Summary Report on ARPA-I RFI Responses

ADVANCED RESEARCH PROJECTS AGENCY • INFRASTRUCTURE

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January 2024

Executive Summary

The Advanced Research Projects Agency—Infrastructure (ARPA–I) Request for Information (RFI)[1] was issued by the U.S. Department of Transportation (DOT) Office of the Assistant Secretary for Research and Technology (OST-R) on June 13, 2023, and received 76 responses from a diverse set of organizations and individuals by the closing date of August 14, 2023. This summary report provides an overview of the major emerging areas of transportation research in which respondents suggest that ARPA-I should focus investing in. Specific technologies that were frequently discussed in the responses included transportation electrification technologies, autonomous vehicles (AV), and machine learning and artificial intelligence (ML/AI). Permeating the discussion in nearly all responses were topics of advanced analytics and the increasing availability of infrastructure data.

ARPA-I is a new agency designated by Congress 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. The focus of ARPA–I will be 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. This RFI was designed to solicit input from interested entities and stakeholders on future innovative R&D funding programs to be undertaken by ARPA–I, to meet the needs of innovating in the areas of Safety, Advanced Construction Materials and Methods, Digital Infrastructure, Freight and Logistics Optimization, and Climate and Resilience.

Aspects of data and digital infrastructure were most notably referenced by respondents. Specifically, numerous respondents recommended that ARPA-I invest in standards for infrastructure condition and performance data, data collection methods, and centralized access to infrastructure data. Directly related to these recommendations were modeling and analysis, which most respondents discussed in reference to a specific topic area. Many respondents discussed ML/AI techniques for modeling and

[1] https://www.federalregister.gov/documents/2023/06/13/2023-12621/potential-research-and-development-areas-of-interest-for-the-advanced-research-projects

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analysis, and discussed the need for data collection, curation, standards, and access as essential for successful implementation of ML/AI solutions.

In addition to the cross-cutting topic of digital infrastructure, respondents discussed more specific focus areas within the areas of concentration identified in the RFI. Within safety, respondents emphasized safety concerns unique to vulnerable road users, predictive analytics for safety, and safety concerns unique to electric vehicles (EVs). Advanced construction materials topics included transportation construction materials with low embodied carbon and additive manufacturing techniques. Digital infrastructure prompted extensive responses and included topics such as data collection, curation, standards, and access, development of digital twins of transportation networks, novel city planning paradigms supported by data, and the increased need for cybersecurity. In the freight and logistics optimization category, respondents discussed freight automation and electrification and supply chain data. Climate and resilience is another category that prompted extensive responses, and respondents focused on research for reducing emissions in transportation and modeling emissions and climate hazards. Altogether, the RFI responses suggested a wealth of innovative topics for ARPA-I to pursue in the future.

1 Introduction

1.1 Background and Overview of RFI

The Advanced Research Projects Agency—Infrastructure (ARPA–I) is a newly-designated agency within the U.S. Department of Transportation (DOT) that was authorized by the Infrastructure Investment and Jobs Act of 2021 (IIJA) November 15, 2021 (also known as the Bipartisan Infrastructure Law). ARPA–I was established by Congress "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." ARPA–I will have 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.

This Report summarizes the responses to a Request for Information (RFI) which solicited input from interested parties on potential areas for future innovative advanced research and development programs to be funded and managed by ARPA–I. The RFI asked questions on what new and emerging areas of innovation, including external early-stage research and development, ARPA–I should contemplate funding, noting the agency's high-risk, high-reward focus. The focal areas for ARPA-I include:

1. Safety
2. Advanced Construction Materials and Methods
3. Digital Infrastructure
4. Freight and Logistics Optimization
5. Climate and Resilience
6. Other Areas In Transportation Infrastructure

1.2 Purpose and Organization of the Report

This Report summarizes insights from the 76 unique, responsive comments[2] received on the RFI to 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 RFI Responses
- Section 3. Safety
- Section 4. Advanced Construction Materials and Methods
- Section 5. Digital Infrastructure
- Section 6. Freight and Logistics Optimization
- Section 7. Climate and Resilience
- Section 8. Other Areas In Transportation Infrastructure
- Section 9. Key Takeaways
- Appendix A. List of RFI Respondents
- Appendix B. Published RFI Text

2 Summary Data on RFI Responses

2.1 Breakdown of RFI Responses

Responses were received from academic institutions, industry, trade associations, federally funded research and development centers, nonprofit organizations, the public sector, and individuals. The distribution of respondent types is shown in Figure 2.1. The count of respondents excludes non-technical comments that were considered to be non-responsive to the RFI.

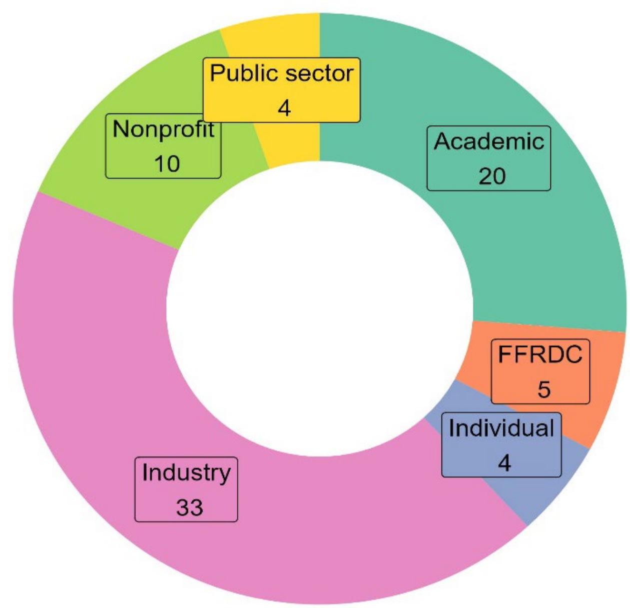

Figure 2.1 The 76 responses to the ARPA-I RFI categorized by organization type, including Federally Funded Research and Development Centers (FFRDC).

2.2 Data on RFI Responses

The RFI sought to collect information on six focal areas that include Safety, Advanced Construction Materials and Methods, Digital Infrastructure,

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

Freight and Logistics Optimization, Climate and Resilience, and Other Areas In Transportation Infrastructure.

RFI response were recorded for length and coded for whether they addressed electrification or artificial intelligence/machine learning, two commonly recurring themes. Figure 2.2 summarizes the number of responses that addressed each of the individual RFI questions.

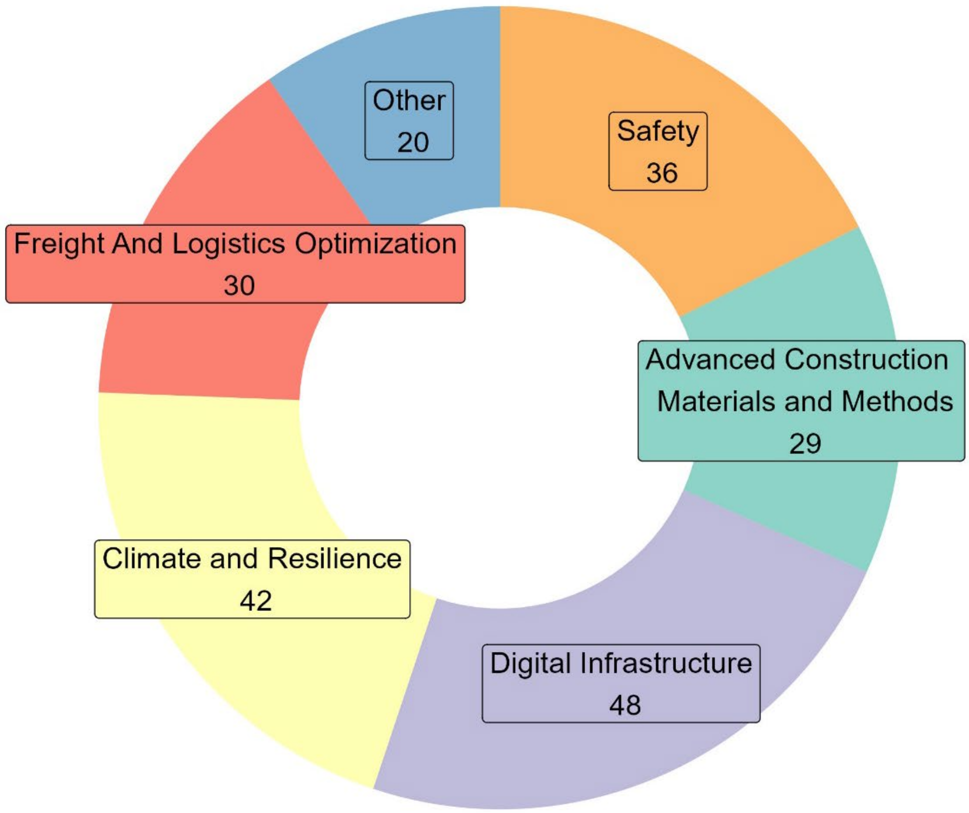

Figure 2.2 Count of responses to the ARPA-I RFI by focus area. A respondent could address multiple responses, so the total sums to greater than the number of unique, responsive comments (76).

To provide a visual summary of the most frequently mentioned single words and two-word phrases found in the responses, the texts of all responses were analyzed using natural language processing (NLP) to generate a word cloud. The larger phrases in Figure 2.3 were the most commonly-used phrases in the responses.

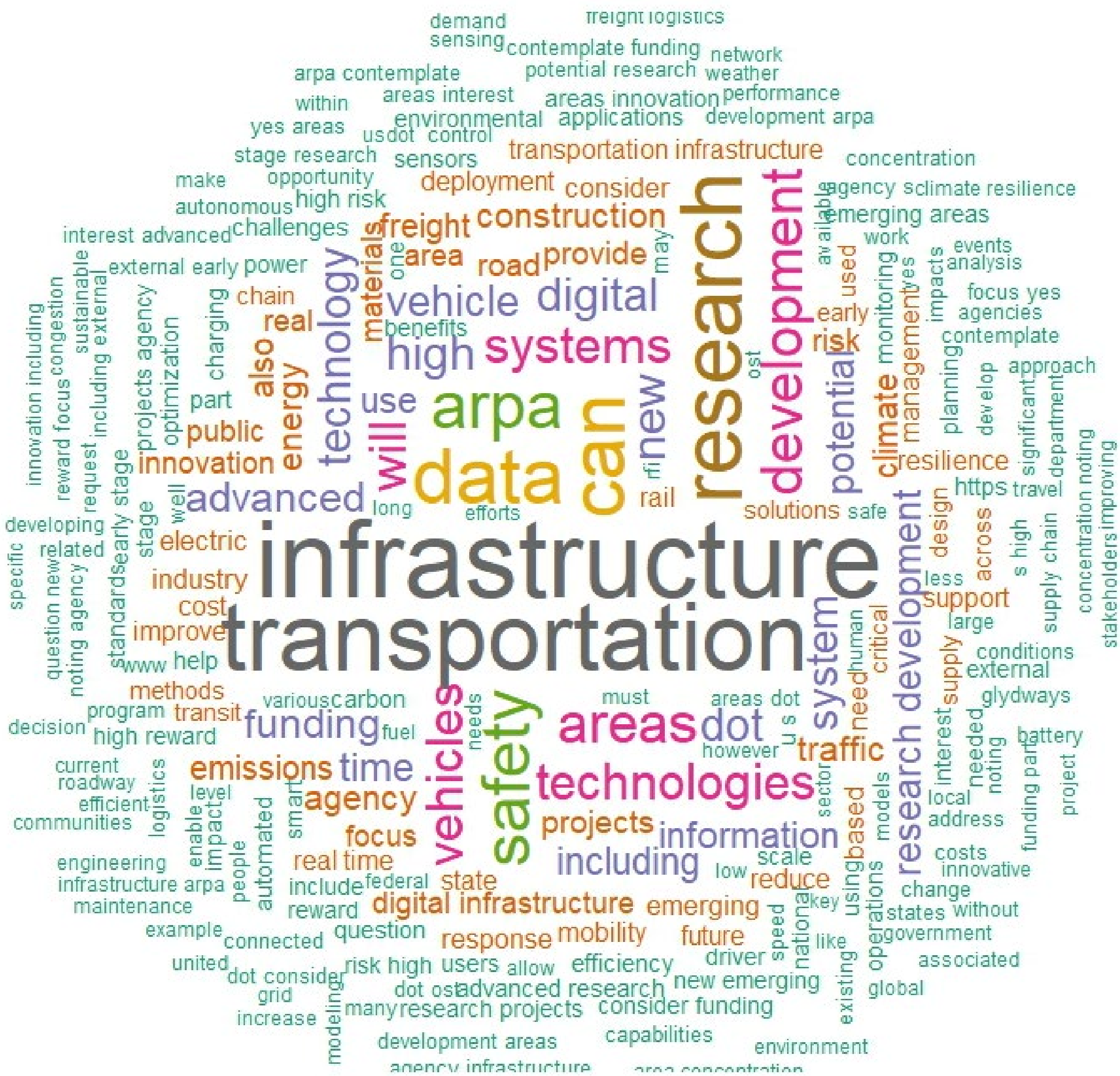

Figure 2.3 Word cloud of responses to the ARPA-I RFI.

3 Safety

3.1 Vulnerable road users

Among the 35 responses that addressed the Safety prompt, about one-third referenced a need to address pedestrian and other vulnerable road user safety in the U.S. Under this section, several respondents (including American Federation for the Blind, Paralyzed Veterans of America, and United Spinal) focused on needed areas of research and development related to safety for persons with disabilities, including how ADS sensors, advanced driving assistance systems, automatic braking systems, and AI can more reliably detect non-ambulatory pedestrians. Several other respondents (including

AASHTO, ITS-America, and Noblis) similarly recommended research and development (R&D) investment in vehicle-based systems such as advanced sensors and AI to provide critical warnings to drivers about pedestrians, or for monitoring the driver's state, without specifically addressing pedestrians who use mobility devices. At least one response (ITS America) recommended V2X for vehicle-to-person vehicle approach warnings, while another (NREL) focused on infrastructure perception and control, proposing data fusion to enable safety-affirmative signaling, including signals that extend clearance times for pedestrians or bicyclists crossing an intersection.

3.2 Predictive analytics

Several respondents refer to investing in or leveraging predictive analytics, with responses broadly falling into two categories: (1) at the vehicle level for reducing real-time crash risk, and (2) at the network level for guiding infrastructure interventions. At the vehicle level, respondents noted that research investment could advance the accurate prediction of short-term road user behavior (AASHTO, SwRI, University of Wisconsin Madison), enhance notification of roadway users of near-term safety risks (SwRI), and predict flooding on depressed roadway sections (AASHTO). At the network level, several respondents (including AASHTO, SwRI) focused on the need for developing crash prediction using leading indicator safety analysis, applying analytics to past incidents to predict future incidents, and using AI/ML to analyze long periods of traffic data to identify potential design changes or control measures to improve corridor or network safety.

3.3 Safety of electrified road transportation

Several respondents (including AASHTO, Battelle, SwRI) raised the need for researching and addressing potential unintended safety consequences of EVs, including characterization and mitigation of lithium-ion battery fire risk as well as the increased weight and collision forces of battery-electric vehicles with other road users.

3.4 Other responses

In addition to the above themes, SwRI suggested research to enable rapid automated detection of roadway collisions, while AASHTO suggested using virtual reality technology to train novice drivers, motorcycle riders, bicyclists, and other road users to prevent behavior that can lead to crashes.

Several respondents commented on automated vehicle (AV)-related safety, including the topic of ensuring AV resilience to cyberattacks and human behavior. The human behavioral concerns that some respondents recommended addressing include: 1) substance abuse, 2) distracted driving, 3) fatigue, and 4) aggressive risk taking. Additional responses on the theme of AVs and safety included making machine-readable pavement markings, including in work zones, and automating roadway inspections to reduce disruptions to the traveling public.

One respondent, Descartes Labs, suggested leveraging Earth observation data, such as satellite imagery, to detect changes in physical infrastructure condition, identify potential risks, and proactively plan asset maintenance. This response highlights the crosscutting themes of the potential for novel sources of infrastructure data and advanced analytics.

Safety of rail systems was a focus of the response from Amtrak, especially noting the need for implementation of a NextGen Positive Train Control system to increase safety at grade crossings. MxV Rail noted the and the opportunity for automated, electrified systems for rail to improve rail safety.

4 Advanced Construction Materials and Methods

Challenges to the transportation construction industry were mentioned in several responses, including labor shortages and supply chain issues, that lead to increased costs and time for constructing transportation infrastructure. In addition, respondents noted the daunting challenge of infrastructure condition, for example with 7.5% of the nation's 617,000 bridges classified to be in "poor" condition.

Several respondents highlighted that the June 2023 I-95 emergency in Pennsylvania used rapid construction methods such as ultra-lightweight foamed glass aggregate for use as fill material. The American Society of Civil Engineers (ASCE) noted that 'Recycled glass aggregate was a key factor in building interim roadway after an Interstate 95 overpass collapsed in Philadelphia in June'.

Some respondents recognized the clear link between Advanced Construction Materials and the Administration priorities for decarbonizing the transportation infrastructure. For example, low carbon materials which can update roadway and railway components, such as low carbon railroad ties using synthetic and composite materials, were noted by several respondents. Climate linkages with materials usage were also noted as EVs may require more durable pavement materials with their heavier weight.

Additive manufacturing of roadway and railway components, using advanced 3D printing, was noted as a high-risk, high-reward early-stage technology by several respondents.

Beyond the important R&D into specific technologies, the development of systems to de-risk the adoption and deployment of innovative technologies was noted by several respondents. For example, Advanced Digital Construction Management Systems (ADCMS) and the Technology and Innovation Deployment Program (TIDP) managed by the Federal Highway Administration (FHWA) provides a model that could be applied across other modes of transportation, with ARPA-I providing cross-modal support.

4.1 Low-Carbon Materials

Given that concrete and the cement in concrete are leading contributors to greenhouse gas (GHG) emissions globally (10% of industrial GHG emissions in the US in 2019, according to the U.S. Environmental Protection Agency), the need for advanced construction materials which focus on reducing emissions from cement was noted by several applicants, including the Portland Cement Association.

Multiple methods for reducing the GHG impact of cement were proposed, including use of fiber-reinforced polymers in precast concrete, carbon-negative cement, alternative cementitious materials, and use of recycled materials such as wind tower blades in concrete production.

Graphene-enhanced asphalt additives, and biologically-based additives like agar-based binder for asphalt were noted by organizations like AASHTO.

Carbon capture utilization and storage (CCUS), and recarbonation and mineralization were also mentioned in responses. For example, a cement industry association noted the potential of “graphene, carbon nanotubes, and other carbon-based materials may be used as strength enhancers or pure carbon sinks in concrete production”.

Biologically-based binders for asphalt were noted by several respondents (AASHTO, Deloitte) as high-impact potential material advances for ARPA-I to invest in.

Beyond these materials, low-carbon steel production has been demonstrated in principle, but there are barriers to scaling this technology. Respondents noted the potential for ARPA-I to lead the way in investing in low-carbon steel for transportation infrastructure materials.

4.2 Additive Manufacturing

3D-printed concrete structures and advances in printing of fiber-reinforced polymer matrix composites (Syracuse University) were noted by several respondents and considered “game-changing” technologies deserving of investment from ARPA-I.

Given the poor condition of many bridges in the United States, techniques such as modular construction were noted by some respondents as providing a promising path forward for bridge repair.

There is an intersection with digital infrastructure, as multiple respondents noted the promise of the combination of 3D printing and digital twins to rapidly construct and deploy bridge and roadway components. Additive manufacturing is also being used for rail components (MxV Rail), although more research was considered to be needed to ensure components meet safety and performance standards.

4.3 Other responses

Other topics suggested for ARPA-I involvement include developing a taxonomy and standards pertaining to concrete, glass, and steel so that transportation infrastructure designers, builders, and suppliers will be able to speak the same language in this rapidly-developing area. Respondents also noted that Accelerated Bridge Construction (ABC) is showing promise in enhancing project delivery times and improving safety, quality, and environmental impacts, but needs further R&D investment to be more widely deployed.

Robotic fabrication and large-scale cooperative robotic construction were noted by several respondents as an area of active research where ARPA-I could invest in. Such approaches potentially could leverage robotic systems with advanced sensing, planning, and control capabilities, reducing labor costs and accelerating construction timelines.

5 Digital Infrastructure

Digital Infrastructure was the most frequently discussed topic among all responses. ARPA-I defines digital infrastructure as the “sensing, computation, networking and communications technologies, systems, and capabilities that underpin physical infrastructure and transportation systems and modes.” Respondents pointed to emerging needs for a modern data stack with increasing volume of data coming from streaming data sources, real-time data feeds, and other large sets of data fed from sensor networks.

5.1 Data, machine learning (ML), and artificial intelligence (AI)

The most frequently discussed digital infrastructure subtopic was “data”. The collection, storage, analysis, and handling of data permeated all discussion of digital infrastructure. Specific technologies often mentioned were connected infrastructure technologies, including V2X (Vehicle to Everything), connected vehicles, and the Internet of Things (IoT). These connected infrastructure technologies will enable the collection of continuous streams of data which will need to be stored, transformed, and analyzed to be useful. Real-time data streams were a subset of continuous data streams that several respondents discussed. The supporting digital infrastructure that enables the effective use of these data will require extensive research and exploration by ARPA-I and its partner organizations.

Most notably, the discussion around data in many responses centered on data enabling machine learning through model training. “Machine learning” and “artificial intelligence” or AI were key words that appeared frequently in many responses across all response categories, and together with continuous and real-time data streams, underlies and enables development of many of the future technologies discussed in the responses. Many respondents specifically discussed data and machine learning as a supporting infrastructural aspect of more specific technologies that fall into one of the other four response categories. Several respondents discussed applications of continuous data streams, such as real-time traffic management, smart power grids, and real-time asset monitoring. Continuous data streams and their supporting infrastructure underly development of future technologies, and the respondents suggest that ARPA-I should fund development of modern data stacks for connected infrastructure and the computational tools for analyzing these data. Respondents also noted the promise of using generative AI to improve the productivity of designers and engineers early in design processes.

5.2 Digital Twins

Several respondents discussed the creation of digital twins of infrastructure systems to support various analysis and asset management tasks. Digital twins can enable simulation and modeling that can be difficult to conduct in other environments. Real-time streaming data from vehicles, roadway sensors, and Internet of Things devices can maintain the recency of the digital twin, further illustrating the importance of data infrastructure in the future. Specific recommendations include using the data derived from advanced driver-assistance systems (ADAS) to provision and keep up to date a digital twin of our nation’s roadways. Respondents suggest that ARPA-I fund development of these digital twins, exchange platforms for sharing digital twins, and data solutions supporting maintenance of digital twins.

5.3 City Planning

Respondents also discussed how digital infrastructure that supports city planning could be a focus area for ARPA-I. Artificial intelligence-powered city planning would require the coordination of several digital infrastructure technologies. Democratized planning methods could also be supported by advances in digital infrastructure. Participatory modeling and collaborative decision-making would be enabled by wider access to larger data and by platforms that support collaboration. It was suggested that ARPA-I could fund the development of these new city planning paradigms.

5.4 Cybersecurity

Related to the proliferation of connected infrastructure and IoT is the increase in vulnerability of critical infrastructure assets to cyber-attacks. Respondents suggested understanding that the level of risk will require research, as will understanding the threats and how organizations can respond to them. A specific technology that is vulnerable to cybersecurity attacks that multiple respondents identified was EV charging infrastructure, which was a technology widely discussed in other response topics.

6 Freight and Logistics Optimization

Contemporary technology innovations in areas such as vehicle automation, wireless communications and data analytics have the potential to meaningfully transform freight and logistics optimization. A number of respondents recommended that ARPA-I can facilitate adoption of these innovations in the freight and logistics space by coordinating development at an accelerated pace and scale, rather than in piecemeal efforts. Numerous respondents addressed the need for enhancing the resilience of the domestic supply chain in light of COVID-19 related disruptions.

6.1 Freight Vehicle Automation and Electrification

The importance of research into the pathways and consequences of automation of heavy-duty (HD) freight vehicles was noted by a number of respondents. This topic spans Climate and Resilience and Digital Infrastructure topics, as there may be a role for ARPA-I in investing in research for smart freight charging, and measurement of emissions benefits of electrified freight. Relatedly, intermodal facility vehicle electrification was considered important for reducing the impact of idling trucks in intermodal facilities such as at ports, and this topic spans the roadway and maritime freight sector in a way not currently addressed by existing modal research.

In this topic, some respondents noted that medium-duty (MD) vehicles are typically overlooked in the discussion yet are crucial for last-mile freight delivery. Specifically, MD fuel-cell electric vehicles (FCEV) may be limited in ability to access hydrogen fueling stations, and MD EVs will need higher charge rates than light-duty vehicles.

Considerations for EV charging time and battery safety for freight vehicles were noted by several respondents.

Weigh-in-motion technology was suggested for ARPA-I investment, as this technology promises to provide more timely information on vehicle weights without impeding roadway traffic and can be useful especially as heavier EVs become the norm.

6.2 Supply Chain Data and Optimization

Respondents noted that gaps exist in freight logistics, specifically in regard to data on freight movements and infrastructure which contribute to supply chain disruptions. Enhancing the quality, coverage, standardization, and accessibility of data on freight movements is an area where ARPA-I may be able to provide critical R&D funding. One respondent noted that for "freight and various goods to be transported in the most efficient manner, stakeholders and their corresponding data systems need to reliably operate in harmonious coordination", and that a comprehensive data platform to view and report on the U.S. supply chain could have a game-changing benefit. Improving the coordination of freight movements will be needed to reduce supply chain lags and under-utilization of the supply chain capacity (MIT FreightLab).

Wireless roadway infrastructure data was proposed to link real-time information on roadway conditions, road weather, parking, and roadway incidents to optimize last-mile deliveries.

Establishing data standards for all steps of the supply chain, from shipping containers to curb management, is an area where ARPA-I leadership was noted as having great potential benefit. ARPA-I was encouraged to consider supporting development of an end to end, scalable, data-sharing ecosystem for American supply chain industry stakeholders and participants. Some respondents further proposed that ARPA-I invest in platforms which use such standardized data to automate supply chain management using machine learning (ML) powered insights.

6.3 Other responses

Beyond these topics, additional freight and logistics topics included an integrated assessment advanced air mobility (AAM) and unmanned aerial vehicles (UAV) for short-haul, last-mile deliveries (Texas Transportation Institute). Additional response noted the need for research in multi-modal weather decision support tools (NCAR).

7 Climate and Resilience

Climate and resilience research activities can be divided into three categories: mitigation, adaptation, and modeling. Mitigation is defined as reducing emissions impact of the transportation system. Adaptation is enhancement of the resilience of transportation networks to climate hazards. Lastly, modeling is the building of predictive and analytical tools for understanding climate impacts on transportation, such as increased flooding due to climate change, and caused by transportation, such as increased greenhouse gas emissions. Respondents discussed mitigation and modeling but did not discuss adaptation.

7.1 Reducing GHG emissions

Respondents typically focused on mitigation of climate change through reducing emissions. Frequently discussed specific technologies were EVs, alternative fuels, vehicle-grid interoperability, energy recapture, and the reduction of embodied carbon in transportation construction and manufacturing inputs. Among the discussed technologies, electrified vehicles were the most frequently mentioned.

Discussion of EVs spanned all five response topics and was not limited in scope to climate and resilience aspects of electrification. According to the EPA, the transportation sector accounts for 28% of total GHG emissions in the U.S. in 2021, the largest of any sector. Correspondingly, many respondents justly focused on electrification. Related to electrified vehicles are the charging infrastructure and battery infrastructure. Efficient, smart-charging infrastructure can reduce loads on power grids and meet the demands of large, electrified fleets. Developing new ways to model battery health, such as non-destructive testing methods, can lead to less premature disposal of used batteries, and reduce incidence of hazards related to degraded batteries.

7.2 Modeling emissions and hazards

Several respondents discussed climate change-related modeling as an important activity that ARPA-I should consider funding. Climate hazards models can support decision making and allocation of resources to the highest-impact actions with regards to resilience. Emissions models can support decision making and allocation of resources to actions which produce the least or mitigate the most greenhouse gas emissions, particulate emissions, and related impacts on public health and environment. Respondents also discussed EV charging demand modeling and battery health modeling. Specific models discussed were coastal flood models, wetland storage capacity, and other flood-related climate hazard models. The primary climate hazard respondents discussed was floods and flooding. Specific emissions modeling techniques discussed include large-eddy scale modeling and machine learning emulators.

8 Other Areas

In addition to the focal areas noted above, respondents provided input on other areas for ARPA-I to consider investing in. At a system level, several respondents noted that accessibility of the transportation system remains challenging for people with disabilities, and ARPA-I could provide leadership from the infrastructure perspective on accessibility. Relatedly, some respondents noted that that the transportation system performance should be measured not just by metrics of trips and miles travelled but also but also by the equitability of access to transportation. A national database of the built environment, including sidewalks and intersections, could be beneficial not just for overall infrastructure asset management but also for analysis of inequities in the accessibility of the surface transportation system.

For transportation technologies, emerging data collection and utilization approaches were noted as an area for ARPA-I to invest in. Namely, there may be opportunities for research into the ability of low-power sensor networks embedded in transportation infrastructure to feed data into the digital infrastructure topics discussed above.

Additional technologies beyond the traditional transportation modes were also noted, such as advanced air mobility (AAM) and unmanned aerial vehicles (UAV), where there may be a need for research on the infrastructure needs of future air mobility to enable these modes.

9 Key Takeaways

The responses to the RFI provide a wealth of innovative topics for ARPA-I to pursue, showing the pressing needs for cross-cutting R&D to improve the safety, efficiency, equitability, and resilience of our nation's transportation system.

Across all six response categories, respondents frequently raised advanced R&D topics that involve data, simulation and modeling, electrification, autonomous vehicles, and machine learning and artificial intelligence (ML/AI). Within the response categories, digital infrastructure was most frequently addressed, followed in order of response frequency by climate and resilience, safety, freight and logistics operations, and advanced construction materials. Although most responses explicitly addressed a specific technology or emerging concern, a focus on the underlying need for data collection, storage, management, sharing, and analysis was a common theme in most responses. Notably, respondents did not explicitly address the question of 'why' an investment is recommended, but rather implicitly addressed that question by providing motivations for the research areas being proposed.

Broadly, the respondents addressed future needs for more advanced simulation and modeling in each of the response categories. Respondents noted that simulation and modeling activities are supported by data pipelines, which fall under the digital infrastructure response category. As a result, developing more advanced digital infrastructure for data collection, storage, and analysis was a widely discussed topic, especially regarding real-time streaming data. Specific technologies discussed included development of new platforms for V2X communication, data sharing, novel methods of data collection, and many different modeling techniques. Machine learning and artificial intelligence (ML/AI) were also frequently discussed, as they form the basis for many current techniques for modeling and simulation. In particular, ML/AI were suggested as useful tools to enable more robust, real-time optimization of freight routes, carrier/shipper matching, traffic flow optimization, pedestrian and VRU detection, automated infrastructure inspection, and other applications.

After digital infrastructure, climate and resilience topics were the most frequently addressed by respondents, and transportation electrification was the leading topic within climate and resilience. Carbon neutrality and researching the effects of embodied carbon in transportation inputs, including in transportation-related construction and manufacturing, was another key area that many respondents addressed. Several respondents focused on a need for climate-related modeling efforts, such as predictive modeling for climate hazards, especially floods. At the intersection of the climate and resilience and advanced construction materials, several respondents (including BSMC and ITS-America) recommended coordination between ARPA-I and ARPA-E (the Advanced Research Projects Agency – Energy of the U.S. Department of Energy) on transportation energy research for roadway and maritime sectors, and for low-carbon concrete manufacturing.

Responses on safety were the next most frequent after climate resilience, most commonly focusing on the topics of vulnerable road user crash safety, especially with regard to Automated Driving Systems (ADS) and advanced driver assistance systems (ADAS) detection algorithms, and emerging safety concerns related to EVs and autonomous vehicles. Improving and deploying predictive models at the vehicle or traffic signal level for reducing real-time crash risk, and at the network level for guiding infrastructure design interventions were also called out in multiple responses. Several disability-focused organizations recommended research on accelerating accessible infrastructure design, wheelchair securement systems, and integration into automated and connected systems, as well as establishing a separate Universal Accessibility priority focus area within ARPA-I.

In freight and logistics optimization, respondents discussed the electrification of freight fleets, autonomous freight vehicles, weigh-in-motion technology, and the need for more and better supply chain data. The supply chain data topics spanned real-time congestion and weather hazard mapping to developing data sharing protocols to facilitate information exchange across the multitude of diverse stakeholders in the supply chain. Respondents suggested that ARPA-I fund the development of an ecosystem where this data sharing could take place.

Additive manufacturing was a recurring topic in the advanced construction materials response category. Development of 3D printing methods for pavement and concrete were specifically called out. Several respondents also considered the intersection of advanced materials with climate and resilience, discussing the development of materials with lower embodied carbon.

Appendix A: List of RFI Respondents

A total of 76 unique, responsive comments to the RFI were received and assessed by U.S. DOT.

Title	Type of Entities
2050 Transportation Vision	Academic
Arizona State University	Academic
Ashley Thrall, University of Notre Dame	Academic
Climate and Resilience Opportunities	Academic
Edvard Bruun, Georgia Institute of Technology, Qipei Mei, University of Alberta	Academic
Eleftheria Kontou, University of Illinois	Academic
Georgia Institute of Technology	Academic
John Popovics, University of Illinois and Thomas Schumacher, Portland State University	Academic
Michigan Tech Research Institute	Academic
MIT FreightLab	Academic
Mohammadhadi Amini, Florida International University	Academic
Northeastern University	Academic
Northeastern University and Stony Brook University	Academic
Texas A&M Transportation Institute	Academic
Tyler Folsom, University of Washington	Academic
University of Maine, Advanced Structures and Composites Center	Academic
University of Pittsburgh, Infrastructure Sensing Collaboration	Academic
University of Southern California METRANS Transportation Consortium	Academic
UW-Madison	Academic
Yeqing Wang, Min Liu, Syracuse University	Academic
Battelle Memorial Institute	FFRDC
Lawrence Berkeley National Laboratory	FFRDC
Los Alamos National Laboratory	FFRDC
National Center for Atmospheric Research (NCAR)	FFRDC
National Renewable Energy Laboratory (NREL)	FFRDC
Alberto Zayas / ITVTCORP	Individual
Antt Adam	Individual
Mariela Alfonzo, State of Place	Individual
Steve Nolan	Individual
aifleet	Industry
Amazon Web Services	Industry
Autos Innovate	Industry

Title	Type of Entities
Bentley Systems	Industry
Biomason	Industry
Blue Planet Systems	Industry
Cambium	Industry
Cavnue, LLC	Industry
Cintra	Industry
Deloitte Consulting LLP	Industry
Descartes Labs, Inc.	Industry
Energy Storage Safety Products International, LLC	Industry
Glid Technology	Industry
Glydways	Industry
Hitachi America, Ltd.	Industry
Institute for Advanced Composites Manufacturing Innovation (IACMI)	Industry
ITS America	Industry
ITVTCORP	Industry
Luna Innovations Incorporated	Industry
MxV Rail	Industry
Oceanit	Industry
P3Mobility	Industry
Palisades Consulting Group, Inc.	Industry
Portland Cement Association	Industry
ProsumerGrid Inc.	Industry
Replica	Industry
SailPlan Maritime, Inc.	Industry
Society of Automotive Engineers New York City Metropolitan Section	Industry
Trimble, Inc.	Industry
United States Council for Automotive Research	Industry
V2XDeploymentPlan	Industry
Wabtec Corporation	Industry
Xtelligent	Industry
American Foundation for the Blind	Nonprofit
American Society of Civil Engineers	Nonprofit
Blue Sky Maritime Coalition (BSMC)	Nonprofit
ClearPath	Nonprofit
Noblis	Nonprofit
OpenCommons	Nonprofit
Paralyzed Veterans of America	Nonprofit
Southwest Research Institute (SwRI)	Nonprofit

Title	Type of Entities
The MITRE Corporation	Nonprofit
United Spinal	Nonprofit
American Association of State Highway and Transportation Officials (AASHTO)	Public sector
Amtrak	Public sector
Climate Mayors	Public sector
Virginia Department of Transportation	Public sector

Appendix B: Published RFI Text (June 2023)

Text from available online as https://www.federalregister.gov/documents/2023/06/13/2023-12621/potential-research-and-development-areas-of-interest-for-the-advanced-research-projects.

Responses to this RFI are intended to inform DOT on areas of focus for future innovative R&D funding programs to be undertaken by ARPA–I.

DOT is providing the following specific questions to prompt feedback and comments. DOT encourages public comment on any of these questions, and also 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 operators, transportation-focused groups, organizations and associations, and the public.

DOT is interested in receiving succinct and relevant responses to the following six questions:

Safety

Question 1: Are there new and emerging areas of innovation, including external early-stage research and development, that ARPA–I should contemplate funding as a part of its Safety area of concentration, noting the agency's high-risk, high-reward focus? If yes, what are these areas, and why should DOT consider funding them?

Advanced Construction Materials and Methods

The development of advanced infrastructure construction materials and methods, including for roads, highways, bridges, airports, ports, railways, and pipelines, has long been a priority for DOT. There are considerable efforts ongoing including at the Federal Aviation Administration (FAA) and FHWA in the development of low embodied carbon materials, new construction materials and new construction methods for infrastructure. For example, these might include 3D concrete printing of large structures such as bridges, culverts, and roadways, and related advanced construction methods.

Question 2: Are there new and emerging areas of innovation, including external early-stage research and development, that ARPA–I should contemplate funding as a part of its Advanced Construction Materials and Methods area of concentration, noting the agency's high-risk, high-reward focus? If yes, what are these areas, and why should DOT consider funding them?

Digital Infrastructure

Advances in digital infrastructure and digitalization abound. These include (but are not limited to) new technologies for mapping, sensing, connectivity and communications, networking, and computation. Transportation infrastructure is one of the largest sectors of our economy that has only begun to participate in the `digital revolution' of information technology. The potential advantages of digitalization are pervasive, from the development of advanced centralized traffic management systems to advanced driver assistance systems (ADAS), GPS (or GNSS) applications, machine vision and artificial intelligence. There is a considerable body of work being conducted across DOT in digital infrastructure, including at FHWA, FAA, the Intelligent Transportation System Joint Program Office (ITS JPO), and the Highly Automated Systems Safety Center of Excellence (HASS COE) within OST–R.

Question 3: Are there new and emerging areas of innovation, including external early-stage research and development, that ARPA–I should contemplate funding as a part of its Digital Infrastructure area of concentration, noting the agency's high-risk, high-reward focus? If yes, what are these areas, and why should DOT consider funding them?

Freight and Logistics Optimization

The seamless movement of freight across transportation modes is an essential requirement for our economic health and well-being. The COVID–19 pandemic exposed the vulnerability of our economy to disruptions in freight and logistics operations, as part of the larger breakdown in supply chains and their continuity. Increasing the resilience of freight and goods movement across our nation is essential to ensuring the uninterrupted flow of food, fuel, commodities, and consumer and industrial products from source to destination. DOT conducts research across all transportation modes in the area of freight and logistics and has recently instituted the Office of Multimodal Freight Infrastructure and Policy within the Office of the Secretary (OST), as established by the IIJA, Section 21101 (49 U.S.C. 118).

Question 4: Are there new and emerging areas of innovation, including external early-stage research and development, that ARPA–I should contemplate funding as a part of its Freight and Logistics Optimization area of concentration, noting the agency's high-risk, high-reward focus? If yes, what are these areas, and why should DOT consider funding them?

Climate and Resilience

Our transportation infrastructure is increasingly susceptible to damage from climate-related events, from drought to floods to sea level rise. Increasing the resilience of our infrastructure and mitigating negative effects on our transportation system across all modes is an imperative for DOT. Climate and resilience research is being conducted across all transportation modes at DOT, including in the newly reestablished DOT Climate Change Center, and includes the reduction of greenhouse gas (GHG) emissions from transportation, the reduction of embodied carbon in infrastructure materials, and increasing physical and cyber resilience across the transportation system.

Question 5: Are there new and emerging areas of innovation, including external early-stage research and development, that ARPA–I should contemplate funding as a part of its Climate and Resilience area of concentration, noting the agency's high-risk, high-reward focus? If yes, what are these areas, and why should DOT consider funding them?

Other Areas in Transportation Infrastructure

DOT currently conducts a considerable amount of R&D work, both internally and externally, in many areas pertinent to transportation infrastructure.

Question 6: Are there other new and emerging areas of innovation associated with transportation infrastructure, including external early-stage research and development, that ARPA–I should contemplate funding, noting the agency's high-risk, high-reward focus? If yes, what are these other areas, and why should DOT consider funding them?