transportation infrastructure, both physical and digital, and supports DOT's strategic goals of Safety, Economic Strength and Global Competitiveness, Equity, Climate and Sustainability, and Transformation. ARPA-I focuses on developing and implementing technologies, rather than developing policies and processes or providing regulatory support. ARPA-I has a single overarching goal and focus: to fund external innovative advanced research and development (R&D) programs that develop new technologies, systems, and capabilities to improve transportation infrastructure in the United States.

The aims of ARPA-I include “lowering the long-term costs of infrastructure development, including costs of planning, construction, and maintenance; reducing the lifecycle impacts of transportation infrastructure on the environment, including through the reduction of greenhouse gas emissions; contributing significantly to improving the safe, secure, and efficient movement of goods and people; promoting the resilience of infrastructure from physical and cyber threats; and ensuring that the United States is a global leader in developing and deploying advanced transportation infrastructure technologies and materials.” (Pub. L. 117-58, section 25012, November 15, 2021; 49 U.S.C. 119). Funding the development and use of AI technologies to address these challenges is expected to be a key future activity of ARPA-I.

Federal Activities on AI Most Closely Related to DOT's Work

E.O. 14110 directs agencies all across government, including the Department of Transportation, to take a wide range of actions that will help ensure the United States leads the way in seizing AI's promise and managing its risks. This work includes actions to manage AI's safety and security risks, promote innovation and competition, advance equity and civil rights, protect Americans' privacy, stand up for consumers and workers, and more. Beyond E.O. 14110, the Federal Government has also fostered and funded work to advance the responsible development of AI and machine learning (ML) for decades. Examples of such work range from early work conducted by the Department of Defense's Advanced Research Projects Agency (now DARPA) to ongoing efforts summarized in the 2023 Update to the National Artificial Intelligence Research and Development Strategic Plan, led by the White House Office of Science and Technology Policy (OSTP).

In general, Federal investments in and other support for basic and applied research in AI in transportation are critical to achieving national priorities and build on applied AI research across the Federal government. Foundational research into and application of AI has been supported by the National Science Foundation (NSF), the Department of Defense (DOD), the Department of Energy (DOE), the Department of Homeland Security (DHS) Cybersecurity and Infrastructure Security Agency (CISA), the National Institute of Standards and Technology (NIST), and the National Aeronautics and Space Administration (NASA). Ongoing AI research at these agencies with high relevance to DOT priorities include developing effective methods for human-AI collaboration, ensuring the safety and security of AI-based systems, developing shared public datasets and environments for AI training and testing, measuring, and evaluating AI-based systems through standards and benchmarks.

DOT Activities on AI
AI approaches are being applied to a range of activities and efforts across DOT; this section provides a brief, non-comprehensive overview.

Operating administrations within DOT have developed and implemented many uses of AI. These range from use of AI and ML technologies to streamline transportation operations (*e.g.,* weather prediction, routing and scheduling, transit automation), to research projects addressing safety (*e.g.,* driver behavior classification, passenger safety, incident risk assessment, grade crossing safety video analytics), to tools for rapid analysis of text and component schematic data submissions, and to perform real-time asset management to maintain a state of good repair. AI and ML tools may have applications across all of DOT's operating administrations, with many actively exploring uses including the Federal Aviation Administration (FAA), Federal Highway Administration (FHWA), Federal Motor Carrier Safety Administration (FMCSA), Federal Railroad Administration (FRA), Federal Transit Administration (FTA), Great Lakes St. Lawrence Seaway Development Corporation (GLS), National Highway Traffic Safety Administration (NHTSA), Maritime Administration (MARAD), and Pipeline and Hazardous Materials Safety Administration (PHMSA).

The Intelligent Transportation System Joint Program Office (ITS JPO) within DOT has established the AI for ITS Program, recognizing the promise that AI offers for achieving significant benefits in transportation safety, mobility, efficiency, equity, accessibility, productivity, and resilience, while achieving reductions to individual and societal costs, emissions, and other negative environmental impacts. Currently, ITS JPO is developing AI-enabled ITS Capability Maturity Model and Readiness Checklists, and the Application of the NIST AI Risk Management Framework for ITS. ITS JPO published a review of AI for ITS in October 2022.

Two DOT initiatives that include the application of AI to serve the Department's policy priorities are being led by the Office of the Assistant Secretary for Research and Technology (OST-R). The U.S. DOT Intersection Safety Challenge (*https://its.dot.gov/isc/*) is a prize-based competition that is exploring how a combination of advanced sensing, perception, path planning and prediction, and AI-based decision making can help to improve intersection safety for vulnerable road users. The Complete Streets Artificial Intelligence (CSAI) Small Business Innovative Research (SBIR) program (*https://its.dot.gov/csai/*) is a multi-phase effort to develop powerful new decision-support tools for public agencies to assist in the siting, design, and deployment of streets and road networks that prioritize safety, efficiency, and connectivity.

Additional AI-related activities at OST-R include extramural research conducted at a number of University Transportation Centers, work at the Highly Automated Systems Safety Center of Excellence, technology demonstration projects through the SMART Grants Program, and research at the U.S. DOT Volpe Center.

Similarly, consistent with E.O. 14110, the Department's internal Non-Traditional and Emerging Transportation Technology (NETT) Council has work underway to identify use cases across the various operating administrations and share observations and potential implications for the use of AI throughout the existing transportation system. Finally, the Transforming Transportation Advisory Committee (TTAC) and the Advanced Aviation Advisory Committee (AAAC) have been directed by Secretary Buttigieg to provide insights on the Department's approach to AI and make recommendations for this technology's integration into operational advancements, in a manner that anticipates AI's benefits, while safeguarding against its negative impacts.

Potential Development and Uses of AI in Transportation

This section provides illustrative use cases to help respondents to this RFI consider the breadth of potential uses of AI in transportation, including physical infrastructure, digital infrastructure, operations, and many other aspects.

Many of the fundamental components of AI technologies and AI tools developed in other domains will be directly applicable to AI in transportation, from algorithmic advances, foundational model development, machine learning, deep learning techniques, and AI assurance methods to methods for ensuring cybersecurity, model transparency and trustworthiness.

As the Federal government has emphasized, there are substantial ethical, legal, and societal risks and potential adverse effects surrounding the application of AI across society. Minimizing risks and adverse effects through developing trustworthy AI and enhancing trust in human-AI interactions, reducing bias in data, protecting privacy, and developing robust AI systems, standards, and frameworks will be integral to ensuring the effective incorporation of these new technologies into transportation and mobility systems.

This RFI employs the meaning of "artificial intelligence" or "AI" as used in E.O. 14110 and set forth in 15 U.S.C. 9401(3): "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." ARPA-I defines "Digital Infrastructure" as the sensing, computation, automation, networking, connectivity, data management, analysis, optimization, control and virtual elements that underpin our physical transportation infrastructure. Beyond transportation-specific use cases, AI also has the potential to increase operational efficiencies for DOT's own internal core business, regulatory, and permitting functions, including such applications as analyzing consumer complaints, compiling and summarizing public comments, streamlining permitting and application processes and more.

Potential areas for funded AI research and development at DOT will span all modes of transportation and mobility and could include:

- Enhancing the safety of pedestrians and vulnerable road users at roadway intersections through technologies such as ML and deep learning for computer vision, perception, sensor fusion, real-time decision making and warning systems,

- Real-time AI-based decision support tools, optimization and control of wide area traffic systems and transit operations,
- Autonomous mobility systems and vehicles on roads and rails, in the air, and on water (AI-intensive computation hardware and its design are beyond the scope of this RFI),
- Optimization of road traffic management systems and signalized intersections in cities and towns across timescales from seconds or minutes to hours, including such elements as variable speed limit control, queue detection and prediction, and wrong-way driving detection,
- Optimization of equitable curb management in urban areas,
- Transportation systems management and operations (TSMO) optimization and control,
- Use of AI to assess traveler behavior and preferences across modes,
- Real-time monitoring of transit rail systems for maintenance assessment and state of good repair,
- Real-time monitoring of transit facilities for incident risk analysis,
- Air traffic control optimization for large-scale aviation operations facilitated by AI,
- Development and operation of secure complementary position, navigation, and timing (PNT) systems using AI-based recognition and utilization of signals of opportunity,
- AI assessment and assurance tools, methods and frameworks, benchmarks, testing environments, validation and verification, and the creation of datasets for AI and AI-enabled systems across all modes of transportation,
- Automating and digitizing physical infrastructure asset management through AI to optimize planning, design, operations, construction, and maintenance, and end of life,
- Optimizing planning, design, build and permitting for infrastructure construction and repair, and reducing construction costs by incorporating best practices developed through generative AI, including natural language processing (NLP) and large language model (LLM)-based processing of existing knowledge and databases,
- Sensor output processing, sensor fusion, data analysis, and ML for analysis and control of large-scale transportation networks and systems, including remote sensing,
- Real-time control and optimization of traffic networks and signalization from the local scale to a full city or region,
- Optimization of multimodal freight and logistics networks and supply chains nationally, including commercial vehicle, marine, rail and aviation freight and logistics systems,
- Safe operation of uncrewed air systems (UAS) in emerging aviation applications,
- Developing shared mobility-on-demand (MOD) services, from AI-based dynamic route scheduling and fleet optimization for city or region-wide passenger demand using traveler decision support tools,
- Offline analysis of traffic data, transportation safety data, and emissions inventories,
- Enhancing mapping and spatial AI for real-time automation and navigation across all modes, as well as for infrastructure design, maintenance, and repair,
- AI-based robotic repair and repurposing of pipeline infrastructure, and
- AI-enhanced robotic mapping of sub-surface infrastructure and utilities for safe, efficient, and cost-effective "dig once" construction.

Specific Questions

This RFI seeks information that will assist ARPA-I and the U.S. Department of Transportation in carrying out responsibilities under section 8 (c)(iii) of E.O. 14110, as noted above. DOT is providing the following specific questions to prompt feedback and comments. DOT encourages public comment on any of these questions and seeks any other information commenters believe is relevant.

DOT is requesting information from all interested entities and stakeholders, including innovators and technology developers, researchers and universities, transportation system and infrastructure owners and operators, transportation-focused groups, organizations and associations, and the public. Where appropriate, responses should include discussion of real-world applications and actual examples of AI technologies, tools, and methods currently being used or contemplated for future use in the transportation and mobility domain. DOT is interested in receiving succinct and relevant responses to some or all of the following questions, keeping in mind the current efforts and potential use cases as described above:

Question 1: Current AI Applications in Transportation
What are the relevant current or near-term applications of AI in transportation? If applicable, describe the mode(s) of transportation that these applications cover, referencing DOT's stated priorities (including safety, climate and sustainability, equity, economic strength and global competitiveness, and transformation) that these applications support.

Question 2: Opportunities of AI in Transportation
What are the future potential opportunities in transportation that AI can facilitate? Describe the mode(s) of transportation that these opportunities cover, referencing DOT's stated priorities (including safety, climate and sustainability, equity, economic strength and global competitiveness, and transformation) as appropriate.

Question 3: Challenges of AI in Transportation
What are the current or future challenges of AI in transportation, including risks presented by the use of AI in transportation and potential barriers to its responsible adoption? Describe the mode(s) of transportation that these challenges cover, referencing DOT's stated priorities (including safety, climate and sustainability, equity, economic strength and global competitiveness, and transformation) as appropriate.

Question 4: Autonomous Mobility Ecosystems
What are the opportunities, challenges, and risks of AI related to autonomous mobility ecosystems, including software-defined AI enhancements? Describe how AI can responsibly facilitate autonomous mobility, including specifically safety considerations.

Question 5: Other Considerations in the Development of AI for Transportation
Comment on any other considerations relevant to the development, challenges, and opportunities of AI in transportation that have not been included in the questions above. These considerations may include ones such as potential priorities in transportation-specific future AI R&D funding, access to transportation datasets, the development of AI testbeds, physical and digital infrastructure needs and requirements, and workforce training and education.