

**United States Department of Transportation
FY 2020 Annual Modal Research Plans**

Intelligent Transportation Systems Joint Program Office (ITS JPO)

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Executive Summary

The Intelligent Transportation Systems Joint Program Office (ITS JPO) was created in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) Public Law 102-240 (December 18, 1991). ISTEA established a federal program to research, develop and operationally test Intelligent Transportation Systems (ITS) and to promote ITS implementation. The ITS Program is designed to facilitate deployment of technology to enhance the efficiency, safety, and convenience of surface transportation resulting in improved access, saved lives and time, and increased productivity.

The mission of the U.S. Department of Transportation (USDOT) is to ensure our Nation has the safest, most efficient and modern transportation system in the world, which improves the quality of life for all American people and communities, from rural to urban, and increases the productivity and competitiveness of American workers and businesses. The ITS JPO serves as the USDOT's multi-modal technology research program, working toward improving transportation safety, mobility, and efficiency; and enhancing productivity through the integration of innovative technologies within the nation's transportation system. Through these efforts, the ITS JPO serves as a Departmental leader in addressing the USDOT's Strategic Goal on Innovation, which is to "lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the nation's transportation system." The **Vision** of the ITS JPO is to "Accelerate the use of ITS to transform the way society moves." That vision is executed through leading collaborative and innovative research, development, and implementation of intelligent transportation systems technologies to improve the safety and mobility of people and goods. By undertaking the research and deployment of advanced and innovative technologies, the ITS JPO serves as the USDOT's organizational resource for avoiding duplication and ensuring the Department is on the forefront of advancing technologies to make certain our transportation system is safe and efficient.

The ITS JPO will continue to provide a focused role for the Department in supporting development of new technologies as well as adopting and adapting innovative technologies from other industries to meet the specific needs of the surface transportation system. By working with industry partners, academia, and stakeholders through cooperative agreements and grant programs, the ITS JPO will continue to develop intelligent and advanced technologies that address some of the more intractable transportation-specific problems. However, the ITS JPO's broad mission is neutral to any particular technology or platform.

Within the context of the Department's strategic goals and research priorities, the ITS JPO's work specifically focuses on the Innovation Strategic Goal, while also assisting modal partners in meeting the goals for Safety, Infrastructure, and Accountability. The ITS JPO achieves these priorities by:

1. Identifying, investigating, and transferring into practice innovative ITS technologies and processes by employing a focused set of goals and strategies that address specific strategic programmatic research areas.

2. Evolving the ITS program based on insights from analysis and evaluation, as well as on new priorities that arise as a result of new innovations, changes in access or economics, and evolving societal trends and needs.

The ITS JPO's mission is neutral to any particular technology or platform as long as it could be useful for addressing the needs and priorities of transportation users. The ITS JPO continually assesses the feasibility, maturity, and benefits of ITS technologies and approaches, and shepherds transportation solutions from inception to implementation. The ITS JPO capitalizes on past investments in key research areas including automation, connectivity, and data access and exchanges. The ITS JPO will continue to augment such efforts with our USDOT partners to focus on new emerging technologies that will impact and transform transportation.

Key to the ITS JPO's mission is collaboration within the USDOT and understanding our constituents and who we serve. Our pursuit is not the development and deployment of technology for technology's sake. Rather, the ITS JPO focuses on ITS as a system, which includes transportation infrastructure, vehicles, back offices, services, and other tools and mechanisms. These components are comprised of all types of transportation users and communities, which range from individual transportation users to wider groups including underserved segments of communities, private-sector vendors of technology equipment and applications, and operators and implementers of discrete ITS components or whole systems (including state and local governments). Listening to these various perspectives and engaging with the appropriate agency, community, or industry representatives ensures that the ITS JPO does not restrict its efforts to specific technologies, but instead aligns its initiatives to the wider objectives of improving safety and mobility for all users.

The ITS JPO includes a portfolio of research and technology deployment support programs focused on diverse systems and technologies geared towards producing the greatest public benefit from transportation's increasing technological transformation. The ITS JPO is responsible for coordinating the ITS Program and initiatives among the various USDOT operating administrations: Federal Highway Administration (FHWA); Federal Motor Carrier Safety Administration (FMCSA); Federal Transit Administration (FTA); Federal Railroad Administration (FRA); National Highway Traffic Safety Administration (NHTSA); Maritime Administration (MARAD) and the St. Lawrence Seaway Development Corporation (SLSDC). In addition, close collaboration with current industry and academic leaders in technology and innovation is a cornerstone of the ITS Program. The research builds on and leverages the technology and applications developed across all modes delivering cross cutting research activities and technology transfer that support all modes in the USDOT.

Through our research activities the ITS JPO serves two distinct roles within the USDOT, as both the project lead and as a multi-modal coordinator, working to ensure effective ITS research and technology deployments are successful. The ITS JPO serves as the lead in forward looking and emerging work that is not limited to just one mode and undertakes emerging projects where cross cutting capabilities are required to manage them. This includes connected data systems and large-scale pilot deployments, such as the current Connected Vehicle Pilot Deployment, which is utilizing infrastructure and vehicle connectivity, and mobile device data to improve the multi-modal surface

transportation systems performance, and enables enhanced performance-based systems management.

Through multi-modal coordination the ITS JPO works to avoid duplicative ITS work and ensures the efficient allocation of resources, especially for emerging technologies. In our multi-modal coordinator capacity, the ITS JPO ensures that capabilities across the USDOT are harnessed to bring about the greatest good. An example of a major initiative supported by the ITS JPO in joint coordination with FTA and FHWA is the Complete Trip Program. This effort is exploring emerging technologies to enhance travel that includes opportunities for people with mobility challenges by providing travel opportunities that are seamlessly integrated into their daily lives. This seamless integration will be the “Complete Trips for All” effort highlighted by the USDOT Topical Research Area – Mobility Innovation working group. The Complete Trips for All vision leverages innovative technologies and facilitates public private partnerships to allow for a traveler-centric approach that improves mobility options for all travelers, including travelers with disabilities, travelers in rural areas, and lower income travelers. The program resources identified in the ITS JPO FY 2019 Spend Plan was used to support defining the Complete Trips for All vision. Internal to USDOT this effort has reached beyond the research team to include the planning, civil rights, and policy disciplines. This multidisciplinary connection is critical to the success of the technology transfer efforts under this program area. This effort would also glean input from a range of interagency Federal partners including the Departments of Health and Human Services (DHHS), Labor (DOL), Defense (DOD), and others.

In the near term, vehicles with various levels of driving automation systems that enter the market potentially offer new benefits in travel comfort, convenience, and affordable accessibility. There is a clear government role in both ensuring public safety as these vehicles are introduced into service, and in ensuring that these vehicles are integrated into the road network in a manner that improves the efficiency of the system, and provides equitable mobility for all. The private sector is leading technology research and development but they are focused on vehicles that are, for lack of a better term, “self-interested.” The vehicles will behave in a way that works best for their own travel needs but without consideration for wider impacts to the road network. As more vehicles are deployed, coordination through connectivity could ensure that the continued introduction of automated driving technologies produces system-wide mobility and congestion-reduction benefits in addition to vehicle-level improvements in safety, comfort, and convenience.

Furthermore, a sustained focus on enabling data access across the automated vehicle (AV) ecosystem is necessary to integrate AVs into the system efficiently and safely. USDOT has heard from stakeholders that access to data is a critical enabler for the safe deployment of AVs, while lack of access could impede actions to accommodate AVs and, thereby, delay their introduction. This need is consistent across all modes of transportation, and within many aspects of AV deployment addressed in the USDOT research portfolio, such as performance measurement, safety assurance, cybersecurity, and insurance. Data exchanges – which increase access to data across the AV ecosystem for specific uses – will be key to accelerating the safe and efficient deployment of AVs.

While USDOT and our stakeholders cannot define all data exchange needs upfront, we can and should build capabilities iteratively, starting with the most critical use cases.

The ITS JPO Automation Program's collaborative and multi-modal research portfolio provides cross-cutting support to the USDOT Research Priorities, including Performance Based Regulations and Safety, Improving the Mobility of Freight, Feasibility of Micro-Transit, and Improving Mobility for Underserved Communities. Through the development of cooperative and standards-based technologies and comprehensive, stakeholder-driven policies, ITS JPO works to ensure the safe and efficient adoption of automated vehicles across the transportation system.

In addition, securing transportation's critical assets and infrastructure against cyber threats is a shared responsibility of both the public and private sectors. A common vision and a framework for achieving that vision are needed to guide the public-private partnerships that will secure transportation systems. Presidential Executive Order 13800 (issued May 11, 2017) on Cybersecurity of Federal Networks and Critical Infrastructure, holds heads of Departments accountable for managing cybersecurity risk of their ecosystem. *USDOT Strategic Plan FY 2018 – 2022* stated that "DOT will encourage the adoption of the National Institute of Standards and Technology (NIST) Cybersecurity Framework by transportation ecosystem stakeholders."

The USDOT has an important role to play in pursuing research and analysis in the area of cybersecurity for ITS to deliver public benefit. Federal leadership offers State and local agencies an opportunity to express their needs and have cybersecurity experts translate those needs into use cases, and requirements, that cross modal boundaries and ensure risk management among intelligent vehicles, intelligent infrastructure, and portable devices. State and local agencies tend not to have this type of expertise nor do they have the time or funding to pursue initiatives that are critical but tangential to their daily operational mission.

The Cybersecurity Program supports the USDOT cybersecurity research priority. This research maps to the Cybersecurity Research Working Groups team scope and annual goals to close gaps, facilitate information sharing, and the use of common risk models. This research will be coordinated with our model partners, and includes areas such as the adaptation of the NIST Cybersecurity Framework for the transportation sector. The research will facilitate developing the capacity of our partners and will inform the skilled workforce that the USDOT must support to proactively and effectively investigate and facilitate the implementation of sound transportation cybersecurity practices. The research will also assist in our efforts to establish the protocols required to coordinate cybersecurity monitoring and reporting activities.

The ITS JPO is uniquely positioned to work across the USDOT with our modal partners to develop and coordinate multimodal projects that are central to cybersecurity research. These efforts should include convening and facilitating the transportation ecosystem around shared priorities, facilitating the development of related policies, identifying and addressing cross-modal issues, sharing best practices and information, and eliminating "silo" activities.

Communications technologies are critical to the safe, secure, and efficient operations of ITS. Transportation agencies have incorporated communications into their operational environments (i.e., field systems, management centers, and public fleets), and vehicle manufacturers are increasingly including multiple types of communications into their vehicles. These emerging communications technologies will continue to have significant impacts on the transportation system. The USDOT has an important role to play in pursuing research and analysis around emerging transportation technologies and their use of telecommunications to deliver public benefit. USDOT's role allows State and local agencies to confer with telecommunications experts and to translate use cases and requirements that cross market boundaries and ensure interoperability.

The ITS JPO is the USDOT's primary mechanism for educating the public sector's transportation workforce about ITS. The ITS JPO will continue to support activities that deliver multimodal ITS learning opportunities to the public-sector workforce by coordinating outreach related to the ITS JPO's research initiatives and providing technical assistance. The ITS JPO has developed and delivered technology transfer in close coordination with partners including the National Highway Institute (NHI), Intelligent Transportation Society of America (ITSA), Institute of Transportation Engineers (ITE), National Operations Center of Excellence (NOCoe), National Association of Development Organizations (NADO), universities and other stakeholders. The public-sector participants representing State DOTs, Metropolitan Planning Organizations (MPOs) and local agencies have benefited from this partnership. Participants have favorably evaluated the ITS JPO technology transfer for its delivery of much needed training and technical assistance with feedback indicating that participants use the training to improve grant applications, purchasing decision, or procurement designs. Evaluators have also mentioned a reassessment of infrastructure vulnerability including information technology (IT)-data management improvements as a result of technology transfer events provided by the ITS JPO.

Interoperability – allowing transportation systems user to access ITS services anywhere they may travel – is essential to maximize safety and mobility benefits from rapidly advancing ITS technologies. To support interoperability, ITS JPO maintains and evolves a reference system architecture and companion software tools and supports the development of ITS standards to enable efficient, safe and secure ITS deployments. ITS JPO cooperates with stakeholders to evolve this architecture reference – currently supporting tailorable implementations over 130 ITS services – to accommodate, and in some cases lead, technological evolution. ITS JPO cooperates with stakeholders to develop needed ITS voluntary technical standards and to specify and adapt appropriate Information and Communications Technology (ICT) standards to support customized local ITS infrastructure implementations as well as large-scale interoperable integration of automation and connectivity technologies. ITS JPO also provides architecture technical support and reference implementations of key standards to assist State and local implementers of ITS technologies. ITS JPO works closely with the Office of the Assistant Secretary for Aviation and International Affairs (OST-X) to support advocating active use of U.S. ITS architecture and standards products in other nations – with notable recent successes in Brazil and Turkey - and to continue support of cross-border and North American interoperability efforts.

The Complete Trip Program supports the USDOT’s mobility/underserved communities research priority. The research maps to the Mobility Research Working Group’s scope and annual goals to address market failures associated with transportation for for all travelers, including travelers with disabilities, travelers from rural areas, and lower income travelers. This research will be coordinated with our model partners across multiple agency disciplines and will develop the capacity of our partners to make improvements in this often-overlooked area.

The Data Access and Exchanges, Emerging and Enabling Technology, and Accelerating Deployment Programs support all USDOT research priority areas. The programs include a variety of efforts related to evidence-based decision making and focuses on questions of investment choices, value, awareness of technologies, and their application in the real world. Cost/benefit data are the cornerstones of any analysis relating to economic impact, performance assessment, feasibility assessment, and impact assessments. Mobility improvements associated with the deployment of technology are assessed through evaluation. Cybersecurity awareness and training will be included under the Professional Capacity Building (PCB) Program.

By constantly engaging with the transportation industry and maintaining ties with national and international practitioners, the ITS JPO research efforts focus on market failures and avoids research already being undertaken by private actors. This allows us to identify transportation problems worth solving and facilitates our engagement within the transportation industry to address market failures including system safety, multimodal improvements, interoperability, underserved populations, and other long-term challenges. *Table 1* below provides an overview of how the ITS JPO Program Categories align with the DOT Research Priorities.

Table 1: DOT Research Priority Matrix

	Automation	Data Access and Exchanges	Cybersecurity for ITS	Emerging/Enabling Technologies	Complete Trip	Accelerating Deployment
Regulatory Reform	X	X	X	X	X	X
Permitting Reform		X				
Performance-Based Safety Rules	X	X		X		X
Value Capture		X				
Asset Recycling						
Freight Mobility	X	X	X			X
Microtransit	X	X		X	X	X
Underserved Communities	X	X	X		X	X
Cybersecurity	X	X	X	X	X	X

Chapter 1. Introduction / Agency-Wide Research Approach

Federal Role/Continued Relevance

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA-91) called for the establishment of a federal program to research, develop and operationally test Intelligent Transportation Systems (ITS) and to promote ITS implementation. In response to federal legislation, the ITS JPO serves as the principal office for the development, deployment, and evaluation of ITS technology. The ITS JPO uses discretionary funding to fund projects in whole, or in coordination with the other USDOT modal administrations. The ITS JPO leads collaborative and innovative research, development, and implementation of intelligent transportation systems technologies to improve the safety and mobility of people and goods. The ITS JPO takes a leadership roles in grant programs, serves as a multi-modal coordinator that leads in the research and development (R&D) stage of ITS technologies and in facilitating emerging projects where cross cutting capabilities and technology transfer are required.

ITS JPO Programs have provided a valuable service to both the USDOT, and the nation's transportation system. Without the ITS JPO, there would have been a void in emerging technology R&D. The ITS JPO Programs work across modes developing emerging concepts, and ensuring that the USDOT is positioned for the long term. By working where no singular Mode has oversight, the ITS JPO has served as a mechanism for providing research 'seed money' to bridge the divides between Modal administrations. Since the establishment of the ITS JPO 1991, the impact of the ITS JPO research programs are evident through a variety of past and present Programs. Without the involvement of the ITS JPO these accomplishments would not have occurred, or would have evolved with less federal leadership. Examples include:

- **5.9 GHz Communication Spectrum Dedicated to Transportation Safety Applications**
 - ITS JPO research led directly to the Federal Communications Commissions (FCC) allocation of 75 MHz of spectrum in the 5.9 GHz range (5825 – 5925 MHz) for Dedicated Short Range Communications (DSRC) in October 1999.
- **511 Traveler Information System**
 - ITS JPO research resulted in the Federal Communications Commissions (FCC) designation of 511 as a single travel information telephone number that provides current information about travel conditions throughout the United States.
- **ITS Standards and Architecture Development**
 - The ITS JPO has led the USDOTs ITS Standards Program since 1996. This work is required to encourage the widespread use of ITS technologies in our Nation's surface transportation systems. Because ITS standards are based on open, non-proprietary technology, their use can facilitate the deployment of interoperable ITS systems, and make it easier for state and local ITS deployers to develop and deploy regionally integrated transportation systems.
- **Crash Avoidance Metric Partnership (CAMP)**
 - Since 2006, the USDOT joined together with a partnership of automotive manufacturers, to develop and test prototype connected vehicle safety applications. The overarching goal was to determine whether this technology would work better

than existing vehicle-based safety systems, like adaptive cruise control, to address imminent crash scenarios. This effort has allowed the USDOT to engage in pre-competitive research with the private sector.

- **Connected Vehicle Pilots**

- The current ITS JPO Connected Vehicle Pilot Deployment, utilizes infrastructure, vehicle connectivity, and mobile device data to improve multi-modal surface transportation systems performance and enable enhanced performance-based systems management. This effort is utilizing decades of ITS JPO research and deploying it in the real world.

Along with undertaking research and development activities, another major component of USDOTs long term planning is understanding the past and present of ITS in practice, and this understating has continually been achieved via the ongoing ITS Deployment Tracking Survey. The ITS Deployment Tracking Survey has been conducted since 1997. It was created and administered to track and manage progress toward a ten-year ITS deployment goal set by the Secretary of Transportation in 1995. The Deployment Tracking Surveys have consistently measured ITS Deployment through a set of indicators related to the major functions of ITS infrastructure components, with a separate set of indicators tracking ITS support for interagency integration. These indicators have historically been used to better understand which agencies tended to need additional encouragement in adopting ITS and integrating their deployments with neighboring agencies and jurisdictions. The survey has also been instrumental in understanding trends in deployment technologies and emerging priorities in agencies' deployment plans.

As ITS technologies continue to evolve and adapt in the coming years, the targeted research and development undertaken by the ITS JPO will continue to serve as a proving ground and accelerator for multimodal efficiency, safety, and reliability of surface transportation systems.

Through our research activities the ITS JPO serves two distinct roles within the USDOT, as both the project lead and as a multi-modal coordinator, working to ensure effective ITS research and technology deployments are successful. The ITS JPO serves as the lead in forward looking and emerging work that is not limited to just one mode, and leads emerging projects where cross cutting capabilities are required. This includes connected data systems and large-scale pilot deployments, such as the current Connected Vehicle Pilot Deployment, which is utilizing infrastructure and vehicle connectivity, and mobile device data to improve the multi-modal surface transportation systems performance, and enables enhanced performance-based systems management.

The mission of the U.S. Department of Transportation (USDOT) is to ensure our Nation has the safest, most efficient and modern transportation system in the world, which improves the quality of life for all American people and communities, from rural to urban, and increases the productivity and competitiveness of American workers and businesses. The ITS JPO serves as a Departmental leader in addressing the USDOTs Strategic Goal on Innovation, which is to “lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the nation’s transportation system.”

The ITS JPO portfolio of research, and technology deployment support programs focus on diverse systems and technologies geared towards producing the greatest public benefit from transportation's increasing technological transformation. The ITS JPO is responsible for coordinating the Departments ITS Program and initiatives among the various USDOT operating administrations: Federal Highway Administration (FHWA); Federal Motor Carrier Safety Administration (FMCSA); Federal Transit Administration (FTA); Federal Railroad Administration (FRA); National Highway Traffic Safety Administration (NHTSA); Maritime Administration (MARAD) and the St. Lawrence Seaway Development Corporation (SLSDC). The ITS JPO builds on, and leverages the technology and applications developed across all of these modes, as well as with current industry and academic leaders to ensure the USDOT is at the forefront of rapid technological change.

The USDOT and the ITS JPO in particular are uniquely positioned to ensure the greatest public good arise from the rapid advancements in transportation related technologies.

Under the FAST Act, the ITS JPO is charged with carrying out the provisions in Title 23, United States Code, Sections 512-518. The law allocates \$100,000,000 for each of fiscal years 2016 through 2020 subject to obligation limitations.

The goals of the ITS Program include:

- Enhancement of surface transportation efficiency and facilitation of intermodalism and international trade to enable existing facilities to meet a significant portion of future transportation needs, including public access to employment, goods, and services, and to reduce regulatory, financial, and other transaction costs to public agencies and system users
- Achievement of national transportation safety goals, including enhancement of safe operation of motor vehicles and non-motorized vehicles and improved emergency response to collisions, with particular emphasis on decreasing the number and severity of collisions
- Protection and enhancement of the natural environment and communities affected by surface transportation, with particular emphasis on assisting state and local governments to achieve national environmental goals
- Accommodation of the needs of all users of surface transportation systems, including operators of commercial motor vehicles, passenger motor vehicles, motorcycles, bicycles, and pedestrians (including individuals with disabilities)
- Enhancement of national defense mobility and improvement of the ability of the United States to respond to security-related or other manmade emergencies and natural disasters
- Enhancement of the national freight system and support to national freight policy goals.

The ITS JPO is positioned to work across the USDOT with our modal partners to develop and coordinate multimodal projects that are central to automation, cybersecurity, data access, emerging/enabling technologies, underserved communities and the education of our public-sector workforce.

The research undertaken by the ITS JPO portfolio is needed in order to ensure that safety, efficiency and mobility benefits arising from emerging transportation technologies are looked at holistically, and to ensure that areas where potential market failures exist do not serve as speed bumps to a safer transportation network. As technology becomes more integrated across all industry sectors, and the level of connectivity between all modes of transportation continues to increase, system-wide mobility and congestion-reduction benefits as well as vehicle-level improvements in safety, comfort, and convenience will continue to require coordination.

For each of the ITS JPO Program Categories, the impacts that would arise from a lack of funding would be similar. There are limited financial incentives for non-governmental groups to focus on all transportation users. Without ITS JPO funded projects there would be minimal coordination amongst the numerous organizations involved in automation and communications; both on a technology side and on the policy side. With data, and emerging technologies, a strong federal role allows State and local governments to learn and expand their capabilities. With the Complete Trip Program we promote complete mobility solutions for travelers with disabilities, travelers from rural areas, and lower income travelers. Information on each of the Program Categories is provided below:

Automation. In the near term, vehicles with various levels of driving automation systems that enter the market potentially offer new benefits in travel comfort, convenience, and affordable accessibility. There is a clear government role in both ensuring public safety as these vehicles are introduced into service, and in ensuring that these vehicles are integrated into the road network in a manner that improves the efficiency of the system, and provides equitable mobility for all. The private sector is leading technology research and development but they are focused on vehicles that are, for lack of a better term, “self-interested.” The vehicles will behave in a way that works best for their own travel needs but without consideration for wider impacts to the road network. As more vehicles are deployed, coordination through connectivity could ensure that the continued introduction of automated driving technologies produces system-wide mobility and congestion-reduction benefits in addition to vehicle-level improvements in safety, comfort, and convenience.

Data Access and Exchanges. A sustained focus on enabling data access across the automated vehicle (AV) ecosystem is necessary to integrate AVs into the system efficiently and safely. USDOT has heard from stakeholders that access to data is a critical enabler for the safe deployment of AVs, while lack of access could impede actions to accommodate AVs and, thereby, delay their introduction. This need is consistent across all modes of transportation, and within many aspects of AV deployment addressed in the USDOT research portfolio, such as performance measurement, safety assurance, cybersecurity, and insurance. Data exchanges – which increase access to data across the AV ecosystem for specific uses – will be key to accelerating the safe and efficient deployment of AVs. While USDOT and our stakeholders cannot define all data exchange needs upfront, we can and should build capabilities iteratively, starting with the most critical use cases.

Cybersecurity for ITS. Securing transportation’s critical assets and infrastructure against cyber threats is a shared responsibility of both the public and private sectors. A common vision and a

framework for achieving that vision are needed to guide the public-private partnerships that will secure transportation systems. Presidential Executive Order 13800 (issued May 11, 2017) on Cybersecurity of Federal Networks and Critical Infrastructure, holds heads of Departments accountable for managing cybersecurity risk of their ecosystem. USDOT Strategic Plan FY 2018 – 2022 stated that “DOT will encourage the adoption of the National Institute of Standards and Technology (NIST) Cybersecurity Framework by transportation ecosystem stakeholders.” USDOT leadership offers State and local agencies an opportunity to express their needs and have cybersecurity experts translate into use cases and requirements that cross modal boundaries and ensure risk management among intelligent vehicles, intelligent infrastructure, and portable devices. State and local agencies tend not to have this type of expertise nor do they have the time or funding to pursue initiatives that are critical but tangential to their daily operational mission.

Emerging/Enabling Technologies. Communications technologies are critical to the safe, secure, and efficient operations of ITS. Transportation agencies have incorporated communications into their operational environments (i.e., field systems, management centers, and public fleets), and vehicle manufacturers are increasingly including multiple types of communications into their vehicles. These emerging communications technologies will continue to have significant impacts on the transportation system. The USDOT has an important role to play in pursuing research and analysis around emerging transportation technologies and their use of telecommunications to deliver public benefit. USDOT’s role allows State and local agencies to confer with telecommunications experts to understand requirements that cross market boundaries and ensure interoperability.

Complete Trip. This effort is exploring emerging technologies to enhance travel that includes opportunities for people with mobility challenges by providing travel opportunities that are seamlessly integrated into their daily lives. This seamless integration will be the “Complete Trips for All” effort highlighted by the USDOT Topical Research Area – Mobility Innovation working group. The Complete Trips for All vision leverages innovative technologies and facilitates public private partnerships to allow for a traveler-centric approach that improves mobility options for all travelers, including travelers with disabilities, travelers in rural areas, and lower income travelers. The program resources identified in the ITS JPO FY 2019 Spend Plan were used to support defining the Complete Trips for All vision. Internal to USDOT this effort has reached beyond the research team to include the planning, civil rights, and policy disciplines. This multidisciplinary connection is critical to the success of the technology transfer efforts under this program area. This effort would also glean input from a range of interagency Federal partners including the Departments of Health and Human Services (DHHS), Labor (DOL), Defense (DOD), and others.

Accelerating Deployment. The ITS JPO is the USDOT’s primary mechanism for educating the public sector’s transportation workforce about ITS. The ITS JPO will continue to support activities that deliver multimodal ITS learning opportunities to the public-sector workforce by coordinating outreach related to the ITS JPO’s research initiatives and providing technical assistance. The ITS JPO has developed and delivered technology transfer in close coordination with partners including the National Highway Institute (NHI), Intelligent Transportation Society of America (ITSA), Institute

of Transportation Engineers (ITE), National Operations Center of Excellence (NOCoE), National Association of Development Organizations (NADO), universities and other stakeholders. The public-sector participants representing State DOTs, Metropolitan Planning Organizations (MPOs) and local agencies have benefited from this partnership. Participants have favorably evaluated the ITS JPO technology transfer for its delivery of much needed training and technical assistance with feedback indicating that participants use the training to improve grant applications, purchasing decision, or procurement designs. Evaluators have also mentioned a reassessment of infrastructure vulnerability including information technology (IT)-data management improvements as a result of technology transfer events provided by the ITS JPO.

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In FY2020 the ITS JPO will be launching new programs that will further the USDOTs goals of innovation by accelerating and expanding the deployment of new technologies and practices and by actively promoting innovations that enhance the safety and performance of the Nation’s transportation system.

Center of Deployment Excellence. In 2019, the ITS JPO proposed to undertake an analysis of the feasibility of a proposed Center – or Centers – of Deployment Excellence which would work across the Department and with all modes to provide integrated and leveraged ITS deployment support across the full lifecycle of deployment, from deployment preplanning, through to project data collection/management, performance measurement and goal setting, training, capacity building, evaluation support, guidance, best practices and analysis to show quantitatively and qualitatively the ROI of ITS deployments and technologies to the nation. The goal is to create a focus within the Department on activities that will accommodate true innovation in management of the performance of deployed ITS projects across the nation. In 2020, based on the outcome of the 2019 effort the ITS JPO will focus on “standing up” the ITS CoDE.

The proposed ITS CoDE is expected to place the USDOT in the forefront of evidence-based decision- and policy-making for transportation technology deployment. The ITS CoDE is expected to:

- Focus on an integrated, leveraged project-lifecycle approach to accelerating and improving stakeholder investment in ITS technologies, applications, and services via evidence-based decision making, information acquisition/management, evaluation, and tech transfer.
- Assist stakeholders with making quantitative and qualitative decisions from pre-deployment/investment planning through to performance measure setting, data collection and management, evaluation, and transfer of results and best practices.

The initial scope of the ITS CoDE is expected to be initially limited to ITS deployment, and incorporate the priorities and needs of JPO partners across all modes in the USDOT.

Artificial Intelligence. Artificial Intelligence (AI) has been identified as an area of prioritization, both for the benefits it promises and the opportunity to extend those benefits across modes within USDOT. Attention to AI has grown significantly over the last several years and has accelerated within the U.S. government after the release of the White House Executive Order, *Maintaining American Leadership in Artificial Intelligence*. Currently, efforts related to AI within USDOT have largely been conducted at the project level. As individual modes make investments in projects that leverage AI technologies, ITS JPO is uniquely positioned to help accelerate knowledge transfer and investment opportunities between these modes. The benefits realized by AI-enabled technologies in one particular mode might be extended across multiple modes, if coordinated properly. Through this program, ITS JPO seeks to coordinate and synchronize AI research, development, and deployment activities across modes. ITS JPO will work with agency modes to identify AI applications that could be leveraged across the transportation system. A draft baseline report on *Artificial Intelligence and Machine Learning*¹ canvassed artificial intelligence activities throughout USDOT and identified immediate impact areas for potential research coordination, such as computer vision, natural language processing, and decision support tools. ITS JPO will inventory AI-related projects already underway, explore possibilities for multi-modal coordination, as well as identify new areas of research where multiple modes can benefit from emerging technologies.

¹ *ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING BASELINING: Findings and Recommendations on Defining AI and Machine Learning for U.S. DOT and Identifying Current Activities, Future Priorities, and Needs*. Report to the Office of the Chief Information Officer and the Office of the Under Secretary for Transportation Policy Draft – December 6, 2018

Research Portfolio Information

The ITS JPO is committed to both the requirements and spirit of the USDOT's plan to increase public access to the results of federally-funded scientific research and other initiatives aimed at making research results easy to discover, access, and use. The ITS JPO has committed staff time and resources to reporting its research portfolio information through the USDOT Research Hub and is coordinating with the OST-R Research Hub managers to determine how best to integrate and execute the dissemination of the outcomes of the ITS JPO research portfolio. ITS JPO has historically published reports to ROSA-P and will continue this effort. In 2018, the ITS JPO formally signed an interagency agreement with the National Transportation Library (NTL) codifying the use of ROSA-P to share final research results data from ITS JPO projects. The ITS JPO maintains robust portfolio management practices to ensure project alignment to the AMRP and the *DOT Strategic Plan*. This commitment to coordination is reflected in our efforts to integrate and execute the ITS JPO research portfolio.

All ITS JPO-funded projects are required to justify their proposed projects relationship to the AMRP program structure, and at a minimum identify planned benefits, and modal partners. The ITS JPO provides significant staff time and resources to help program managers include public access requirements in procurements, oversee compliance, and work with the NTL and other data access partners to publish quality data in a timely manner; in FY18 the ITS JPO piloted improved data procedures and in FY19 it expanded coverage to all ITS JPO-funded projects. In FY19-FY20, the Data Access program will build on this foundation to more explicitly require new projects to register in the Research Hub, (following procedures described at <https://ntl.bts.gov/public-access>) and ensure the use of terminology consistent with the AMRP program structure. In FY19-FY20, the ITS JPO will also identify ways to incorporate additional types of research outputs, beyond data sets and reports, into ROSA-P; this could include making it easier to find the benefits, costs, and lessons learned database via the Research Hub and ROSA-P.

Acquisition/Assistance

The ITS JPO is staffed and administered through the FHWA. The Program uses a broad array of acquisition and assistance mechanisms to support and stimulate highway related research. Research funding is authorized by statute to allow discretion in the selection of contracts, grants, cooperative agreements, and interagency agreements where appropriate for the specific project. The selection of the appropriate acquisition or assistance vehicle is made by a warranted Contracting Officer in FHWA's Office of Acquisition and Grants Management in consultation with the requiring program office. This decision is made at the earliest stage of the planning process and helps shape important factors such as the degree of control ITS JPO may have in the direction of the project, rights in ownership of research results, potential leveraging of non-Federal funds, and the marketplace of interested vendors or recipients.

Acquisition – contracts and purchase orders

Acquisition encompasses the mechanisms used to acquire supplies or services primarily through the issuance of contracts and purchase orders that are for the direct benefit of the Government. The term contract applies to awards made for supplies or services of value above the Federal Acquisition Regulation's Simplified Acquisition Threshold (currently \$150,000). Simplified acquisition procedures, which are quicker and more streamlined, may be used for needs under \$150,000. An acquisition award under \$150,000, using simplified acquisition procedures is referred to as a purchase order – within the research program purchase orders are most commonly used to acquire supplies necessary for operation.

The ITS JPO strives to utilize the most efficient and effective methods to support research activities with contracts that offer economical, best value for the taxpayers while engaging a myriad of highly sophisticated private sector organizations; ranging from small disadvantaged business enterprises to Fortune 500 corporations and universities. The ITS JPO research program has highly diverse needs. Contract types span the breadth from short term firm fixed price awards and cost reimbursement studies with uncertain outcomes to multi-year indefinite delivery indefinite quantity awards that allow expeditious ordering of goods and services. Additionally, solicitation methods such as Broad Agency Announcements (BAA) enable industry to propose unique and innovative solutions to address problem statements and allow ITS JPO to make multiple awards from a single announcement and using both acquisition and assistance award types.

Assistance – grants and cooperative agreements

Assistance describes the process by which the Government provides support to accomplish a public purpose that is authorized by Federal statute. The instruments used to carry out assistance are grants and cooperative agreements. The majority of research grants and cooperative agreements require a minimum non-Federal matching contribution, typically 20 to 50 percent, as required by the specific legislative authority for the program. Grants and cooperative agreements are similar and are governed by the same regulations found in [2 CFR Part 200](#)². The distinction between the

² https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title02/2cfr200_main_02.tpl

two is the degree of Federal involvement in the carryout of the specific award. Grants are used when no substantial government involvement is envisioned in the technical direction of the award. Cooperative agreements are used when the ITS JPO contemplates substantial technical involvement during performance with the recipient.

Interagency and Intra-agency agreements (IAA)

Interagency and Intra-agency agreements are awards between ITS JPO and another Federal entity. An interagency agreement is used if the partner agency is outside the USDOT. Intra-agency agreement is the term when the partner agency is another USDOT operating administration. The ITS JPO research program both receives funds to conduct work for other agencies and sends funding to other agencies to participate in collaborative research of interest to both partnering agencies. Aside from the Volpe Center, nearly all ITS JPO research funded IAAs are awarded under the authority of the Economy Act, which requires a determination that it is more efficient and economical to conduct the work with the specific partnering agency versus contracting with the private sector. IAAs with Volpe are not subject to the Economy Act as the Volpe Center has specific authority to perform research for USDOT operating administrations.

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Technology Transfer

Deployment and Research Technical Assistance

The ITS Program is involved in sharing best practices and lessons learned from projects undertaken within the Program. The ITS JPO's Professional Capacity Building (PCB) Program is the primary mechanism for educating the public sector's transportation workforce about ITS. One of the ITS JPO's PCB teams' primary objectives is to promote technology transfer and education to accelerate deployment of ITS research and technologies. The Program supports activities that deliver multimodal ITS learning opportunities to the public-sector workforce by coordinating outreach related to the ITS JPO's research initiatives providing technical assistance to public-sector ITS deployers through ITS Peer- and Talking Technology Transportation (T3) webinar programs, and delivering ITS training through partners. The Program monitors and tracks attendance, participation levels and training course reviews as ways to track performance and identify areas for continuous improvement. These performance reports are monitored within the ITS JPO.

In 2017, the *Intelligent Transportation Systems Professional Capacity Building Program Strategic Plan, 2017-2021*, was developed. As part of the development of the PCB Strategic Plan, the Program identified and defined 18 audience segments, which were categorized into six groups based on their relationships to ITS, CVs, and AVs. The figure below shows the six stakeholder groups and 18 audience segments identified in 2017.

Agency Management -Executives and General Managers	Transportation System Users -Commercial Vehicles/Freight -General Public
Technical Development/Device -Agency IT/Tech Support -Automakers/Original Equipment Manufacturers (OEMs) -Software Engineers/Technology Managers/Application Developers -Infrastructure Integrators/Equipment Vendors -Communications Engineers (DSRC, Satellite, Cellular, Wi-Fi)	Transportation Management -Transportation Management Center Operations -Transportation Operations/Traffic Engineers -ITS Project Manager -Transit Professionals
Policy and Planning -Legal and Legislative -Planners -Public Safety Professionals	Specialized Operations -Incident Management Operators -Maintenance Engineers -Safety Analysts/ Engineers

Figure 1: PCB Audience Segments (Source: ITS JPO)

To ensure that these identified audiences are given necessary knowledge sharing and technology sharing support, the ITS PCB Program works in partnership with professional associations, universities, state, regional and local public agencies, and the training programs of USDOT modal administrations to engage the broad technical and organizational expertise needed to develop and deliver ITS learning. Specific partners include:

- Federal Highway Administration (FHWA)
 - Office of Infrastructure

- Office of Innovative Program Delivery – Center for Transportation Workforce Development
- Office of Operations
- Office of Planning, Environment, and Realty
- Office of Research, Development, and Technology (RD&T)
- Office of Safety
- Office of Safety Research and Development (R&D)
- National Highway Institute
- Resource Center
- Federal Transit Administration (FTA)
- Maritime Administration (MARAD)
- American Planning Association (APA)
- American Public Transportation Association (APTA)
- Institute of Transportation Engineers (ITE)
- International Municipal Signal Association (IMSA)
- ITS America (ITSA)
- National Association of Development Organizations (NADO)
- National Network for the Transportation Workforce (NNTW)
- National Operations Center of Excellence (NOCoE)
- National Transit Institute (NTI)

Each of these Federal program offices, educational organizations, or professional associations act as a sounding board from which the ITS PCB Program receives information on educational and training needs and also as a distribution channel through which the ITS PCB Program disseminates various ITS educational materials or training courses developed. The ITS PCB Program will continue to enhance coordination efforts with all USDOT modal partners in FY2020. Through the implementation of the *PCB Strategic Plan*, the Program continues its mission to prepare transportation industry professionals (both current and future) for an ITS and connected automated transportation system. Creating, maintaining, and expanding effective partnerships is a critical component of the Program's strategy. Through its numerous partnerships, the Program is able to undertake the following for internal and external audiences:

- Determine the knowledge and skills needed for the ITS workforce and develop an ITS and connected automated curriculum that adjusts as needed to reflect industry needs.
- Provide structured learning directly or through partners on ITS core competencies.
- Serve as a clearinghouse for ITS learning opportunities and instructional techniques.
- Facilitate knowledge sharing among researchers, practitioners, and decision makers so that everyone gains from the experience of applying ITS in the real world, and new research results are quickly adopted and put into practice.

The Program has learned the most effective way to provide successful knowledge sharing is to provide training and support on a specific program area (e.g., active traffic management, advanced vehicle safety systems, cyber security, public transportation management, traveler information, etc.) through an assortment of methods. The Program deploys seven types of training and education methods, often in collaboration with its partners. Methods include:

1. Webinars (e.g. Talking Technology and Transportation (T3) Webinars – approximately 18 per year)
2. Workshops (e.g. ITS State Chapter Workshops – 10 to 14 per year)
3. Online Training Modules (e.g. 77 ITS Standards modules)
4. Technical Assistance (e.g. Connected Vehicle Deployment Technical Assistance (CVDTA) Cohorts Program, CVDTA Roadside Equipment Loan Program, ITS Help Line, ITS PCB Peer Program)
5. Classroom / Courses (e.g. National Highway Institute’s ITS courses)
6. Educational Materials (e.g. ITS Knowledge Resources Databases, ITS ePrimer online modules)
7. Academic Support (e.g. ITS University and Community College Workshops and Academic Communities of Practice projects, ITS case studies)

Through increased coordination with its partners, the Program foresees an increased ability to provide ITS knowledge sharing and technical assistance to the various audience segments. This activity will be documented with metrics such as the number of participants reached by online and instructor led training, engagement levels by state and/or geographic areas, number of ITS JPO PCB sponsored educational offerings developed each year, and progress in filling gaps identified in a recently completed training needs assessment. The PCB Program has a long-established effort to evaluate both individual events and product usage, to measure the benefits for each user. The Program will continue to conduct annual surveys to understand user preferences and identify ways to improve program delivery and maximize its impact. The annual survey also seeks to identify specific results and outcomes from the use of the ITS PCB products. A few of the specific outcomes cited during the 2017 survey include:

- Directed funding opportunities for ITS project or improved funding grant applications.
- Helped better inform purchase decisions and improve system or facility design.
- Gained better knowledge on system vulnerabilities and how to assess and manage to avoid, identify, or respond to these potential risks.
- Aided in direct input into Strategic Planning activities and policy decisions.
- Applied ITS PCB materials to presentations before other audiences further providing additional knowledge sharing.

During the first 15 years of the ITS PCB Program, between 1,500 and 3,000 professionals used one or more ITS trainings each year. Since 2011, the annual users have increased to an estimated 50,000 professionals or students, with a portfolio of about 300 individual courses and other educational products, available for free. The Program continues to expand awareness with a wide range of professional development offerings by participating in established and emerging industry events and conferences. In 2019, the PCB Program presented information at two large industry events: the Transportation Research Board’s Annual Meeting (this meeting attracts more than 13,000 transportation professionals from around the world and covers all transportation modes) and the South by Southwest Education Conference (SXSW EDU), a component of the SXSW family of conferences and festivals. SXSW EDU, has over 16,000 attendees, and fosters innovation in learning

by hosting sessions, in-depth workshops, engaging learning experiences, mentorship, policy discussions, competitions, and exhibitions.

The ITS PCB Program also offers the Connected Vehicle Deployment Technical Assistance Programs. One aspect of that program includes a Connected Vehicle Pilot Cohort designed to assist the CV Pilots with interoperability. In 2018, the CV Pilot sites gathered at Turner Fairbank Highway Research Center (TFHRC) to test interoperability. Interoperability was demonstrated in staged scenarios over the test period on TFHRC's closed road course. In total, 102 interoperability test runs were conducted for four test cases. Through partnership with the TFHRC, the ITS PCB Program continues to provide technical assistance to grant recipients and transferring that knowledge to other early deployers.

Intelligent Transportation Systems (ITS) Architecture and Standards (A&S)

Interoperability – allowing transportation systems user to access ITS services anywhere they may travel – is essential to maximize safety and mobility benefits from advancing ITS technologies. As ITS are focused on the application of Information and Communications Technology (ICT) to manage and operate the surface transportation network, interoperability needs are partially analogous to those of the internet with the added dimension of ITS supporting safe operation of physical systems which move people and goods - where failures can have severe consequences. Beginning with the 1991 Intermodal Surface Transportation Equity Act (ISTEA) and continuing through the current 2015 Fixing America's Surface Transportation (FAST) Act, in addition to legislation directing the ITS research program, there is specific legislative direction requiring USDOT, via the ITS JPO, to develop and maintain a National ITS reference architecture and cooperate with Standards Development Organizations (SDO) to facilitate ITS implementation.

A&S Program goals are to enable safe, efficient, interoperable, secure and cost-effective ITS infrastructure, automation and connectivity implementations that benefit all users of the transportation system. The ITS Architecture Program provides a framework to guide State and local planning and project implementation, providing the reference and tools needed to customize ITS implementations to meet local needs while maintaining commonality necessary for interoperability. The Architecture Program makes available both regional and project planning software toolsets as well as a reference architecture with 130+ ITS services that are tailorable to meet implementers' needs. The architecture identifies interfaces for standardization and -along with suitable ICT and ITS standards – identifies and enables multiple suitable technology choices whenever viable. The Program also conducts extensive implementation support activity, providing technical support along with systems engineering and architecture implementation workshops to State and local customers Nationwide as well as supporting cross border interoperability with Canada and Mexico.

Standards define interfaces within system architectures to enable required interoperability and support efficient, non-proprietary ITS deployment. Most of the standards needs for ITS can be met through appropriately choosing available ICT standards. When this is not viable, the ITS Standards Program supports development, testing and implementation for standards requirements unique to ITS which cannot be met using available ICT standards, including both supporting development of

ITS-unique standards as well as adaption of ICT standards to better accommodate ITS needs. As part of this support, ITS JPO participates in key ICT standards efforts in 5th generation wireless technology (“5G”), over-the-air communications security, and internet of things (IoT) among other relevant spaces to better understand ITS opportunities; and when viable, recommends enhancements beneficial to ITS needs.

As ITS evolves from primarily infrastructure systems (for example traffic signal coordination or ramp metering; some interconnected, some standalone) towards a nationwide or, preferably North American, complex “system of systems” including automated and connected vehicles of many classes, secure system-wide interoperability becomes far more important. Incorporating vehicles – both automated and human operated capabilities - via Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) or Vehicle-to-Everything (V2X) (collectively “connectivity”) offers great promise to improve safety and mobility. However, once vehicles, which can easily travel across North America and become part of the ITS system, multi-regional interoperability becomes a requirement rather than merely a benefit. Additionally, connecting what were standalone ITS systems into the internet also creates security challenges that must be addressed. Beyond interoperability, standards-based ITS deployments can facilitate more competitive procurement of ITS components and systems and incentivize innovation. Open, interoperable and secure systems can reduce life-cycle cost and increase performance.

Looking forward in the longer term, A&S Programs will seek to continue to become more agile so that products can be consistently made available ever earlier in the technological lifecycle to proactively support applied research, pilots and expedited integration of emerging technologies into to the transportation system, while continuing to maintain backward compatibility such that dated but functional systems can remain in service as long as beneficial and such that the system remains fully accessible to all users.

ITS Architecture: Working in cooperation with industry and governmental stakeholders, ITS JPO maintains and evolves reference architectures with software tools to support ITS infrastructure, connectivity and automation deployments and provides extensive deployment support.

The recently released current architecture reference and toolsets, are the first to fully incorporate wireless connectivity with mobile participants in the transportation system. The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) and its accompanying software tools are available at no cost from www.arc-it.net. ARC-IT provides 130+ tailorable ITS services for implementers to choose from in a unifying framework that covers ITS comprehensively, covering traditional infrastructure ITS capabilities and connectivity capabilities which can also support connected automation. ARC-IT follows a technology-neutral approach, identifying multiple suitable technologies and their associated ICT and ITS standards whenever multiple means of satisfying performance requirements are available. ARC-IT and the accompanying toolsets help implementers develop regional architectures to effectively meet their needs (and ensure regulatory compliance), as well as project architectures to facilitate efficient, secure, and interoperable ITS deployments. ARC-IT also includes two companion software tools –the Regional Architecture Development for

Intelligent Transportation (RAD-IT) tool for regional architecture developers and the Systems Engineering Tool for Intelligent Transportation (SET-IT) tool for project architectures. Good engineering practice – and legislation – requires that regions have architectures in place prior to expending Federal Highway Administration funding on ITS deployments. The ITS reference architecture provides a basis for regions to develop and implement customized ITS architectures to meet their needs most effectively. It should be noted that there has been significant publicity associated with the “Internet of Things” (IoT) concept which is essentially a “system of systems” architecture concept. The ITS architecture is similar in concept to what is commonly referred to as IoT and reflects the capabilities of incorporating multiple systems into a larger system – the transportation system – to achieve broad public benefit.

Near-term planned evolution includes: (1) adding additional automation-specific ITS services, (2) better adapting existing ITS services to take maximum advantage of the safety and mobility benefits of interoperable integration of automation into the surface transportation system, (3) seeking consensus on an high-level optional interface architecture between automated vehicles and the infrastructure, (4) adding additional viewpoints and tools to better serve a broader user base including the planning community, (5) continuing to increase the level of detail in key architecture views including more detailed standards, profile, and security recommendations based on results of applying the Nation Institute of Standards and Technology’s (NIST) Cybersecurity Framework and internationally cooperative analyses, (6) continuing support of US implementation assistance, including enhanced outreach to the transportation planning community, and (7) continued support of cross-border and North American interoperability efforts in cooperation with the Office of the Assistant Secretary for Aviation and International Affairs (OST-X). All of this work will be conducted with broad stakeholder input and will be informed by emerging technological evolution from both USDOT sponsored and outside research efforts.

ITS Standards: Just as the meaning of a red traffic signal has been standardized to assure a common understanding by drivers, components of the ITS system – including vehicles and other mobile participants – must fit within an architecture containing interfaces whose data exchange is governed by consensus-based standards to assure system-wide interoperability and accessibility for all participants. ITS JPO cooperates with industry-led Standards Development Organizations (SDOs) and stakeholders to develop and maintain ITS standards to support interoperable automation, connectivity and infrastructure ITS deployments; with more than 100 ITS voluntary technical standards published. Federal funding is leveraged by extensive contributions by private sector stakeholders to develop broadly acceptable, complete and correct ITS-unique standards via SDOs’ consensus-based processes. Federal funding support is used to assure the inclusion of public sector needs and requirements, expedite development of key standards that are of greatest public interest, and facilitate cooperation among diverse stakeholder groups as well to as to provide technical expertise needed to assure complete and correct standards products. In the ITS space, with numerous competitive vehicle and equipment manufacturers and 13,000+ localities responsible for their ITS deployments, Federal resources and leadership provide an essential means to facilitate expedited stakeholder consensus on those key standards needed to support Nationwide implementation of advanced technologies. In addition to supporting ITS-specific

standards development, ITS JPO also supports ITS-relevant activity within ICT standards activity when ICT is a necessary component for ITS deployment. For example, the Program monitors and participates via technical support in wireless communication standards activity including the IEEE 802 working group currently examining both next-generation vehicular standards as well as 5th generation wireless (5G) capabilities, along with the 3rd Generation Partnership (3GPP) responsible for current Long Term Evolution Cellular (LTE) standards and working on future 5G capabilities which could support automation, connectivity and ITS infrastructure backhaul needs. This participation supports adaptation of these ICT standards to more easily accommodate ITS needs, reducing the need for ITS-specific standards development efforts.

ITS JPO also supports testing of standards, development of test tools and development and maintenance of standards reference implementations to: (a) provide additional information to support deployment, and (b) provide implementation experience information to feedback into improving standards products. Near-term planned activities include: (1) identifying and initiating development of standards to support interoperable integration of automation with the ITS infrastructure and additional associated connectivity services, (2) maintaining and updating current ITS standards including adaptations to improve cybersecurity, (3) development efforts to fill ITS standards gaps identified by an internationally cooperative effort to identify architecture-wide standards recommendations, (4) initiating testing of additional standards in the Center-to-Center (C2C) and Center-to-Field (C2F) family, and (5) updating the SAE J2735 data dictionary to better support emerging connectivity and automation needs. Standards activity is conducted consistent with the Office of Management and Budget (OMB) Circular A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities", including direct Federal participation in standards working groups when appropriate. All of this work will be conducted with broad stakeholder input including inputs from the relevant SDO working groups.

The ITS Program supports interoperability via cross-modal cooperation with FHWA including the Office of Operations on V2I deployment, NHTSA on vehicle matters, FTA in transit and mobility as a service, and with other surface transportation modes along with state, local, industry and academic partners. The Standards Program has developed specific language for inclusion in research funding agreements and actively cooperates with research programs to appropriately enable researcher participation in standards processes, including providing candidate standards content and feedback on implementation experiences back into the SDO-managed standards development processes, to broaden scope and improve quality of standards products.

International Cooperation: A&S Programs seek to cooperate internationally when it is beneficial to US interests. The Programs have developed extensive cooperative relationships with SDOs (which tend to be international in their focus, even for those based in the US), governments and stakeholders with common interests, which has allowed the USDOT to successfully co-lead multiple internationally cooperative efforts and leverage resources, thus meeting US needs at significantly reduced cost while allowing access to global expertise and achieving more harmonized approaches to architecture and standards than might otherwise result. Harmonization can allow more similar –

and often identical – hardware, software and equipment to be used for vehicles and equipment destined for multiple markets. This can both reduce cost and speed deployment of advanced technologies and ease the burdens on industry of complying with similar, but incompatible, requirements across multiple markets. Going forward, the program will continue to leverage these cooperation opportunities to the maximum extent viable within institutional constraints whenever beneficial to the US. A&S programs also support extensive interoperability cooperation with Canada and Mexico in cooperation with OST-X, recognizing the importance of assuring both North American interoperability and cross-border efficiency as connectivity and automation implementation advance. Further, the A&S Programs support OST-X Office of International Transportation and Trade programs, including providing technical assistance and outreach support on A&S topics to international customers. Substantial adoption of US A&S products and approaches has been achieved internationally for the benefit of US industry. The larger global footprint of US approaches in turn benefits US implementation by broadening the marketplace for goods and services and benefits US suppliers of equipment and engineering services.

Funding: Historically, annual funding of \$5.5 – 7.5 million from the ITS budget supports A&S activities. This funding is leveraged by extensive US private and public sector stakeholder contributions to standards content development and architecture content as well as substantial benefits gained from international intergovernmental, SDO and stakeholder cooperation. To execute standards development activity, ITS JPO maintains multiple types of cooperative relationships with both North American and global SDOs active in the ITS space and underlying communications standards, as well as in other areas relevant to ITS system architecture. Arrangements including direct contractual relationships with the Institute for Transportation Engineers (ITS) ITE and SAE International, as well as contractual means to directly engage in IEEE and other high-priority SDO activity. For ITS architecture activity and standards testing and reference implementations, USDOT relies primarily on competitively awarded contracts and/or tasks. Intergovernmental cooperation via Interagency Agreements is utilized when beneficial; example include NIST for cybersecurity, the National Telecommunications and Information Administration (NTIA) for engagement in some 5G standards activity and the USDOT Volpe Center for policy and technical expertise. International cooperation is conducted via “twinning” and similar flexible cooperative structures that avoid international funding transfers and do not create formal obligations for US DOT. Cooperative efforts are structured such that each partner funds their portion of the work via their contractual/grant processes (no co-mingling of funds) and the overall program/project structure is agreed to by the parties in advance and the work effort is co-led by governmental or contractor leads via consensus-based management principles. The A&S Program is experienced and well-suited to executing such approaches efficiently as these are analogous to the stakeholder consensus-based approaches legislatively directed for the ITS Standards Program.

Access: ITS Architecture and Standards products are promptly made publicly available via suitable means: (1) Research reports are published via the USDOT process and entered in the National Transportation Library; (2) the ARC-IT reference architecture and associated toolsets are maintained online and publicly available without cost, and (3) published standards are made available via the publishing SDOs or consortia. By making the reference architecture and published

standards products available directly from their sources, we can better assure that users always are able to access the most recent versions of these products. USDOT ITS Program websites provide up-to-date links to available A&S products.

Performance Assessment: A&S contract performance is measured against contractual requirements. Stakeholder acceptance can be inferred from numbers of downloads of architecture and standards products, demand for architecture deployments support workshops, number of times Professional Capacity Building standards training modules are accessed, as well as the degree of incorporation of advanced capabilities in regional ITS architectures identified via periodic surveys. The effectiveness of A&S outreach and training can be measured by the level of technical assistance required of FHWA Resource Center staff by ITS implementers.

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Evaluation / Performance Measurement

The ITS JPO engages on Evaluation/Performance Measurement in two (2) ways:

1. **Nationwide ITS Deployment Assessment, Analysis, and Reporting:** The ITS JPO collects nationwide benefits, costs and lessons learned data to maintain a longitudinal repository of information to assist deployers with evidence-based decision-making, and conducts detailed surveys of ITS deployments to track the extent of ITS deployment, the types of ITS technologies that are deployed, the location of these ITS assets and, all together, to better understand the overall effectiveness of ITS deployment investments.
2. **Support for Independent Evaluation:** The ITS JPO works with independent evaluators to assess the performance of ITS JPO-funded model deployments, demonstrations, pilots, and other projects that use ITS JPO funds, including grants, to ensure that the technologies, applications, and services in these deployments performed as expected and achieved performance goals.

Nationwide ITS Deployment Assessment, Analysis, and Reporting

The primary way the ITS Deployment Evaluation Program engages in performance measurement is by helping to determine the extent, effectiveness and benefits of deployed ITS across the nation, and ultimately assess the value/return on investment of ITS Program interventions and deployment support activities – even if they are not directly funded by the ITS JPO. Evaluation, assessment, and deployment tracking are critical to ensuring progress toward the USDOT’s vision of integrated intelligent transportation systems and achieving ITS deployment goals. Evaluation and deployment tracking activities are also critical to an understanding of the value, effectiveness, and impacts of ITS Program activities overall and to allow for the continual refinement of the ITS Program's strategic plan and direction.

The overall objectives of this effort are to:

- Provide information to decision makers of all types, both inside and outside of the Department, to help plan, procure, and assess effectiveness of ITS investments (both current and future investments);
- Support future deployment by 1) tracking the extent of ITS deployment 2) disseminating data on benefits, costs, best practices/lessons learned related to deployed ITS; and 3) analyzing data related to deployment trends, adoption trends, and effectiveness of ITS JPO/government interventions.

Background: Benefits Costs Lessons Learned Databases

The collection of deployment data (benefits, costs, lessons learned, extent of deployment nationally) was first authorized by Congress in 1996; the ITS JPO has been actively and consistently collecting this information since that time. These databases are the only longitudinal databases of their kind in

the world (with over 20 years of data contained within each of them), and serve as the industry standard and an international resource on the performance of ITS technologies, and their evolution.

The benefits, costs, and lessons learned databases collect publicly-available information on ITS deployments constantly and continuously and provide concise summaries of these data for the consumption of the general public. The databases currently have approximately 2,100 of these summaries, including 1,100 benefits entries, 371 system cost entries, 4,748-unit cost entries, and 663 lessons learned narratives.

- Benefits are reported according to various performance measures used in project evaluations such as benefit-cost ratios, dollars saved, reductions in crashes, reductions in fatalities, reductions in travel time, reductions in fuel consumption and emissions, increased vehicle throughput, and other performance measures related to safety, mobility, and environmental impacts.
- Costs are reported for installation of ITS systems, as well as Operation and Maintenance (O&M) of these systems, if provided.
- Unit Costs are reported for the furnishing and installation of individual pieces of equipment (subcomponents), as well as associated Operation and Maintenance (O&M) costs if provided.
- The lessons learned narratives are qualitative assessments of best practices from individual ITS deployments.

Recent findings on specific ITS technologies are summarized in short fact sheets available on the ITS JPO website and published as an updated report on a 2-3-year cycle (1999, 2001, 2003, 2005, 2008, 2011, 2014, 2017, 2018). The fact sheets provide synthesis of data on specific technologies in the benefits, costs, and lessons learned databases, including summaries of benefit-cost ratios, and where available, performance metrics related to the benefits of ITS deployment such as crash reduction, travel time reduction, and vehicle speed through a corridor.

Background: ITS Deployment Tracking Survey

The ITS Deployment Tracking Survey has been conducted since 1997. It was created and administered to track and manage progress toward a ten-year ITS deployment goal set by the Secretary of Transportation in 1995. The first Survey was conducted in 1997 and targeted 108 metropolitan areas, including 78 large and 30 medium-sized areas, and covered freeway, arterial and transit deployment in those areas. The Deployment Tracking Survey(s) have consistently measured ITS Deployment through a set of 34 indicators related to the major functions of nine ITS infrastructure components, with a separate set of 34 indicators tracking ITS support for interagency integration. These indicators have historically been used to better understand which agencies tended to need additional encouragement in adopting ITS.

The ten-year tracking period ended in 2007, with surveys having been conducted in 1997, 1999, 2000, 2002, 2003, 2004, 2005, and 2006. After the tracking period ended, the survey has been

conducted every three years (2010, 2013 and 2016-17). The most recent survey was completed in 2016-2017, and the next major survey is expected in the 2019 - 2020 timeframe. Current and future surveys are focused on tracking deployment indicators, and asking about agency intentions regarding future ITS technologies such as connected vehicles. These findings are being used to inform various ITS program research elements about issues such as deployment readiness, plans for deployment, reasons for not deploying certain technologies, and areas that might benefit from greater government intervention.

All the information from the databases and the Survey is free and publicly available via detailed reports and updates. The cost/benefit/lessons learned databases are also public, free, and searchable. The ITS Deployment Evaluation program also conducts frequent webinars and workshops to inform and train stakeholders on what is in the databases, how to search them, and explain the meaning of deployment tracking results and trends. The most recent webinar series - conducted in 2018 (one in February 2018 and two in March 2018) - provided the public with training, information and data on three topics: a summary of the results of the 2016-2017 ITS Deployment Tracking Survey, a summary of the results from the new Connected Vehicle-related survey questions, and a training on how to use the benefits/cost/lessons learned databases to answer questions to support deployment decision making. Each webinar had from 180 to almost 400 participants calling in.

Major Program Activity Goals FY 2020

Modernizing the Databases and revamping the ITS Deployment Tracking Survey: The ITS Deployment Evaluation Program is working to modernize, and make more efficient, how the benefits/costs/lessons learned databases operate and are presented to the public. The program is also gearing up for the next major ITS Deployment Tracking Survey and actively seeking stakeholder input into new questions and topics. The Program is also conducting its activities in very close coordination with the ITS PCB Program to leverage partnerships and ensure continued value of these data resources. Further, the Program will continue its analytics work using longitudinal and new ITS deployment data, and continue to populate the databases and manage the online presence of these data.

Standing up a “Center of Deployment Excellence”: The Program is reexamining the role of ITS Deployment Evaluation overall with the objective of integrating it far deeper into the ITS JPO research program, particularly with our modal partners and across the Department as a whole – and fine-tuning the Technology Transfer techniques and opportunities to make this happen.

In 2019, the focus of the ITS Deployment Evaluation Program was to revamp and modernize how the ITS JPO collects data on ITS deployments nationwide, and also how it brought all the elements of successful individual deployment evaluations together with its partners across the Department via a “Center of Deployment Excellence” (CoDE) in order to accommodate true innovation in management of the performance of deployed ITS projects across the nation. The extensive and growing pipeline of these projects have the potential to be a major driver of the US economy in the

future, and cover all areas of the country from urban areas to rural environments. Therefore, the ITS JPO is engaged in developing a Concept of Operations/Analysis of Alternatives for the CoDE.

The initial vision was to coordinate across the entire Department and its Working Groups and with all modes to provide integrated and leveraged ITS evaluation support, guidance, best practices and analysis to show quantitatively and qualitatively the Return on Investment (ROI) of ITS deployments and technologies to the nation and to the Department – and engage with the Working Groups and the PCB Program to ensure the best possible techniques and strategies for technology transfer of this information.

There is a large pipeline of ITS grantees currently beginning CV and AV projects across the United States. These projects are located in a wide variety of locations, involve a wide variety of situations, and address a wide variety of problems and issues. This presents an opportunity to address the following critical issues:

- The Department does not yet currently have a robust, or clearly articulated, mechanism to compare information and results across ITS deployment projects; there currently exists no true way to, for example, compare the results of a deployment in (as a hypothetical example) Indianapolis to one in Anchorage even if they are essentially deploying the same types of technologies to address similar problems. It is likely that they are looking at different KPIs, or even if there are similar KPIs, each might be using different data or methodologies to address them. This makes it exceedingly difficult to compare results with accuracy.
- There is no efficient way to compare and contrast performance metrics/measures, evaluation methodologies, or the relative success of similar (yet subtly different) uses of technologies and applications. For example, if two sites are both deploying a similar application, but use different methods of deploying it, those different methods make it difficult to parse differences in performance results.
- There is not yet a common set of best practices or guidance documents that the Department can currently offer connected vehicle or automated vehicle deployers and future deployers, making deployment activities much more challenging, time consuming, and costly for them, and thereby potentially needlessly discouraging deployment and/or reducing the performance and benefit of those deployments.

A more integrated, leveraged, and centralized approach to the evaluation lifecycle of deployment projects can and will provide value to the Department (and the stakeholder community) by supporting an integrated platform to facilitate the meaningful analysis and development of common performance measures as part of a common core set of data, methods, approaches, best practices and guidance developed by and facilitated by the ITS JPO and its modal and Departmental partners. This core set could include:

- Core set of performance metrics that deployers can focus on, in addition to more localized measures, that will enable comparison and dashboarding;

- Core guidance related to basic data acquisition strategies and methods, data management, data storage, data security, data sharing, data maintenance, and data quality control/independent verification and validation (IV&V);
- Core guidance on minimum data sets for the CV evaluation – vehicle data, operating data, cost data, financial data, institutional data, socio-economic data, etc.;
- Core guidance and best practices on methodologies for evaluation, based at the micro-level – for example, best practices for data identification and collection related to specific performance measures and hypotheses;
- Core standards and performance specifications for a variety of technologies typically used in deployments; and
- Core targets for level of benefits a deployment should expect at a minimum, for specific Key Performance Indicators (KPIs).

The expectation is for all surface modes will participate/lead in the development, maintenance and technology transfer of the “core” elements, and also for the Department’s Working Groups to be an integral part of the operation of the CoDE. The effort is expected to mesh well with and bolster the performance-based approach of the Department overall, and also integrate closely with the Data Access Program area.

In 2020, the ITS JPO expects to stand up a CoDE based on the recommendations presented in the Concept of Operations/Analysis of Alternatives that was started in FY2019.

Evidence Based Decision making to Improve and Facilitate the Long-Term Planning Process: In FY2020, the ITS JPO will begin working with the planning Community to ascertain how the data collected via the ITS Deployment Evaluation Program can be best put to use in order to assist MPOs and other transportation planning entities with the information they need to make sound decisions on the transportation planning process, and specifically how best to invest in ITS.

Independent Evaluation of ITS JPO-Funded Deployments

The concept of independent evaluation is important to the effective long-term strategic management of the ITS JPO’s research program. Typically, an Independent Evaluator (IE) is responsible for: applying quantitative and qualitative evaluation methodologies to conduct in-depth cost-benefit assessments and other measures or Key Performance Indicators (KPIs) of a deployment effort; assessing user acceptance/satisfaction with the elements of the deployment program and the overall deployment itself; documenting lessons learned, challenges and approaches for overcoming them; developing guidance documents on evaluation results; estimating total impacts, costs, and Return on Investment (ROI) of the deployment program; and assessing if the deployment program achieved the Department’s vision and expectations/requirements cost-effectively.

An IE is also typically responsible for assisting a funding recipient in identifying a set of targeted performance measures and performance hypotheses that relate to the primary impacts of their proposed deployment and that address the goals and objectives of the Department as stated in the procurement that was issued. The IE also can assist a funding recipient by ensuring that the systems that the recipient deploys can generate the data needed to calculate performance measures over time – that is, to show how well the system is performing with respect to these target measures.

Independent evaluation is typically required to assist the funding recipient with site baselining, assist with performance measure/hypothesis development, validation of site system performance with respect to the targeted measures, to collect or infer contextual data that allows for the isolation and mitigation of confounding factors, and to provide supplementary evaluation with respect to a broader set of public agency efficiency measures of interest to the Department and to the ITS JPO. The funding recipient is, in turn, responsible for supporting the independent evaluator’s access to the site and to site staff to conduct evaluation-related experiments, interviews, and surveys.

The funding recipient, the ITS JPO, the Department and an IE work together as a team from the inception of the deployment project because each team member has a stake in the success of the deployment, the accurate reporting of what happened in the deployment, and an accurate assessment of performance during and at the conclusion of a deployment.

It is important to note that the ITS JPO also prefers to use an IE to maintain the absolute objectivity of an evaluation. In addition, the ITS JPO - as a core value - views all evaluations as critical learning opportunities. When deploying new technologies, applications and systems, it is vitally important that the Department and the stakeholder community learn – objectively - what works, what doesn’t work, and what best practices are to move the needle of success and progress continuously in the right direction over time.

Relationship to the USDOT Strategic Plan

The goals of the USDOT strategic plan apply to this area as follows:

- **Safety: Reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System.** The ITS benefits database contains summaries from 20 years of collecting the safety benefits of deployed ITS according to performance metrics such as reduction in fatalities, reduction in crashes, reduction in vehicle-pedestrian collisions, reduction in vehicle-bicycle collisions, as well key safety indicators such as vehicle speeds, stopping distance, and braking time. Note that the databases contain summaries of individual ITS projects, not the program as a whole. Also, an integrated, Department wide approach to evaluating, and collecting data on, this KPI is of critical importance.
- **Infrastructure: Invest in Infrastructure to Ensure Safety, Mobility and Accessibility and to Stimulate Economic Growth, Productivity and Competitiveness for American Workers and Businesses.** The ITS Deployment Tracking Survey(s) measure the extent of

the ITS deployment according to 34 technology indicators set in 1996 by the Secretary's 10-year ITS Deployment goal, and report on 20 years of ITS deployments trends. Tracing the deployment and development, as well as the unit and operating/maintenance costs of ITS infrastructure is highly valuable in an effort to encourage continued adoption of these technologies.

- **Innovation: Lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation's Transportation System.** The ITS Deployment Tracking Survey(s) reports on agency intentions regarding the adoption of innovative ITS technologies, such as connected vehicles. It also surveys state and local agencies about their deployment readiness and barriers to ITS adoption. The ITS Benefits, Costs and Lessons learned databases are essential tools for agencies preparing to procure and deploy ITS technologies, providing estimates of benefits to be realized, costs of comparable projects, and best practices to follow for successful ITS deployment. The ability to develop and disseminate best practices related to evaluation of CV technologies and applications raises the bar for innovation across the stakeholder base.
- **Accountability: Serve the Nation with Reduced Regulatory Burden and Greater Efficiency, Effectiveness and Accountability.** The ITS Lessons Learned databases contain qualitative summaries of best practices regarding ITS planning, procurement and deployment, including topics related to regulatory practices and workforce development. A highly integrated, department-wide effort to excel at performance measurement and management of ITS investments is a valuable accountability tool and can serve as the industry standard moving forward.

Chapter 2. High Priority Project Descriptions

New High-Priority Research Projects for FY 2020:

1) Automation:

Automation is a key component of the ITS JPO's Strategic Plan. The Program's goal is to enable safe, efficient, and equitable integration of automation into the transportation system. To achieve this goal, the ITS JPO is conducting enabling technical and policy research, assessing impacts; communicating results; convening and coordinating internal and external stakeholders; providing guidance, education, and assistance.

Research Project Name/Topic Area	Systems Dynamics Models of AV Impacts
Expected Total Project Cost	Unknown
Total Funding in FY2020	\$750,000
Period of Performance	2020-2021
AMRP Program	Automation

Why should we pursue (or invest in) this research?

System dynamics is a quantitative method for modeling complex systems that takes into account feedback effects and changes over time. As the impacts of automation are far-reaching, complex and uncertain, it is critical to have a systems-level framework for evaluating the potential implications of these new technologies on the transportation system. System dynamics is emerging as a research modeling focus area for automated vehicles due to its ability to support more dynamic and quantitative evaluation and forecasting of impacts.

Who else is researching this issue?

Significant research is underway at both the Massachusetts Institute of Technology (MIT) in the U.S. and across other non-federal organizations. The ITS JPO is actively coordinating with leading systems dynamics experts both to conduct joint research and to leverage research done internationally. Collaborative efforts include a joint project with MIT to model the transitional dynamics of the U.S. new vehicle market over the coming decades, and ongoing partnerships with researchers that have provided valuable input for ITS JPO activities.

Have we invested in this topic in the past and what have we learned to date?

This work will build upon USDOT research undertaken in 2017 and 2018 to develop models of safety, mobility, equity, and user response for automated vehicle (AV) benefits. Previous ITS JPO projects developed a framework for estimating the potential safety, mobility, energy, and environmental benefits (including potential dis-benefits) of technologies contributing to the automation of the nation's surface transportation system; estimated the preliminary target crash population for concept L2 to L5 AV functions for light vehicles; estimated traffic and energy effects of cooperative adaptive cruise control; and developed preliminary models of travel behavior. Results of this past work will provide inputs to future modeling efforts.

1. Due to substantial worldwide interest in the framework, it has gone through several iterations in response to comments. For example, European researchers have recently used it to organize a survey on key performance indicators, whose results are now available to us.

2. The target crash population work has given us a mapping of automation applications to potential reductions in particular types of crashes, and thus to potential safety benefits.
3. We have integrated a traffic simulation model (Vissim) with the EPA MOVES energy/emissions model, producing mobility/energy/emission results for several CACC freeway scenarios.
4. We performed a meta-analysis of CACC and ACC models to understand the differing impacts of these systems on traffic flow and energy consumption.

On the system dynamics of user response to automation we:

- Developed basic quantitative relationships of how auto ownership, demand for travel and vehicle/ride sharing might respond to the new service offerings enabled by automation.
- Partnered with MIT to develop a model of how demand for new automobiles might change in response to the use of shared automated vehicles.

In this work, we have been able to articulate the key uncertainties (in policy, technology, and user response) that are likely to affect the outcomes of automation.

Objectives, activities, and what is the problem being addressed?

ITS JPO will facilitate automated vehicle deployment in a way that advances the safety, infrastructure, innovation, and accountability goals for the Department. This research will provide the USDOT with:

- Identification of important research by others and how it can inform USDOT understanding and decision-making.
- Methods for the quantitative evaluation and forecasting of the system-level impacts of automated vehicles.
- A model of system-level impacts of automated vehicles which can be used to assess various automation scenarios.

This research will provide USDOT with a more quantitative and holistic understanding of the expected impacts of automated vehicles, enabling USDOT to foster innovation in a way that serves the public interest.

Alignment with DOT Strategic goals and/ or DOT research priorities

This research priority aligns with all four of the DOT strategic goals:

- **Innovation:** Systems dynamics techniques enable the consideration of feedback effects when assessing the impacts of automation. Quantitative evaluation and forecasting of system aspects can enable accelerated deployment of innovative AV technologies in the transportation sector.
- **Accountability:** Leveraging relevant research by others helps to avoid duplication of effort. Systems dynamics research and collaboration improves USDOT's ability to ensure that investment in automation research projects will provide a public benefit.
- **Safety:** Systems dynamics research supports the evaluation of the impacts of new technologies in the transportation system and accelerates their safe deployment.

- **Infrastructure:** Improved understanding of likely future demands on infrastructure (resulting from changes in vehicle operations and changes in travel behavior) will inform an improved understanding of infrastructure needs.

Is there a non-Federal financial contribution? If so, how much?

The ITS JPO expects to continue to collaborate with academia and other non-federal organizations. The ITS JPO does not expect direct financial contribution from non-federal partners.

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2) Cybersecurity for Intelligent Transportation Systems (ITS):

Cybersecurity is a serious and ongoing challenge for the transportation sector. Cyber threats to transportation systems can impact national security, public safety, and the national economy. Securing transportation’s critical assets and infrastructure against cyber threats is a shared responsibility of both the public and private sectors. A common vision and a framework for achieving that vision are needed to guide the public-private partnerships that will secure transportation systems.

Research Project Name/Topic Area	Application of a NIST Cybersecurity Framework to the ITS Ecosystem
Expected Total Project Cost	Unknown
Total Funding in FY2020	\$1,000,000
Period of Performance	2020-2021
AMRP Program	Cybersecurity for Intelligent Transportation Systems (ITS)

Why should we pursue (or invest in) this research?

The USDOT Strategic Plan FY 2018 – 2022 stated that “DOT will encourage the adoption of the National Institute of Standards and Technology Cybersecurity Framework by transportation ecosystem stakeholders.” Current research continues to translate the National Institute for Technology and Standards (NIST) Cybersecurity Framework into the transportation environment. The tenets of cybersecurity that relate to transportation operations and equipment include: identify, protect, detect, respond, and recover. The NIST Framework provides a process that assists entities in understanding their cybersecurity risk and what can be done to mitigate the risks.

FHWA and ITS JPO will work with transportation cybersecurity stakeholders to translate our efforts into best practices for State and local transportation organizations. The best practices will expose transportation professionals to the NIST Framework; translated for the transportation sector, and the protocols and procedures associated with participating in cyber risk management monitoring and information sharing. In addition, research will be conducted to develop and prototype a transportation cyber assessment tool. The tool will assist transportation professionals in applying the NIST Framework and to understand their organizations cyber status. The research will produce an inventory of assets that will include descriptions and specifications that support cyber risk assessment.

Who else is researching this issue?

There is extensive research sponsored by the private sector and other Federal agencies including NIST, DHS and DOD. In addition to their in-house efforts, much of this research is also conducted for them by academia, private and non-profit research institutions. However, it is important to recognize that none of this research is focused on the ITS ecosystem. This proposed effort is not focused on basic research but is seeking to translate our efforts into best practices for State and local transportation organizations.

Have we invested in this topic in the past and what have we learned to date?

USDOT, modal partners, and stakeholder partners have invested in a limited set of modal specific research and analyses activities, including:

- FHWA - Development of a Roadway Transportation System Cybersecurity Framework
- NHTSA – Cybersecurity Prevention, Detection, Response and Recovery Research for Vehicles
- ITS JPO – Application of the NIST Cybersecurity Framework for Connected Vehicles

One of the lessons learned is that the transportation environment introduces unique requirements for cybersecurity. There is a need to adapt the expertise and developments from other sectors for the ITS ecosystem. The biggest challenge to the ITS ecosystem is a result of the increased value of ITS data and connectivity. Concerns about cybersecurity for ITS and traffic management deployments are related to both current technologies and legacy systems, coupled with the growing trend to integrate ITS deployments with other networks. This combination has introduced new threat categories that have not yet been encountered in this domain. The distributed ownership, operation and oversight of the transportation system between, Federal, State, and local governments as well as the private sector imposes complexities for implementing cybersecurity solutions and information sharing in this ecosystem.

Objectives, activities, and what is the problem being addressed?

This research will document best practices for information sharing across the transportation-ecosystem and with other sectors, training needs for transportation professionals, and organizational preparedness. The research will produce an inventory of assets that will include descriptions and specifications that support cyber risk assessment. To advance State and local entities implementation of cyber risk management practices, research will be conducted to identify and provide cybersecurity procurement guidance. The procurement guidance will provide information regarding cyber specifications for transportation equipment and cyber requirements when procuring cyber technical support and services.

The USDOT has an important role to play in pursuing research and analysis in the area of cybersecurity for ITS in order to deliver public benefit. Federal leadership offers State and local agencies an opportunity to express their needs and have cybersecurity experts translate into use cases and requirements that cross modal boundaries and ensure risk management among intelligent vehicles, intelligent infrastructure, and portable devices. State and local agencies tend not to have this type of expertise nor do they have the time or funding to pursue initiatives that are critical but tangential to their daily operational mission.

Alignment with DOT Strategic goals and/ or DOT research priorities

This research priority aligns with the USDOT strategic goal for Innovation. The Cybersecurity research program supports the development and deployment of innovative practices and technologies to improve the safety and performance of the Nation’s transportation system by managing the risk of cybersecurity. This targeted research will advance the state of knowledge regarding the cybersecurity risk introduced

by the innovative technology being implement by our partners. The research will also position our partners to proactively prepare for and start to implement the organizational capacities that will be needed to protect the viability of the transportation systems and recover when a cyber event occurs.

Is there a non-Federal financial contribution? If so, how much?

The ITS JPO expects to continue to partner with Federal agencies (NIST), industry organizations and public-sector organizations in a manner that provides technical contributions with a financial value.

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3) Emerging/ Enabling Technologies:

Communications technologies are critical to the safe, secure, and efficient operations of transportation systems across the Nation. Transportation agencies have incorporated communications into their operational environments (i.e., field systems, management centers, and public fleets), and vehicle manufacturers are increasingly including multiple types of communications into their vehicles. While much research has been conducted with Wi-Fi, DSRC, cellular, and satellite communications, there are emerging communications technologies such as Cellular-V2X (C-V2X) and 5G which could also have significant impacts on transportation systems. For example, the 5G capabilities are relatively undefined at this time and it is not clear if transportation needs and requirements are being taken into consideration. Cellular-V2X technology is being designed and developed by an industry led group as a potential replacement technology for DSRC.

The USDOT has an important role to play in pursuing research and analysis in the area of transportation technologies and their use of telecommunications to deliver public benefit. Federal leadership offers State and local agencies an opportunity to express their needs and have Federal telecommunications experts translate those needs into use cases and requirements that cross market boundaries and ensure interoperability among vehicles, infrastructure equipment, and mobile devices. State and local agencies tend not to have this type of expertise nor do they have the time or funding to pursue initiatives that are important but tangential to their daily operational mission.

Research Project Name/Topic Area	C-V2X and 5G Communications Evaluation
Expected Total Project Cost	\$9,000,000
Total Funding in FY2020	\$3,000,000
Period of Performance	2019-2020
AMRP Program	Emerging/ Enabling Technologies

Why should we pursue (or invest in) this research?
This research will build on the collaborative partnership initiated in 2018 between the ITS JPO and the Ford Motor Company to conduct performance testing of the C-V2X communications to determine its potential to provide benefits to the transportation system. This research will also analyze and provide input to the evolution of cellular communications from LTE to 5G networks in order to assess the impacts on the transportation system.
Who else is researching this issue?
Most of the on-going research into next generation communications is funded by the private sector and is focused on enhancing technical performance of existing equipment or development of new radios. The private sector, academia, and governments around the world have formulated questions associated with whether these new communications technologies can enable safety-critical applications, provide crash avoidance, and support automation. Chipset and vehicle manufacturers are working on prototypes to prove out the concept while experts are working to design performance-

based test procedures that demonstrate the capabilities as well as the gaps that still need to be addressed.

Have we invested in this topic in the past and what have we learned to date?

For the existing communications technologies in use with transportation today, USDOT, modal partners, and stakeholder partners have invested in a wide range of research and analyses including:

- Comparison of cellular, Wi-Fi, and satellite capabilities and costs to support transportation applications
- Establishment of a test facility at the US Army's Aberdeen Test Center to conduct radio frequency communications testing
- Assessment of DSRC and Wi-Fi interference in the 5.9 GHz spectrum

One of the lessons learned is that the transportation environment introduces unique requirements for telecommunications; for instance, users and equipment move at high speeds—over 80 miles per hour, which can cause interference. This unique requirement imposes high frequency and reliability requirements. Another is that any viable communication technology needs to scale to allow hundreds of nearby devices to communicate without causing channel congestion.

We have also learned that the telecommunications industry evolves at a rate that is dramatically different from the deployment of these technologies in State, regional and local transportation system operations. The replacement cycle within the telecommunications industry is typically 18-24 months whereas the replacement cycle within transportation system operations is typically 10-15 years. This disparity is impacting how and what transportation agencies will procure in near future as well as their longer-term investment planning.

Objectives, activities, and what is the problem being addressed?

Evolving to the next generation of communications technology can have major impacts on the transportation system, and this research project is intended to evaluate the capabilities of current LTE communications and develop strategies to prepare for the deployment of 5G communications in 2020. The results of this research will be extremely informative to transportation agencies and other stakeholders that are deploying communications technology into the transportation system. Activities would be conducted in formal collaboration with the modes, OCIO, OST-P, and OST-R and include:

- Conduct additional joint testing with vehicle manufacturers (Ford) and telecommunications companies to evaluate the radio performance and potential interference in the 5.9 GHz band with C-V2X communications.
- Collaborate with public and private sector organizations to identify transportation safety and mobility use cases to support the incorporation of transportation requirements into 5G communications technologies.
- Develop evolutionary scenarios from present day communications in the transportation system to 5G communications to help inform transportation agencies and stakeholders in making investment decisions.

Alignment with DOT Strategic goals/ or DOT research priorities

This research priority aligns with the USDOT strategic goal of innovation by supporting the development and deployment of innovative technologies such as C-V2X and 5G communications.

Is there a non-Federal financial contribution? If so, how much?

The ITS JPO expects to continue to partner with private sector firms in a manner that provides technical contributions with a financial value. For instance:

- ITS JPO has partnered with automotive companies in a pre-competitive forum to assess the impacts of new communications technologies on vehicles as well as to study interference associated with proposals for spectrum sharing. This was accomplished with a 20% cost share through a cooperative agreement.
- ITS JPO is partnering with automotive firms, tier one suppliers, and chipset manufacturers to form an understanding of new communications innovations through testing and data analyses. The private sector firms are providing prototypes as well as sharing their test approaches with USDOT as a means of forming consensus on the level of rigor and depth appropriate to assessing their new technology for safety and other features critical for the transportation environment. This is being accomplished through a partnership agreement.

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4) Complete Trip:

The USDOT Topical Research Area – Mobility Innovation working group is leading departmental efforts at defining what elements make up a complete trip, and working to identify gaps within related efforts. The Complete Trip Program will identify opportunities to leverage and combine existing technologies into new and complete solutions that can be implemented to meet the needs of all travelers. The current ATCMTD Grants Program, the FTA’s Integrated Mobility Innovation (IMI) demonstration projects, and the Automated Driving Systems (ADS) Notice of Funding Opportunity (NOFO) are providing the USDOT with real world deployments and demonstrations of emerging capabilities. By working closely with and aligning our research to support these Programs, the Complete Trip Program will avoid duplication, and will be able to ensure the USDOT is moving forward on improving mobility for all travelers.

Research Project Name/Topic Area	Complete Trip – ITS4US Deployment
Expected Total Project Cost	\$ 40,000,000
Total Funding in FY2020	\$ 5,000,000
Period of Performance	2020-2021
AMRP Program	Complete Trip

<p>Why should we pursue (or invest in) this research?</p> <p>The Complete Trip Program is a joint USDOT initiative, co-led by FTA, FHWA, and the ITS JPO. It is exploring emerging technologies to enhance travel that includes opportunities for people with mobility challenges by providing travel opportunities that are seamlessly integrated into their daily lives. This seamless integration will be the “Complete Trips for All” effort highlighted by the USDOT Topical Research Area – Mobility Innovation working group. The Complete Trips for All vision leverages innovative technologies and facilitates public private partnerships to allow for a traveler-centric approach that improves mobility options for all travelers, including travelers with disabilities, travelers from rural areas, and lower income travelers. The Accessible Transportation Technologies Research Initiative (ATTRI) helped define the complete trip and developed pieces of technology that would enable the complete trip. However, not all elements of the complete trip are fully defined or developed yet. This project will support defining the Complete Trips for All vision.</p>
<p>Who else is researching this issue?</p> <p>On-going research into technologies and services for travelers with disabilities are being funded by the private and public sectors, as well as academia.</p> <ul style="list-style-type: none"> • Federal Government: The Program has partnered with several Federal agencies that are actively researching and developing accessible transportation technologies: <ul style="list-style-type: none"> ○ The National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR) within DHHS has been a strong partner of USDOT’s ATTRI Program. NIDILRR funded the ATTRI international scan of accessible transportation research and ongoing prototype development projects under the robotics and automation application area.

- U.S. Army: the ATTRI program and the U.S. Army Applied Robotics for Installation and Base Operations (ARIBO) program have partnered to research automated vehicles systems for veterans with disabilities.
- FTA: The Federal Transit Administration is currently funding and providing technical support to several of the ATTRI prototype development projects.
- Department of Labor (DOL): DOL's Office of Disability Employment Policy (ODEP) has partnered with USDOT to conduct stakeholder outreach on accessible transportation technologies to help increase access to jobs and increase participation in the workforce.
- FHWA: Through the FHWA's Exploratory Advanced Research (EAR) program several accessible transportation technologies have been developed and demonstrated.
- **States/MPOs/Locals:** State and local governments are funding research and technology to help improve accessible transportation including improving paratransit services and mobility for all travelers.
- **Public Transit Agencies:** Public transit agencies are funding research to improve the efficiency of paratransit services and transition users from paratransit to independent travel using new technologies.
- **Private Organizations:** Original Equipment Manufacturers (OEMs) and transportation providers are developing more accessible vehicles and integrating accessible technologies for all travelers. Many private companies are also developing applications for navigation, personal assistance, and other services to help people with disabilities.
- **Academia:** Researchers are developing innovative robotics applications and assistive mobile devices for people with disabilities as well as researching the impacts that improved access to jobs, healthcare, education, and recreation for people with disabilities will have on the economy.

Have we invested in this topic in the past and what have we learned to date?

Through the Accessible Transportation Technologies Research Initiative (ATTRI) Program, the USDOT has conducted foundational research to prepare for its vision of a Complete Trip deployment. ATTRI's foundational research includes a comprehensive user needs assessment; state of the practice, innovation, and assessment of research scans; policy and institutional impacts assessment; international research coordination; extensive stakeholder engagement and outreach; and accessible transportation prototype development.

ATTRI is exploring emerging technologies to enhance travel for people with disabilities by providing wayfinding and navigation applications, pre-trip concierge and virtualization services, improved safe intersection crossing for travelers needing additional help, and assistive robotics and automation applications. ATTRI is supported by a range of interagency Federal partners including the Departments of Health and Human Services (DHHS), Labor (DOL), Defense (DOD), and others.

Objectives, activities, and what is the problem being addressed?

The flagship effort will support the demonstration of the “Complete Trip for All” for one or more of the travelers with disabilities, travelers from rural areas, and/or lower income travelers. An Independent Evaluation of the demonstration will run concurrent with the program.

Alignment with DOT Strategic goals/ or DOT research priorities

This project supports the following near term and long term goals. Near-Term: Demonstration of Complete Trip can be deployed successfully with positive outcomes. Long-Term: Show that a comprehensive concept development effort based on sound systems engineering principles leads to a faster, better, cheaper, more effective deployment, fully integrated into operational practice and financially sustainable over the long run. These outcomes align with the USDOT strategic goals of innovation, infrastructure, and safety:

- Innovation: The Program is developing innovative technology applications to enable an integrated multimodal environment that will provide fully accessible complete trip options to all travelers.
- Infrastructure: The Program is developing innovative technology applications to improve the mobility and accessibility of all travelers. Investments in technology infrastructure for transit stations, surface networks, and other infrastructure would enable the success and scalability of mobility and accessibility applications currently being prototyped and stimulate economic growth in the impacted regions.
- Safety: The Program is prototyping applications that provide safer and more reliable travel for all, including people with mobility challenges by providing travel opportunities that are seamlessly integrated into their daily lives.

Is there a non-Federal financial contribution? If so, how much?

The Non-Federal financial contribution would be consistent with a 20% cost-share requirement.

5) *ITS Center of Deployment Excellence (ITS CoDE):*

The extensive and growing pipeline of ITS Deployments (particularly in CV/AV) have the potential to be a major driver of the US economy in the future, and cover all areas of the country from urban areas to rural environments. Therefore, in 2019, the ITS JPO proposed to undertake an analysis of the feasibility of a proposed Center – or Centers – of Deployment Excellence which would work across the Department and with all modes to provide integrated and leveraged ITS deployment support across the full lifecycle of deployment, from deployment preplanning, through to project data collection/management, performance measurement and goal setting, training, capacity building, evaluation support, guidance, best practices and analysis to show quantitatively and qualitatively the ROI of ITS deployments and technologies to the nation. The hope was to create a focus within the Department on activities that will accommodate true innovation in management of the performance of deployed ITS projects across the nation.

The initial vision was to coordinate across the entire Department and its Working Groups and with all modes to ensure the development of a feasible, purposeful ITS Center of Deployment Excellence (ITS CoDE) that provides true value to stakeholders within and outside of DOT.

The work to assess the viability and feasibility of a possible ITS CoDE was approved in early 2019. The next step in 2020 - provided the assessment concludes that an ITS CoDE is indeed viable and feasible and the proposed Concept of Operations for the ITS CoDE is acceptable to the Department's leadership - is to initiate the first phases of "standing up" the ITS CoDE.

Research Project Name/Topic Area	Initiate Development of ITS Center of Deployment Excellence ("ITS CoDE")
Expected Total Project Cost	Unknown
Total Funding in FY2020	\$3,000,000
Period of Performance	2020-2021
AMRP Program	Accelerating Deployment

Why should we pursue (or invest in) this research?

Across government, there is a push to support a variety of activities that meet the letter and spirit of the recently passed "Foundations for Evidence-Based Policymaking Act" (01/14/2019, Public Law No: 115-435) which focuses on improving government's capacity to generate and use evidence/data in support of improved decision making and policy making³. The proposed ITS CoDE is expected to place the USDOT in the forefront of evidence-based decision- and policy-making for transportation technology deployment. The ITS CoDE is expected to:

- Focus on an integrated, leveraged project-lifecycle approach to accelerating and improving stakeholder investment in ITS technologies, applications, and services via evidence-based decision making, information acquisition/management, evaluation, and tech transfer.

³ See: <https://www.congress.gov/bill/115th-congress/house-bill/4174/text>

- Assist stakeholders with making quantitative and qualitative decisions from pre-deployment/investment planning through to performance measure setting, data collection and management, evaluation, and transfer of results and best practices.

The initial scope of the ITS CoDE is expected to be initially limited to ITS deployment, and incorporate the priorities and needs of ITS JPO partners across all modes in the USDOT.

The ITS CoDE will integrate activities in three topic areas: ITS deployment evaluation, data management/access, and professional capacity building (PCB)/technology transfer.

In FY2019-20, an Analysis of Alternatives (“AoA”) and Concept of Operations (ConOps) will be developed to assess execution options and strategies.

Who else is researching this issue?

The 2019 effort to develop the AoA and ConOps will delve into this issue extensively – the goal is to learn more about successful Centers of Excellence across government (and outside government) and adapt those best practices to the ITS JPO’s ITS CoDE.

Have we invested in this topic in the past and what have we learned to date?

There is currently a large number of ITS early adopters starting CV and AV projects across the United States. These projects are located in a wide variety of locations, involve a wide variety of situations, and address a wide variety of challenges. This ITS CoDE presents an opportunity to address the following critical issues/gaps/needs:

- The Department could benefit from a robust, clearly articulated, way to compare information and results across ITS deployment projects. There could be great benefit in a meaningful comparison of deployment results across different jurisdictions even if they are essentially deploying the same types of technologies to address similar problems – they may be using different KPIs, or even different data or methodologies to address them.
- There is benefit in the ability to compare and contrast performance metrics/measures, evaluation methodologies, or the relative success of similar (yet subtly different) uses of technologies and applications. For example, if two sites are deploying similar technologies, but use different methods of data collection or deployment techniques/specifications, this makes it difficult to parse differences in performance results.
- There is benefit to developing a core set of best practices that the Department can currently offer to CV/AV deployers, making deployment activities much less challenging, less time consuming, and even less costly, thereby potentially encouraging deployment and/or improving reducing the performance of those deployments.

Objectives, activities, and what is the problem being addressed?

A more integrated, leveraged, and centralized approach to the lifecycle of deployment projects can and will provide value to the Department (and the stakeholder community) by supporting an integrated platform to facilitate the meaningful analysis and development of a common core set of data, methods, approaches, best practices and tools

developed by and facilitated by the ITS JPO and its modal and Departmental partners.

This core set could **potentially** include:

- Core set of performance metrics that deployers can focus on, in addition to more localized measures, that will enable comparison and dashboarding, and including perhaps Capability Maturity Models/TRLs;
- Core best practices related to basic data acquisition strategies and methods, data management, data storage, data security, data sharing, data maintenance, and data quality control/ independent verification and validation (IV&V);
- Core best practices on minimum data sets for CV evaluation – vehicle data, operating data, cost data, financial data, institutional data, socio-economic data, etc.;
- Core best practices on methodologies for evaluation, based at the micro-level – for example, best practices for data identification and collection related to specific performance measures and hypotheses;
- Core performance standards and performance measures for a variety of technologies typically used in deployments; and
- Core targets for level of benefits a deployment should expect at a minimum, for specific KPIs.
- Core set of tech transfer tools, methods, and artifacts that can be used by DOT as well as deployers in the field

The expectation is for all surface modes to participate in the development, maintenance, and lab to market (L2M) technology transfer of the “core” elements. The effort is expected to mesh well with and bolster the evidence-based policymaking approach of the Department overall.

Alignment with DOT Strategic goals/ or DOT research priorities

This research priority aligns with all four of the DOT strategic goals:

- **Innovation:** Improved data acquisition/management, quantitative evaluation best practices, and effective technology transfer/PCB have the potential to significantly enable accelerated deployment of innovative CV/AV technologies in the transportation sector.
- **Accountability:** Leveraging existing efforts in the areas of data, evaluation and technology transfer improves USDOT’s ability to ensure that investment in CV/AV research and deployment will provide a public benefit and result in a positive ROI for the Department’s investment in ITS.
- **Safety:** This work supports the evaluation of the impacts of new technologies in the transportation system and accelerates their safe deployment.
- **Infrastructure:** Improved understanding of likely future demands on infrastructure (resulting from changes in vehicle operations and changes in travel behavior) will inform an improved understanding of infrastructure needs.

Is there a non-Federal financial contribution? If so, how much?

The ITS JPO expects to continue to collaborate with academia and other non-federal organizations. The ITS JPO does not expect direct financial contribution from non-federal partners.

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Two High Priority projects that were completed in FY 2018 or FY 2019:

1) Security Credential Management System proof-of-concept (SCMS POC): The USDOT is committed to ensuring that connected vehicle technologies operate in a safe, secure, and privacy-protective manner. As connected vehicle applications exchange information among vehicles, roadway infrastructure, traffic management centers, and wireless mobile devices, a security system is needed to ensure that users can trust in the validity of information received from other system users—indistinct users whom they have never met and do not know personally.

The United States Department of Transportation (USDOT) has successfully concluded research efforts to identify and explore viable strategies for the establishment and governance of a nationwide, full-scale Security Credential Management System (SCMS) ecosystem. After several years of research, the USDOT, in coordination with Crash Avoidance Metrics Partnership (CAMP) has concluded the design, deployment, and documentation of a state-of-art Security Credential Management System (SCMS) Proof-of-Concept (POC). The USDOT conducted two stakeholder workshops under the National Security Credential Management System Deployment Support Project. These workshops involved 59 unique participants from the range of groups holding interest in the successful development and eventual deployment of a full-scale SCMS in the U.S. connected vehicle environment.

Based heavily on structured engagement with a variety of stakeholder groups, the USDOT has identified issues, drivers, and suggested guidance around structure and organizational roles and responsibilities as security implementations on connected vehicle systems evolve from pilots and limited-scale deployments to an expected future state of widespread production deployments. Therefore, the USDOT will strive to investigate and/or take the leadership in the following:

- Promote an industry-led ownership and governance model with some level of government assistance;
- Some type of initial deployment funding from the government;
- A minor level of government input on initial policy or standards development;
- An initial type of government representation on a Board of Directors or Advisory Board.

2) ITS MARAD Business Case Analysis and Truck Staging Study:

The Maritime Administration (MARAD), Intelligent Transportation Systems Joint Program Office (ITS JPO), the Federal Highway Administration (FHWA), and the Federal Motor Carrier Safety Administration (FMCSA) have collaborated to address maritime port challenges by evaluating the impacts of Intelligent Transportation Systems (ITS), including automation and increased connectivity. This effort furthers the two key ITS Program priorities of the ITS Strategic Plan 2015-2019: realizing connected vehicle implementation and advancing automation. The effort included two projects, a business case analysis that examined four potential ITS applications that could be used in addressing maritime and freight challenges, as well as a more in depth study, that looked specifically at truck staging.

The first project involved a comprehensive port technology scan, gap analysis and the development of four business cases. The business case assessments involved diverse candidate ITS solutions: Port Community System (PCS); Queue Detection and Wait Time Systems (QD); Truck Appointment System (TAS) & Advanced Transportation Management Information and Security System (ATMIS) and the Freight Advanced Traveler Information Systems (FRATIS). These business case assessments can be used to provide guidance to port authorities, terminal operators, metropolitan planning organizations (MPOs), and related stakeholders on how to best leverage FAST ACT grant programs for ITS solutions to port industry challenges.

The second project was a focused truck staging study, which established the foundation for the long-term development and demonstration of port truck staging concepts. The program aimed to improve the safety, access, reliability and readiness of port facilities through advanced technologies and techniques to increase the reliability and efficiencies of truck movements. The overarching research objectives were “to determine the state of the practice regarding truck staging, including access, queuing, and parking, at maritime ports and to identify port operators’ and trucking industry needs; and to perform an economic feasibility study of automated truck queuing as a technology solution.”

The truck staging study included two economic feasibility analyses. The first analysis is a high-level evaluation of the economic feasibility for the future deployment of port staging technologies at port facilities, including technologies and partnerships between port authorities and commercial freight companies and operators. The second economic feasibility analysis addresses increased productivity through automated port queuing. It includes the technology concept of an automated slow-speed, in-queue truck application that meets the standards of Level 4 as defined in SAE J3016.⁴ On March 20th the projects FHWA Talking Freight webinar was featured in the American Shipper Magazine. The article summarized the webinar findings and highlighted one of the projects outcomes, which stated that “a level 4 automated truck in queue with an off-site staging area” was found to have the greatest benefit.

⁴ SAE International, “Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles,” J3016_201806. (June 15, 2018)

The ITS MARAD program research outputs, outcomes, documents and findings are being shared by MARAD through their stakeholders and partners. The project involved no non-federal dollars.

Further efforts that will leverage the research undertaken include the current OST Priority Project efforts (Project #7- Improving the Assessment of Port Performance) will assesses the adequacy of available data for US port performance measurement and the potential value of additional proprietary data, with a focus on connectivity between ports and other transportation assets. Other related efforts that will leverage this research include a future Port Autonomous/Connected Drayage Truck Development and Testing project.

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Chapter 3 – FY 2020 Program Descriptions

FY 2020 RD&T Program Funding Details

RD&T Program Name	FY 2020 Enacted Budget (\$000)	FY 2020 Basic (\$000)	FY 2020 Applied (\$000)	FY 2020 Development (\$000)	FY 2020 Technology (\$000)
Automation			\$16,308		
Data Access and Exchanges			\$3,624		
Cybersecurity for Intelligent Transportation Systems			\$2,718		
Emerging/Enabling Technologies			\$16,308		
Complete Trip			\$9,060		
Accelerating Deployment			\$16,308		
Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)					\$19,026
Small Business Innovation Research (SBIR)			\$1,812		
Program Support			\$5,436		
Totals	\$90,600		\$71,574		\$19,026

FY 2020 Enacted Budget: President's Budget (\$100M) adjusted for 9.4% "lop-off"

FY 2020 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2020 Enacted Budget (\$000)	SAFETY (\$000)	INFRA-STRUCTURE (\$000)	INNOVATION (\$000)	ACCOUNT-ABILITY (\$000)
Automation				\$16,308	
Data Access and Exchanges				\$3,624	
Cybersecurity for Intelligent Transportation Systems				\$2,718	
Emerging/Enabling Technologies				\$16,308	
Complete Trip				\$9,060	
Accelerating Deployment				\$16,308	
Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)				\$19,026	
Small Business Innovation Research (SBIR)				\$1,812	
Program Support					\$5,436
Totals	\$90,600			\$85,164	\$5,436

FY 2020 Enacted Budget: President's Budget (\$100M) adjusted for 9.4% "lop-off"

Automation Program

Funding Request (\$16,308,000)

Program Description/Activities/Objectives:

Automated vehicles have the potential to bring about transformative safety, mobility, energy, and environmental benefits to our nation's surface transportation system. These benefits could include crash avoidance, reduced energy consumption, lowered vehicle emissions, reduced travel times, improved travel time reliability, multi-modal connectivity, and improved transportation system efficiency and accessibility, particularly for persons with disabilities and the growing aging population. ITS JPO automation research will support the federal role in automation safety performance, infrastructure and interoperability, and policy analyses.

Program Objectives:

As automated vehicles increasingly enter the broad transportation system, the ITS JPO proposes a multi-modal automation research in collaboration with Operating Agency partners including NHTSA, FHWA, FTA, and FMCSA. This research will focus on safety performance, infrastructure interoperability, and policy analyses, including:

Safety Performance

- Understanding user behavior in the context of automated vehicles operating on roadways is critical. ITS JPO along with FHWA and NHTSA will conduct human factors studies to improve understanding of safe operations and gather input from the public related to driver behavior. Outcomes will include integrating the Cooperative Automation Research Mobility Applications (CARMA) into the Highway Driving Simulator to enable a more robust simulation testing environment for automated driving systems (ADS) and to improve the sharing and use of data.
- Adverse weather conditions affect the performance of automated vehicles. ITS JPO will conduct research in how road weather conditions negatively affect the abilities of AVs to operate safely. Outcomes will include actionable data and decision support results for infrastructure owner/operators and information providers.

Infrastructure and Interoperability

- The interaction of automated vehicles with highway infrastructure is essential to safety and mobility. ITS JPO and FHWA in partnership with NHTSA, FMCSA, and FTA will conduct research with stakeholders to understand actions necessary for infrastructure owner operators to plan for and initiate design, build, and maintenance activities to support infrastructure readiness for automated vehicle testing and deployment.
- There is an opportunity to improve the efficiency of the system through having these vehicles cooperate with each other and the transportation management system. Cooperation is achieved through exchanging information and then the vehicle taking the appropriate automated action. In partnership with FHWA and FMCSA, ITS JPO will conduct research on early deployment truck platooning. We will evaluate on-road safety, operations,

and infrastructure impacts of in-service truck platoon systems. We will also partner with States and the private sector. Outcomes will support assessments of bridge and pavement performance as well as regulatory and technical issues that may inhibit nationwide truck platooning.

- ITS JPO in partnership with FHWA and the automotive industry through the Collision Avoidance Metrics Partnership (CAMP) and will conduct research on light duty vehicle automated driving systems to improve the operations of freeways and surface streets, with an early focus on traffic signal systems. The outcomes will be cooperative automation applications and data exchanges to enable automated vehicles to operate safely in work zones and around incidents, to enable speed harmonization on freeways, and to support cooperative traffic optimization for signalized corridors. Additionally, these activities will provide support to infrastructure owner operators (IOOs) and contribute to standards-development processes.
- In partnership with FHWA and FTA, ITS JPO will support the CARMA platform to develop a concept of operations for Transportation Systems Management and Operations (TSMO) and advance cooperative automated driving technology through industry collaboration.
- Comprehensive stakeholder engagement and collaboration efforts help catalyze national readiness for highway automation. ITS JPO, in partnership with FHWA, CAMP, and the Cooperative Automated Transportation (CAT) Coalition, will support and coordinate with stakeholders to identify, conduct, and implement key AV research and deployment activities.
- AV technology applications offer benefits across the transportation system, beyond traditional highway applications. In partnership with MARAD, ITS JPO will conduct research to support the development of automated vehicle applications and use cases through the CARMA program to include loading and unloading of chassis and containers.
- System operations can be improved through the efficient interoperable integration of automation. In cooperation with standards development organizations and the stakeholder community, ITS JPO will provide technical input and facilitation resources for updates to existing standards and the development of new ITS automation-focused voluntary technical standards.

Policy Analyses

- A clear understanding of AV impacts, and how AV adoption will affect the public interest, is of great importance to Federal, State and local policy-making. ITS JPO will conduct research on the impact of AV use on travel behavior and transportation demand. We will study the economic impacts of AVs at the regional and national level with attention to agglomeration effects of AV investment. This research will support managing uncertain futures in performance-based planning and programming. Outcomes will include the assessment and implementation of performance measures as well as develop supportive models for exploratory scenario planning that are sensitive to anticipated feedback effects (e.g., ability to multi-task in the car makes long trips more attractive).
- Safe and efficient AV adoption will require a coordinated, cross-modal approach to policy development. ITS JPO will conduct literature reviews, monitor automation legislation at the

Federal and state level, assess technology developments and implications for policies and regulations, and review external policy studies to inform internal agency decision-making.

- Safe interaction with vulnerable road users is a critical consideration associated with AV adoption. In partnership with FHWA, ITS JPO will identify AV concerns related to the safety and operation of bicycle and pedestrian facilities and networks.

Statutory Requirements:

Is this program statutorily mandated (Y/N): **Yes:** This Program is authorized in sections 512 to 518 of Title 23, United States Code.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Safety, Infrastructure, Innovation and Accountability:

- **Safety:** *Reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System.* Large safety gains from automation will depend on market penetration of highly automated vehicles (HAVs). Mobility enabling cooperative solutions (to counter congestion increases from vehicle miles travelled (VMT) growth and autonomous operations) will be essential for consumer and societal acceptance.
- **Infrastructure:** *Invest in Infrastructure to Ensure Safety, Mobility and Accessibility and to Stimulate Economic Growth, Productivity and Competitiveness for American Workers and Businesses.* Compatible roadways along with an interoperable digital overlay to the physical infrastructure can enable substantial increases in capacity and efficiency, improved accessibility for underserved communities, and additional gains in the baseline safety from ADS.
- **Innovation:** *Lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation's Transportation System.* This capability fills a gap recognized by industry and state and local governments to ensure long-term public mobility.
- **Accountability:** *Serve the Nation with Reduced Regulatory Burden and Greater Efficiency, Effectiveness and Accountability.*

USDOT Research Priorities:

The ITS JPO Automation Program's collaborative and multi-modal research portfolio provides cross-cutting support to the USDOT Research Priorities, including Performance Based Regulations and Safety, Improving the Mobility of Freight, Feasibility of Micro-Transit, and Improving Mobility for Underserved Communities. Through the development of cooperative and standards-based technologies and comprehensive, stakeholder-driven policies, ITS JPO works to ensure the safe and efficient adoption of automated vehicles across the transportation system.

Research Collaboration Partners:

FHWA and FMCSA are developing methods for operating platoons of vehicles – both heavy and light duty – cooperatively on highways to ensure that the latency from sensors detecting vehicles in front does not propagate into major disturbances in traffic flow. FHWA is also designing ways for traffic

signals to communicate their status to approaching vehicles in such a way that an automated vehicle can slow its approach to a red light without stopping, reaching the intersection just after the light changes to green and traffic has dispersed.

Many public agencies, academic centers, and private companies are in the early stages of planning and developing data exchanges to support AV deployment. Through the December 2017 *Roundtable on Data for Automated Vehicle Safety*, USDOT validated with our private and public-sector stakeholders that there is a unique federal role in convening and facilitating voluntary data exchanges to accelerate safe deployment of AVs that complements and enables activities outside the federal government.

USDOT, modal partners, and a few stakeholders have invested in limited application development and impact analysis activities, including:

- FHWA – Driver assisted truck platooning exploratory advanced research.
- ITS JPO and FHWA – Development and testing of cooperative adaptive cruise control (CACC), speed harmonization and lane/change merge applications. Simulator-based studies of driver acceptance of CACC.
- ITS JPO and FHWA – Analysis, modeling, and simulation of the impacts of cooperative automation.
- FHWA, FMCSA, MARAD, FTA, NHTSA – Connected Automated Research and Mobility Applications (CARMA) reusable software platform.

Analyses and operational testing have demonstrated the fuel efficiency gains of truck platooning (~6% savings in two-truck platoons at 50-foot separation) and a 66% increase in road capacity with cooperative highly automated vehicles compared to operations with only unconnected ones.

Various USDOT modes are incubating projects aimed at increasing access to data to support AV research and deployment. At a multimodal level, ITS JPO has been actively working with stakeholders to understand critical use cases for data exchange and to identify the appropriate federal role to enable such exchanges while protecting privacy and proprietary interests. This work has included drafting the Department's *Guiding Principles on Voluntary Data Exchanges to Accelerate Safe Deployment of Automated Vehicles* to help bring government and industry stakeholders together for meaningful conversations, and through hosting the *Roundtable on Data for Automated Vehicle Safety* to discuss potential priorities and federal role. At the Roundtable, participants identified several priorities for voluntary data exchange and USDOT assembled multimodal teams to enable some of these exchanges, starting with Work Zone and Cybersecurity data. Through this process, we have learned that data exchange is an inherently multi-modal and multi-sectoral issue that will require regular dialog and collaboration to move forward.

The ITS JPO expects to continue to partner with private sector firms and non-Federal public-sector organizations under cost-sharing cooperative agreements.

Data Access and Exchanges

Funding Request (\$3,624,000)

Program Description/Activities/ Objectives:

This research area will focus on cultivating the unified USDOT approach to Data. For example, the Work Zone Data Exchange (WZDx) project, which is co-managed by ITS JPO and FHWA, will help drive ubiquitous access to harmonized work zone data across the nation. As part of this mission to increase access to data through exchanges, this research area will continue to incubate and drive the adoption of modern technology best practices, and consistent data access and evaluation across all USDOT-funded ITS research and deployment projects. This, in turn, will increase return on federal investment in research and demonstration projects and will accelerate multimodal, data-driven, trusted evaluations of potential safety, mobility, and other benefits to inform future policy and investment decisions.

USDOT has heard from stakeholders on how to help catalyze stakeholder engagement to move the WZDx vision forward. Our research will continue to pursue interconnected tracks, continuing with investment made to lay the groundwork from FY19 funding, and coordinated the efforts of a multi-modal implementation team.

Program Objectives:

In 2019, the ITS JPO proposed to undertake an analysis of the feasibility of a proposed Center – or Centers – of ITS Deployment Excellence⁵ which would work across the Department and with all modes to provide integrated and leveraged ITS deployment support across the full lifecycle of deployment, from deployment preplanning, through to project data collection/management, performance measurement and goal setting, training, capacity building, evaluation support, guidance, best practices and analysis to show quantitatively and qualitatively the ROI of ITS deployments and technologies to the nation.

The ITS Center of Deployment Excellence (CoDE) will integrate activities in three topic areas: ITS deployment evaluation, data management/access, and professional capacity building (PCB)/technology transfer. As this relates to data, the ITS CoDE aims to support consistent data access and evaluation for all USDOT-funded ITS research and demonstration projects. It operates in collaboration with the Office of the Chief Information Officers (OCIO's) Digital Transformation initiative and the Department's professional capacity building programs to help government program managers at the federal, state, and local level overseeing ITS projects effectively procure and manage projects that use innovative practices and methodologies. These innovative solutions include machine learning, agile development, and collaborative source code development, all of

⁵ A "Center of Excellence" is generally described as a team (or entity) that provides leadership, best practices, research activities, and/or support/training in a specific focus area. A COE is a coordinating function that ensures that initiatives related to the topic are delivered consistently, well, and through standard processes and via subject matter experts. A COE also brings together difference disciplines to focus on one area and offer a comprehensive set of services, capabilities, and collaboration.

which are foundational to the next generation of ITS projects and data management needed to evaluate the effectiveness of new ITS technologies.

All activities are conducted in formal collaboration with the modes, OCIO, OST-P, and OST-R, and include:

A. Data for AV Integration

- Identify multimodal priorities for data exchange to accelerate safe integration of AVs and enable consistent USDOT AV data policies and research plans.
- Continue to convene multimodal stakeholders to refine our understanding of priorities for data exchange and appropriate federal role, and launch multimodal projects to accelerate development of data exchanges in priority areas such as work zones, cybersecurity, and scenarios.

B. Innovative Practices

- Work with partners in the national innovation community to bring proven innovative practices and methodologies into the transportation enterprise through targeted, progressive workforce development activities.
- Develop and deliver trainings for government program managers at the federal, state, and local level overseeing ITS projects that focus on the inherently governmental role in procuring and managing projects that use innovative practices and methodologies such as machine learning, agile development, and collaborative source code development.
- Convene multimodal communities of practice for practitioners who are actively working on projects using these innovative practices and methodologies so they can cultivate their skills and knowledge, share best practices, and access templates and other resources.
- This research effort will conclude when an understanding of these practices will be sufficiently institutionalized across the USDOT enterprise and transportation sector to enable hand-off to operational organizations to scale adoption.

C. Research Data Access and Evaluation

- Maintain and enhance standard contracting language, data management and evaluation planning templates, pre-solicitation, and source selection processes for data access and evaluation across the ITS research portfolio that builds on the foundation of the Department's broader public access and digital transformation initiatives.
- Maintain and enhance a federated set of approved USDOT and third-party systems to provide consistent and rapid access to data for evaluation and analysis to the appropriate users (e.g., public, controlled access) and ensure data is provided to the appropriate systems consistent with contract requirements and user needs and retained for an appropriate amount of time.

- Provide consulting support and technical assistance to program managers and project delivery teams at key parts of the program design, procurement, and execution process.
- Enable evaluation and analysis teams to determine the effectiveness of USDOT-funded ITS research and deployments and inform policy and investment decisions.

Statutory Requirements:

Is this program statutorily mandated (Y/N): **Yes:** This Program is authorized in sections 512 to 518 of Title 23, United States Code.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation, Accountability, and Safety:

- **Innovation:** accelerates incorporation of innovative practices and methodologies into the transportation enterprise that are foundational to the next generation of ITS projects, and accelerates deployment of innovative technologies in the transportation sector.
- **Accountability:** improves oversight and return on investment of federally-funded research and demonstration projects.
- **Safety:** supports evaluation of the safety benefits of new technologies in the transportation system and accelerates their safe deployment.

USDOT Research Priorities:

The Data Access and Exchanges Program supports all USDOT research priority areas. Developing data systems to support data-driven technologies and decision making in real time is one of the overarching themes of the USDOT RD&T Strategic Plan. Advances in data processing are enabling governments and private companies alike to improve transportation services and better target investments.

Research Collaboration Partners:

The private technology sector and some leading-edge public agencies and academic centers have created well-tested and documented approaches to managing modern technology projects. These techniques include lean or agile management approaches, digital tools for implementing these approaches, and policies that encourage cross-pollination of best practices across internal divisions and external organizations. Many companies and federal innovation centers like the US Digital Service have also released data science tools as open source code that governments can use with the right management, procurement, and technical expertise. However, none of these potential partners have focused on bringing these proven innovative practices into the transportation enterprise or preparing the government workforce to procure and manage projects that use these practices.

Similarly, there are many public agencies, academic centers, and companies focused on creating services that collect, manage, and provide access to data from transportation projects. However,

none are focused primarily on evaluating public benefit of these projects and applying consistent methodologies to provide timely access to these data to all qualified parties while respecting privacy and proprietary limitations. The USDOT Safety Data Initiative and [Public Access Plan](#)⁶ are establishing a foundation for improved multimodal data management and data science within the Department. However, they are not focused on emerging ITS technologies such as automated vehicles, connected technologies, and shared mobility services that produce high volume and velocity data and require new approaches to data management and analysis that go beyond the current capabilities of these broader programs.

In the past, the ITS JPO and our multimodal partners have administered several large-scale ITS research and demonstration projects, including the Connected Vehicle Pilots, Mobility on Demand Sandbox, Advanced Transportation and Congestion Management Technologies Deployment Program (ATCMTD), and Smart City Demonstration, which have pushed the limits of the current federal, state, and local government capabilities. We have invested in various technical assistance, training, and data access and evaluation programs aimed at helping managers of these projects adapt to the new technology paradigm, resulting in a small number of successes where researchers and deployers adopted agile development methodologies and provided real-time data to USDOT evaluators and the public via the ITS Public Data Hub and Secure Data Commons proof-of-concept systems (launched in FY18 in collaboration with the Office of the Chief Information Officer (OCIO), Office of the Under Secretary for Policy (OST-P), and Office of the Assistant Secretary for Research and Technology (OST-R)). However, it has proven impossible for many of these research and demonstration projects to adapt mid-stream due to limitations in the original procurements and current project delivery teams, and lack of a holistic, consistent, and robust USDOT approach to technical assistance, data access, and evaluation across the multimodal ITS research and demonstration project portfolio. As a result, few of these projects will provide data to the USDOT and the public, and those that do will provide limited, inconsistent data well after data collection begins. USDOT is also not yet prepared to rapidly access and analyze these data across programmatic and modal siloes.

The ITS JPO expects that many of the research and demonstration projects that this research area supports will involve a non-Federal financial contribution. The Data Program itself will not have direct non-Federal financial contribution, but in the future, may involve cost-share. For example, third party evaluators may share the cost of collecting, curating, and analyzing data. We do expect non-federal groups to play a significant role in providing non-financial contributions. For example, Waze currently provides data to the USDOT at no cost via its Connected Citizens Program. The Waze data is hosted alongside analytical and collaboration tools in the ITS JPO-funded Secure Data Commons Proof-of-Concept system, which provides access to analysts across the Department via a collaboration with the OCIO. Non-federal groups may also voluntarily partner with the USDOT to help scale the adoption of technology and data best practices incubated and demonstrated through this research program.

⁶ <https://www.transportation.gov/sites/dot.gov/files/docs/Official%20DOT%20Public%20Access%20Plan.pdf>

Cybersecurity for Intelligent Transportation Systems (ITS)

Funding Request (\$2,718,000)

Program Description/Activities/ Objectives:

The USDOT has an important role to play in pursuing research and analysis in the area of cybersecurity for ITS to deliver public benefit. Federal leadership offers State and local agencies an opportunity to express their needs and have cybersecurity experts translate those needs into use cases and requirements that cross modal boundaries and ensure risk management among vehicles, infrastructure equipment, and portable devices. State and local agencies tend not to have this type of expertise nor do they have the time or funding to pursue initiatives that are important but tangential to their daily operational mission.

This research will address two key objectives. 1) Build awareness among state and local agencies to create a cybersecurity aware culture and, 2) Increase cybersecurity capabilities of transportation organizations demonstrating and deploying ITS.

Initiating the awareness of transportation organizations to the need for cybersecurity: The long-term goal of this research is to establish a multimodal intelligent-transportation system that is resilient to cyber-attacks. FHWA and the ITS JPO will undertake research that initiates an awareness of good cybersecurity practices and translate these practices to the transportation environment to build to the goal of a cyber resilient transportation system.

The *USDOT Strategic Plan FY 2018 – 2022* stated that “DOT will encourage the adoption of the National Institute of Standards and Technology Cybersecurity Framework by transportation ecosystem stakeholders.” Current research continues to translate the National Institute for Technology and Standards (NIST) Cybersecurity Framework into the transportation environment. The tenets of cybersecurity that relate to transportation operations and equipment include: identify, protect, detect, respond, and recover. The NIST Framework provides a process that assists entities in understanding their cybersecurity risk and what can be done to mitigate them. In addition to adapting the Framework, research was also undertaken to understand how the transportation sector should connect with cyber risk management practices that include communication with Department of Homeland Security (DHS) entities that monitor cyber activity and organization (Information Sharing and Analysis Centers) that support information sharing regarding cyber vulnerabilities and attacks. The research investigated protocols, terminology, interfaces, and explained the overall process regarding cyber event monitoring and reporting. This effort formed the basis of establishing the need for cybersecurity.

FHWA and ITS JPO will work with transportation cybersecurity stakeholders to translate our efforts into best practices for State and local transportation organizations. The best practices will expose transportation professionals to the NIST Framework; translated for the transportation sector, and the protocols and procedures associated with participating in cyber risk management monitoring and information sharing. In addition, research will be conducted to develop and prototype a transportation cyber assessment tool. The tool will assist transportation professionals in applying

the NIST Framework and to understand their organizations cyber status. The research will produce an inventory of assets that will include descriptions and specifications that support cyber risk assessment. To advance State and local entities implement cyber risk management practices, research will be conducted to identify and provide cybersecurity procurement guidance. The procurement guidance will provide information regarding cyber specifications for transportation equipment and cyber requirements when procuring cyber technical support and services.

This Program will be managed jointly between FHWA and the ITS JPO in coordination with modes across USDOT working through the cybersecurity working group. This will allow for a comprehensive approach to transportation cybersecurity that considers the interdependencies created via the connectivity among the modes that impact cyber risks.

Cybersecurity Best Practices for the Transportation Sector: This research will document best practices for information sharing across the transportation-ecosystem and with other sectors, as well as identify training needs for transportation professionals, and material to ensure organizational preparedness. This includes developing training content and technology transfer to strengthen the cybersecurity skills and practices of relevant ITS stakeholders.

To facilitate investigation and implementation of best practices, the research will include development, prototyping, and trial use of a Transportation Cyber Assessment Tool. The tool will assist transportation professionals in assessing their organizational cyber risk and providing ways to mitigate risk in line with the NIST Cybersecurity Framework.

To enhance the success of assessments, research will be conducted to identify all types of transportation control systems that may create a cyber risk. These control systems could include controls for tunnel ventilation, pumping stations for water control, or movable bridge controls. The research will produce an inventory of transportations control systems to facilitate inclusion in cyber assessment. The inventory also provides a resource to characterize control systems to cyber professionals including those monitoring cyber activity. The inventory will provide descriptions regarding operations and connections to management systems to support cyber risk assessments.

The best practices will also include procurement guidance. Due to the current capabilities of transportation sector organizations, many transportation organizations will need to procure transportation equipment that meets cybersecurity requirements and/or they will need cybersecurity technical assistance or services. The procurement guidance will provide information on the provisions to include in the procurement requests and subsequent contracts to support obtaining the appropriate cyber functionality or services.

Research activities will meet the following high priority areas:

- Establishing an understanding of federal level cyber monitoring and stakeholder participation.
- Identifying the continuum of transportation control systems that may need to be considered in a cyber risk assessment and cyber monitoring.

- Ensuring transportation organization can obtain cyber ready equipment and qualified technical support/services.

Key FY20 Cybersecurity R&T Program Activities.

Activity	Period of Performance	Partners/Notes
<p>Cybersecurity Best Practices for the Transportation Sector</p> <p>This research will document best practices for information sharing across the transportation-ecosystem and with other sectors, training needs for transportation professionals, and organizational preparedness.</p>	2020-2022	State and local transportation organization; transportation equipment providers; cybersecurity providers
<p>Transportation Cyber Assessment Tool</p> <p>The tool will assist transportation professionals assess their organization cyber risk and ways to mitigate risk in line with the NIST Cybersecurity Framework.</p>	2020-2022	State and local transportation organization; State and local Information Technology officials; Local law enforcement
<p>Cybersecurity Procurement Guidance</p> <p>The procurement guidance will provide information on the provisions to include in the procurement requests and subsequent contracts to support obtaining the appropriate cyber functionality or services.</p>	2020-2022	State and local transportation organization; State and local Information Technology officials
<p>Transportation Control Systems Inventory</p> <p>The research will produce an inventory of transportations control systems to facilitate inclusion in cyber assessment and cyber monitoring.</p>	2020-2022	State and local transportation organization; transportation equipment providers; cybersecurity providers; DHS/cybersecurity monitoring

Statutory Requirements:

Is this program statutorily mandated (Y/N): **Yes:** This Program is authorized in sections 512 to 518 of Title 23, United States Code.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation:

- **Innovation:** The Cybersecurity research program supports the development and deployment of innovative practices and technologies to improve the safety and performance of the Nation's transportation system by managing the risk of cybersecurity. This targeted research will advance the state of knowledge regarding the cybersecurity risk introduced by the innovative technology being implement by our partners. The research will also position our partners to proactively prepare for and start to implement the organizational capacities that will be needed to protect the viability of the transportation systems and recover when a cyber event occurs.

USDOT Research Priorities:

Cybersecurity is a USDOT research priority. The research described above maps to the cybersecurity research working group team scope and annual goals to close gaps, facilitate information sharing, and use of common risk models. This research will be coordinated with our model partners, with efforts such as the adaptation of the NIST Cybersecurity Framework for the transportation sector. The research will facilitate developing the capacity of our partners, but will also inform us regarding the skilled workforce USDOT must support to proactively and effectively investigate and facilitate the implementation of sound transportation cybersecurity practices. The research will also assist in our efforts to establish the protocols required to coordinate cybersecurity monitoring and reporting activities.

Research Collaboration Partners:

Many stakeholders through various venues such as Transportation Research Board, American Association of State Highway and Transportation Officials, Intelligent Transportations Systems of America, Institute of Transportation Engineers, FHWA Automated Driving Systems (ADS) Request for Comments, and the National Dialogue on Highway Automation have identified the challenges of cybersecurity and the lack of the capacity on the public roadway providers side to adequately address the challenge. Various State transportation organization are already familiar with systems being hacked. Many of the organization above have instituted committees to address cybersecurity issues. Internally, DHS and FBI discussions have taken place so that the entities obtain a better understand regarding roadway operation and assets related to possible cyber events. This research benefits our external and internal partners by establishing the protocols that will enable all the partners to interface and collectively address cybersecurity challenges.

Emerging /Enabling Technologies

Funding Request (\$16,308,000)

Program Description/Activities/ Objectives:

The Emerging/Enabling Technologies Program focuses on cultivating the next generation of transportation systems. As the scale of Intelligent Transportation Systems (ITS) increases, vehicle manufacturers, infrastructure providers, innovators, and entrepreneurs discover new opportunities to use technology and the data that will be generated. These technological advances, along with new functionality, new applications, new operational concepts, and disruptive innovations, need to be tracked and planned for by the USDOT to determine technological, market, and demographic trends throughout the globe and across industries to seek, evaluate and sometimes incubate emerging capabilities that demonstrate the potential to transform transportation. As this happens, the USDOT will be positioned and engaged as a partner to guide research, development, and technology adoption in a systematic manner. Through multi-modal coordination, the ITS JPO works to avoid duplicative ITS work and to ensure the efficient allocation of ITS resources.

For example, Artificial Intelligence (AI) has been identified as an area of prioritization, both for the benefits it promises and the opportunity to extend those benefits across modes within USDOT. Attention to AI has grown significantly over the last several years and has accelerated within the U.S. government after the release of the White House Executive Order, Maintaining American Leadership in Artificial Intelligence.⁷

Meanwhile, efforts related to AI within USDOT have largely been conducted at the project level. As individual modes make investments in projects that leverage AI technologies, ITS JPO is uniquely positioned to help accelerate knowledge transfer and investment opportunities between these modes. The benefits realized by AI-enabled technologies in one particular mode might be extended across multiple modes, if coordinated properly.

Through this program, ITS JPO seeks to coordinate and synchronize AI research, development, and deployment activities across modes. ITS JPO will work with agency modes to identify AI applications that could be leveraged across the transportation system. A draft baseline report on Artificial Intelligence and Machine Learning⁸ canvassed artificial intelligence activities throughout USDOT and identified immediate impact areas for potential research coordination, such as computer vision, natural language processing, and decision support tools. ITS JPO will inventory AI-related projects already underway, explore possibilities for multi-modal coordination, as well as identify new areas of research where multiple modes can benefit from emerging technologies.

⁷ <https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/>

⁸ *ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING BASELINING: Findings and Recommendations on Defining AI and Machine Learning for U.S. DOT and Identifying Current Activities, Future Priorities, and Needs.* Report to the Office of the Chief Information Officer and the Office of the Under Secretary for Transportation Policy Draft – December 6, 2018

On a similar note, communications technologies are critical to the safe, secure, and efficient operations of transportation systems across the Nation. Transportation agencies have incorporated communications into their operational environments (i.e., field systems, management centers, and public fleets), and vehicle manufacturers are increasingly including multiple types of communications into their vehicles. While much research has been conducted with Wi-Fi, Dedicated Short Range Communications (DSRC), cellular, and satellite communications, there are emerging communications technologies such as Cellular-Vehicle-to-Everything (C-V2X) and 5G, which could also have significant impacts on transportation systems. For example, the 5G capabilities are relatively undefined at this time and it is not clear if transportation needs and requirements are being taken into consideration. Cellular-V2X technology is being designed and developed by an industry led group as a potential replacement technology for DSRC.

The USDOT has an important role to play in pursuing research and analysis in the area of transportation technologies and their use of telecommunications to deliver public benefit. Federal leadership offers State and local agencies an opportunity to express their needs and have Federal telecommunications experts translate into use cases and requirements that cross over market boundaries and ensure interoperability among vehicles, infrastructure equipment, and portable devices. State and local agencies tend not to have this type of expertise nor do they have the time or funding to pursue initiatives that are important but tangential to their daily operational mission.

In our multi-modal coordinator capacity, the ITS JPO also supports operating administrations (OAs), for example, the FTA on the Mobility on Demand (MOD) Program. In addition, ITS JPO will cooperate with FHWA on Electronic Toll Collection (ETC) system interoperability. Advancing ITS and business operations technologies have made some combination of technical and business solutions more viable to support interoperability across toll systems using differing ETC systems. The ITS JPO will cooperate with stakeholders to identify and reach consensus on preferred technically viable and institutionally acceptable approaches to support increased ETC interoperability across regions and Nationally.

The ITS JPO will cooperate with FHWA on pilot studies with states and MPOs on enhancing their planning process to address technology solutions through scenario planning. This effort will provide a more effective agile capability for planning agencies to advance technological changes as new needs and potential solutions arise and evolve. We will cooperate with USDOT stakeholders to develop effective scenario planning approaches that can flexibly and responsively support prioritization of technology advances.

Program Objectives:

This research program focuses on cultivating the next generation of transportation systems. As emerging technologies offer the potential to enter the transportation environment, ITS JPO will evaluate their fit in meeting transportation needs and work with agency modes to extend resulting benefits from these technologies across the transportation system.

This research program will build on the collaborative partnership initiated in 2018 between the ITS JPO and the Ford Motor Company to conduct performance testing of the C-V2X communications to

determine its potential to provide benefits to the transportation system. This research will also analyze and provide input to the evolution of cellular communications from LTE to 5G networks in order to assess the impacts on the transportation system.

Given the magnitude of impacts that transitioning to the next generation communications can have on transportation, the ITS JPO proposes the establishment of a focused research initiative. There are three proposed research objectives that will concern the USDOT moving into the future:

A. Institutional adoption of next generation communications technologies:

- Promote adoption with State and local agencies by gathering needs, analyzing impacts, and coordinating transition planning.
- Analyze the additional skills/knowledge needed by transportation workers to manage each next generation of communications technologies, equipment, and systems.
- Work with transportation private sector equipment manufacturers and application developers to facilitate transition of safety-critical elements and interoperability.

B. Safety and security framework development:

- Develop and maintain a set of transportation communications threshold requirements associated with safety against which any new technology can be assessed and tested.
- Analyze, develop, and demonstrate approaches to test for interference or other harms to existing operations.

C. Public sector representation:

- Conduct necessary research and analysis in partnership with modal administrations and stakeholders to gather public sector needs and requirements.
- Create transportation safety use cases to facilitate the incorporation of transportation safety requirements into each next generation of communications technologies.
- Participate in and leverage existing relationships with domestic (SAE, IEEE) and international (ITU, 3GPP) standards development organizations to ensure that the transportation needs are represented in each generation communications systems.

Statutory Requirements:

Is this program statutorily mandated (Y/N): **Yes:** This Program is authorized in sections 512 to 518 of Title 23, United States Code.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation:

- **Innovation:** This research priority aligns with the USDOT strategic goal of innovation by supporting the development and deployment of innovative technologies such as 5G communications.

USDOT Research Priorities:

The Emerging and Enabling Technologies Program supports all USDOT research priority areas. The programs include a variety of efforts related to evidence-based decision making and focuses on questions of investment choices, value, awareness of technologies, and their application in the real world. Cost/benefit data are the cornerstones of any analysis relating to economic impact, performance assessment, feasibility assessment, and impact assessments.

Research Collaboration Partners:

Most of the on-going research into next generation communications is funded by the private sector and is focused on enhancing technical performance of existing equipment or development of new radios. The private sector, academia, and governments around the world have formulated questions associated with whether these new communications technologies can enable safety-critical applications, provide crash avoidance, and support automation. Chipset and vehicle manufacturers are working on prototypes to prove out the concept while experts are working to design performance-based test procedures that demonstrate the capabilities as well as the gaps that still need to be addressed.

For the existing communications technologies in use with transportation today, USDOT, modal partners, and stakeholder partners (e.g., Federal Communications Commission and National Telecommunications and Informational Administration) have invested in a wide range of research and analyses including:

- Development of a band plan for the 5.9 GHz part of the spectrum.
- Comparison of cellular, Wi-Fi, and satellite capabilities and costs to deliver interoperable, low-latency messages.
- Assessment of out-of-band and adjacent channel interference in the 5.9 GHz spectrum.

One of the lessons learned is that the transportation environment introduces unique requirements for telecommunications; for instance, users and equipment move at high speeds—over 80 miles per hour, which can cause interference. This unique requirement imposes high frequency and reliability requirements. Another is that any viable communication technology needs to scale to allow hundreds of nearby devices to communicate without causing channel congestion.

We have also learned that the telecommunications industry evolves at a rate that is dramatically different from the deployment of these technologies in State, regional and local transportation system operations. The replacement cycle within the telecommunications industry is typically 18-24 months whereas the replacement cycle within transportation system operations is typically 10-15 years. This disparity is impacting how and what transportation agencies will procure in near future as well as their longer-term investment planning.

The ITS JPO expects to continue to partner with private sector firms, modal partners, and stakeholder partners (e.g., Federal Communications Commission and National Telecommunications and Informational Administration) in a manner that provides technical contributions with a financial value. For instance:

- ITS JPO has partnered with automotive companies in a pre-competitive forum to assess the impacts of new communications technologies on vehicles as well as to study interference associated with proposals for spectrum sharing. This was accomplished with a 20% cost share through a cooperative agreement.
- ITS JPO is partnering with automotive firms, tier one suppliers, and chipset manufacturers to form an understanding of new communications innovations through testing and data

analyses. The private sector firms are providing prototypes as well as sharing their test approaches with USDOT as a means of forming consensus on the level of rigor and depth appropriate to assessing their new technology for safety and other features critical for the transportation environment. This is being accomplished through a partnership agreement.

DRAFT

Complete Trip Funding Request (\$9,060,000)

Program Description/Activities/ Objectives:

Complete Trip is a joint USDOT initiative, co-led by FTA, FHWA, and the ITS JPO. It is exploring emerging technologies to enhance travel that includes opportunities for people with mobility challenges by providing travel opportunities that are seamlessly integrated into their daily lives. This seamless integration will be the “Complete Trips for All” effort highlighted by the USDOT Topical Research Area – Mobility Innovation working group. The Complete Trips for All vision leverages innovative technologies and facilitates public private partnerships to allow for a traveler-centric approach that improves mobility options for all travelers, including travelers with disabilities, travelers from rural areas, and lower income travelers. The Program resources identified in the ITS JPO FY 2019 Spend Plan will be used to support defining the Complete Trips for All vision. Internal to USDOT this effort will reach beyond the research team to include at a minimum the planning and civil rights disciplines. This multidisciplinary connection is critical to the success of the technology transfer efforts under this program area. This effort would also glean input from a range of interagency Federal partners including the Departments of Health and Human Services (DHHS), Labor (DOL), Defense (DOD), and others.

The USDOT Topical Research Area – Mobility Innovation working group is leading departmental efforts at defining what elements make up a complete trip, and working to identify gaps within related efforts. By working collaboratively, the USDOT will bridge the gap between current USDOT efforts and the realization of “Complete Trips for All”. The Complete Trip Program focuses on identifying opportunities to leverage and combine existing technologies into new and complete solutions that can be implemented to meet the needs of all travelers. The Accessible Transportation Technologies Research Initiative (ATTRI) helped define the complete trip and developed pieces of technology that would enable the complete trip. However, not all elements of the complete trip are fully defined or developed yet. The current ATCMTD Grants Program, the FTA’s Integrated Mobility Innovation (IMI) demonstration projects, and the Automated Driving System (ADS) Notice of Funding Opportunity (NOFO) are providing the USDOT with real world deployments and demonstrations of emerging capabilities. By working closely with, and aligning our research to support these Programs, the Complete Trip Program will avoid duplication, and will be able to ensure the USDOT is moving forward on improving mobility for all travelers.

The lack of transportation options for all travelers, including travelers with disabilities, travelers from rural areas, and lower income travelers is a persistent challenge for access to jobs, education, healthcare and other activities. The Complete Trip Program identifies, collaborates, coordinates, develops, and implements transformative solutions in advancing accessible transportation and independent mobility. The Program will:

- Engage stakeholders to assess impacts and effectiveness of accessible technologies, define complete trip and what it means and what is missing.

- Advance technological innovation for accessible transportation through foundational research, prototype development, and technology transfer programs.
- Improve transportation systems integration including pedestrian and built environments.
- Coordinate with key partners, within the federal government, the research community, stakeholder organizations, and private industry.
- Demonstrate, deploy, evaluate and provide guidance for accessible transportation technologies.

The flagship effort will support the demonstration of “Complete Trips for All” for one or more of the travelers with disabilities, travelers from rural areas, and/or lower income travelers. An Independent Evaluation of the demonstration will run concurrent with the program.

Statutory Requirements:

Is this program statutorily mandated (Y/N): **Yes:** This Program is authorized in sections 512 to 518 of Title 23, United States Code.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation, Infrastructure and Safety:

- **Innovation:** The Program is developing innovative technology applications to enable an integrated multimodal environment that will provide fully accessible complete trip options to all travelers.
- **Infrastructure:** The Program is developing innovative technology applications to improve the mobility and accessibility of all travelers. Investments in technology infrastructure for transit stations, surface networks, and other infrastructure would enable the success and scalability of mobility and accessibility applications currently being prototyped and stimulate economic growth in the impacted regions.
- **Safety:** The Program is prototyping applications that provide safer and more reliable travel for all, including a safe intersection crossing application and remote monitoring and assistance applications for people with disabilities.

The research and deployment activities within the Complete Trip Program bring positive impacts to all communities, both rural and urban, including improved and reliable traveler options for people with disabilities, increased independent travel opportunities, and shift from paratransit services.

USDOT Research Priorities:

The Complete Trip Program supports the USDOT mobility/underserved communities research priority. The research maps to the mobility research working group’s scope and annual goals to address market failures associated with transportation for for all travelers, including travelers with

disabilities, travelers from rural areas, and lower income travelers. This research will be coordinated with our model partners across multiple agency disciplines and will develop the capacity of our partners to make improvements in this often-overlooked area.

Research Collaboration Partners:

The Program is a collaborative effort co-led by FHWA, FTA and ITS JPO. The team has been successful in partnering with other federal agencies including the National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR) and the DOL’s Office of Disability Employment Policy (ODEP), NASA, and the Interagency Committee on Disability Research (ICDR) to research and develop transformative solutions to help people with disabilities effectively plan and execute their travel.

DRAFT

Accelerating ITS Deployment Funding Request (\$16,308,000)

Program Description/Activities/ Objectives:

As new Intelligent Transportation Systems (ITS) technologies and systems evolve into market-ready products, the ITS Accelerating Deployment Program is addressing questions associated with adoption and deployment. The goal of the Accelerating Deployment Program is to speed up the transformation of ITS research and prototypes into market-ready technologies that are commercially viable and adopted by the transportation community. This Program provides communication and education support to facilitate awareness, understanding, acceptance, adoption, and deployment of ITS technologies across stakeholder groups; and ensures effective partnerships are fostered and developed at various levels – executive, program, and project. The ITS JPO seeks to spur adoption of technology, and help stakeholders and localities deploy maturing ITS systems. The Program provides knowledge transfer, and supports technical assistance, training, outreach, program evaluation, and other stakeholder engagement. The Program supports advancing ITS research, to initial adoption, and subsequently on to wider scale deployment in coordination with other stakeholders at the federal, state, regional and local levels. The Program’s key areas are discussed in the following:

- Training – As Connected and Automated Vehicle (CAV) technologies progress, the workforce will need new knowledge, skills, and abilities to drive implementation, the ITS Professional Capacity Building (PCB) Program will continue developing courses to advance the ITS workforce.
- Technical Assistance – The Connected Vehicle (CV) deployment test bed/technical assistance program and CV Pilot Program will continue development of an agile platform to deliver support to test sites remotely using a help desk model with targeted in-person testing capabilities and coordination between early deployers.
- Stakeholder outreach through workshops and webinars – The PCB Program will offer ITS knowledge and lessons learned from CV deployments to stakeholder’s in-person and then package these materials for a wider audience through an economical and scalable platform.
- The Communications Program updates and maintains the ITS JPO website and develops microsites on selected topics of interest such as CV basics and connected vehicle deployment.
- The ITS JPO supports knowledge and technology transfer in key areas with our USDOT partners as well as American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), ITS America (ITSA), and other stakeholders. The ITS Evaluation Program supports CV pilot deployment and smart city evaluation efforts, conduct the ITS Deployment Tracking Survey, document benefits, costs, and lessons learned from ITS deployments, and conduct studies of ITS program effectiveness.

- The Communications Program provides support for any ITS JPO-funded research project. This includes presentations, articles, and fact sheets about connected vehicle, automated vehicle and all other ITS activities. These materials are used to educate the public and provide stakeholders with the tools they need to promote deployment of ITS technology.
- The Standards and Architecture Program provides a framework to guide State and local planning and project implementation, providing the reference and tools needed to customize ITS implementations to meet local needs while maintaining desired levels of necessary interoperability. The Architecture Program makes available both regional and project planning software toolsets as well as a reference architecture with 130+ user services, along with identifying interfaces for standardization and recommending suitable ICT and ITS standards – identifying and enabling multiple suitable technology choices whenever viable. The Program also conducts extensive implementation support activity, providing technical support along with systems engineering and architecture implementation workshops to State and local customers Nationwide.
- The Interoperability budget funds key technical research to advance ITS architecture and standards, cyber security, certification/testing and human factors guidelines that support efficient, secure large-scale deployment of ITS technologies and regulatory decision-making. Interoperability programs support test beds and pilot deployments and serve to assure a broad, competitive marketplace for ITS equipment and services. The goal of this research is to ensure effective connectivity from the device level to the transportation system level.

Program Objectives:

The objectives of the Accelerating Deployment Program are to define and improve evidence-based decision making, collaboration and communication mechanisms and targets to encourage public and private investment (Research); to develop comprehensive cost benefits and analytic tools that allow deployers to understand the financial and operational benefits of new technologies and systems (Development); and to establish the tools that support the new user base (Adoption). The Program is also tasked to develop and evolve a comprehensive National ITS reference system architecture to support large scale interoperable ITS infrastructure, connected vehicle, and connected automation deployments across the nation – especially across borders with Canada and Mexico (Development); to develop and maintain an inventory of candidate interfaces for standardization and support standards development efforts for interfaces where there is greatest public interest and benefit, including those interfaces required to support regulatory activity (Development); to cooperate internationally, leveraging common interests to reduce US resource requirements, access broader expertise, speed development and harmonize architecture and standards to support an international marketplace for US vendors (Adoption); and to facilitate availability of testing and certification processes and procedures to ensure required interoperability and regulatory compliance (Adoption).

Statutory Requirements:

Is this program statutorily mandated (Y/N): **Yes:** This Program is authorized in sections 512 to 518 of Title 23, United States Code.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation:

- **Innovation:** The Program supports the strategic goal of innovation by working to accelerate and expand the deployment of new technologies and practices across the Nation to enable safety benefits to be realized rapidly.

USDOT Research Priorities:

To the extent that the Accelerating Deployment Program supports a variety of efforts related to evidence-based decision making and focuses on questions of investment choices, value, and awareness of technologies and their application in the real world, the Program can be said to touch on most, if not all, of these research priority areas. Cost/benefit data are cornerstones of any analysis relating to economic impact, performance assessment, feasibility assessment, and impact assessment. Mobility improvements associated with the deployment of technology are also assessed via evaluation.

Research Collaboration Partners:

Each of the elements of the Accelerating Deployment Program area are crosscutting and, as such, have at their core the objective of reaching out to all types of stakeholders, and across all modes.

To ensure that these identified audiences are given necessary knowledge sharing and technology sharing support, the ITS PCB Program works in partnership with professional associations, universities, state, regional and local public agencies, and the training programs of USDOT modal administrations to engage the broad technical and organizational expertise needed to develop and deliver ITS learning. Specific partners include:

- Federal Highway Administration (FHWA)
 - Office of Infrastructure
 - Office of Innovative Program Delivery – Center for Transportation Workforce Development
 - Office of Operations
 - Office of Planning, Environment, and Realty
 - Office of Research, Development, and Technology (RD&T)
 - Office of Safety
 - Office of Safety Research and Development (R&D)
 - National Highway Institute
 - Resource Center
- Federal Transit Administration (FTA)
- Maritime Administration (MARAD)
- American Planning Association (APA)
- American Public Transportation Association (APTA)
- Institute of Transportation Engineers (ITE)
- International Municipal Signal Association (IMSA)

- ITS America (ITSA)
- National Association of Development Organizations (NADO)
- National Network for the Transportation Workforce (NNTW)
- National Operations Center of Excellence (NOCoE)
- National Transit Institute (NTI)
- International Partners (Canada Mexico, European Commission (EC) and Transport Certification Australia (TCA))

Each of these Federal program offices, educational organizations, or professional associations act as a sounding board from which the ITS PCB Program receives information on educational and training needs and also as a distribution channel through which the ITS PCB Program disseminates various ITS educational materials or training courses developed. The ITS PCB Program will continue to enhance coordination efforts with all USDOT modal partners in FY2020. Through the implementation of the *PCB Strategic Plan*, the Program continues its mission to prepare transportation industry professionals (both current and future) for an ITS and connected automated transportation system. Creating, maintaining, and expanding effective partnerships is a critical component of the Program's strategy.

DRAFT

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Funding Request (\$19,026,000)

Program Description/Activities/Objectives:

The ATCMTD is statutorily required in the FAST Act Section 6004, 23 U.S.C. 503(c)(4). The ITS JPO contributes a mandated percentage of funding through FHWA to annually satisfy the requirement. The ATCMTD grants are managed by FHWA.

The USDOT provides a total of \$60,000,000 for ATCMTD, with \$39,000,000 coming from FHWA and \$21,000,000 from the ITS JPO. The ITS JPO has a role in coordinating USDOT's overall ITS research program to ensure multimodal collaboration and avoid duplication of efforts. Staff from ITS JPO and modal agencies work jointly to accomplish the defined ITS research program and avoid duplication. The ITS research program provides \$21 million of the \$60 million annual ATCMTD grant program funding in FY 2020. FHWA administers the ATCMTD program.

The language provided here duplicates the language provided in the FHWA AMRP for consistency.

The Advanced Transportation and Congestion Management Technologies Deployment Initiative (ATCMTD) Program is intended to provide funding for eligible entities to develop model deployment sites for large scale implementation and operation of a diverse set of technologies in various geographic regions. As the program is aimed at the rapid deployment of advanced technologies, limited expenditures for infrastructure construction is anticipated in grant application. The stated purpose is to reduce costs and improve return on investments; deliver environmental benefits through increased mobility; improve transportation system operations; improve safety; improve collection and dissemination of real-time information; monitor transportation assets; deliver economic benefits; and accelerate deployment of connected and autonomous vehicle technologies. Successful proposals will contain quantifiable system performance objectives, use innovative technologies and strategies, and a plan for long term operation and maintenance of the deployed technologies. Partnering between the private sector, public agencies, research institutions, technology leaders, and other transportation stakeholders is encouraged

Statutory Requirements:

Is this program statutorily mandated (Y/N): **Yes**, FAST Act Section 6004, 23 U.S.C. 503(c)(4).

Program Alignment with Strategic Goals:

Goals for the ATCMTD Program are directly linked to USDOT's Strategic Goals and DOT RD&T Critical Transportation Topics and include:

- Reduced costs and improved return on investments, including through the enhanced use of existing transportation capacity (Infrastructure)

- Delivery of environmental benefits that alleviate congestion and streamline traffic flow (Preserving the Environment)
- Measurement and improvement of the operational performance of the applicable transportation networks (Improving Mobility)
- Reduction in the number and severity of traffic crashes and an increase in driver, passenger, and pedestrian safety (Safety)
- Collection, dissemination, and use of real-time transportation-related information to improve mobility, reduce congestion, and provide for more efficient and accessible transportation, including access to safe, reliable, and affordable connections to employment, education, healthcare, freight facilities, and other services (Improving Mobility)
- Monitoring transportation assets to improve infrastructure management, reduce maintenance costs, prioritize investment decisions, and ensure a state of good repair (Improving Infrastructure)
- Delivery of economic benefits by reducing delays, improving system performance and throughput, and providing for the efficient and reliable movement of people, goods, and services (Improving Mobility)
- Accelerated deployment of vehicle-to-vehicle, vehicle-to-infrastructure, and automated vehicle applications, and autonomous vehicles and other advanced technologies (Innovation)
- Integration of advanced technologies into transportation system management and operations (Innovation)
- Demonstration, quantification, and evaluation of the impact of these advanced technologies, strategies, and applications towards improved safety, efficiency, and sustainable movement of people and goods (Safety, Improving Mobility)
- Reproducibility of successful systems and services for technology and knowledge transfer to other locations facing similar challenges (Innovation)

Fixing America's Surface Transportation (FAST) Act Section 6004 instructs the USDOT to ensure that the selection of grant recipients represent diverse geographic areas of the United States, including urban and rural areas.

Research Collaboration Partners:

ATCMTD is not a research program, rather it is a discretionary grant program established in the FAST Act, however, public and stakeholder input is considered in the development of the annual Notice of Funding Opportunity (NOFO).

To be selected for an ATCMTD award, an applicant must be an eligible applicant. Eligible applicants are State or local governments, transit agencies, metropolitan planning organizations (MPO) representing a population of over 200,000, or other political subdivisions of a State or local government (such as publicly owned toll or port authorities), or a multi-jurisdictional group or consortia of research institutions or academic institutions. Partnership with the private sector or public agencies, including multimodal and multi-jurisdictional entities, research institutions, organizations representing transportation and technology leaders, or other transportation stakeholders, is encouraged.

Typically, a consortium is a meaningful arrangement with all members involved in planning the overall direction of the group’s activities and participating in most aspects of the group; the consortium is a long-term relationship intended to last the full life of the grant. Any application submitted by a sole research or academic institution and that is not part of a consortium will not be considered for selection.

Partnerships with the private sector or public agencies, including multimodal and multijurisdictional entities, research institutions, organizations representing transportation and technology leaders, or other transportation stakeholders, is encouraged. Numerous awards from FY 2016 and 2017 include non-governmental partners. Non-governmental partners traditionally have provided non-Federal matching funds in the form of technical services, hardware, and software.

Program partners (both government and non-government), benefits derived from partnerships, and partner contributions are summarized in the table below.

Partner Organization	User Perspective on Needs	Industry Perspective	Standard Setting	Field Trials	Deployment	Research Collaboration	Specialized Expertise or Capabilities	Donation of Material or	Funding
ATCMTD partners are the individual grant recipients (benefits of partnerships are identified in FAST Act Section 6004 and 23 U.S.C. 503(c)(4)). Benefits of partnership and partner contributions will be detailed in FAST Act-mandated Secretary’s report, which is due May 2020.				X					

Small Business Innovation Research (SBIR)

Funding Request (\$1,812,000)

Program Description/Activities/Objectives:

The SBIR Program is a highly competitive, awards-based Program that encourages domestic small businesses to engage in research and development addressing high priority research areas within USDOT. The SBIR Program favors research that has the potential for commercialization through products and applications sold to the private sector transportation industry, State DOTs, USDOT, or other federal agencies.

The Program is administered by the Volpe Transportation Center. The SBIR Program Office publishes one or two solicitations each fiscal year for proposals on specific research topics of interest to USDOT operating administrations.

Program Objectives:

To encourage small businesses to engage in research or research and development (R/R&D) that has the potential for commercialization and meets federal R/R&D objectives. The SBIR Program is uniquely positioned to support both the interests of the Agency as well as the small business. In this respect, the SBIR Program aims to provide essential funding to small businesses with aim toward commercialization of products that align with Agency and Departmental goals.

The SBIR Program offers unique services to the small businesses to aid in their technical and commercial development. Specifically, the SBIR Program recently introduced a Commercialization Assistance Program to provide consulting services to the SBIR participants to help conduct market research, commercialization plans, and other services. In addition, in FY19 the FHWA SBIR Program will pilot a Technology Readiness Level (TRL) assessment program to help the Small Businesses conduct an independent assessment of the technological status of the innovations developed through the SBIR Program.

Key FY20 SBIR Program Activities:

Activity	Period of Performance	Partners/Notes
Technology Readiness Level (TRL) Services Pilot	2019	N/A
Annual Solicitation of Topics	2019	N/A

Statutory Requirements:

Is this program statutorily mandated (Y/N): **Yes** - On December 31, 2011, the President signed into law the National Defense Reauthorization Act of 2012 (Defense Reauthorization Act), P. L. 112-81. Section 5001, Division E of the Defense Reauthorization Act contains the Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Reauthorization Act of 2011 (SBIR/STTR Reauthorization Act), which extended both the SBIR and Small Business Technology Transfer (STIR) programs through September 30, 2017. On November 30, 2016, a 5-year

reauthorization was signed by the President, extending the expiration date to September 30, 2022. Funding amounts are established in Law, as noted in the Defense Reauthorization Act (Sec.5102(a)(1)), each year Federal agencies with extramural research and development (R&D) budgets at the Department level that exceed \$100 million are required to allocate 3.2 percent of their R&D budget to these programs as listed below. Agencies may exceed these minimum percentages.

Program Alignment with Strategic Goals:

The SBIR Program solicits research and technology topics from the ITS JPO and FHWA R&T offices annually. Topics are selected based on the merit, suitability for the SBIR Program, as well as consideration of alignment with Agency and Departmental goals. As a result, the SBIR Program supports all of the USDOT Strategic goals.

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Chapter 4 – FY 2021 Program Descriptions

Automation Program

Program Description/Activities/ Objectives:

Automated vehicles have the potential to bring about transformative safety, mobility, energy, and environmental benefits to our nation’s surface transportation system. These benefits could include crash avoidance, reduced energy consumption and vehicle emissions, reduced travel times, improved travel time reliability and multi-modal connectivity, and improved transportation system efficiency and accessibility, particularly for persons with disabilities and the growing aging population. ITS JPO automation research will support the federal role in safety performance, infrastructure and interoperability, and policy analyses.

Safety Performance: These activities build off the FY20 research to improve understanding of safe AV operations and generate actionable data and decision support results for the broader stakeholder community.

Infrastructure and Interoperability: ITS JPO will continue to conduct multi-modal research to support the safe interaction of automated vehicles with among themselves, with other road users, and with highway infrastructure.

Policy Analysis: AV technology development continues to advance at a rapid pace, requiring a nimble and coordinated approach to policy development. Building on previously established efforts, ITS JPO will continue to assess the impacts of AVs on the general public and identify and evaluate critical issues related to AV adoption.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goals for Safety, Infrastructure, Innovation and Accountability:

- **Safety:** *Reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System.* Large safety gains from automaton will depend on market penetration of highly automated vehicles (HAVs). Mobility enabling cooperative solutions (to counter congestion increases from vehicle miles travelled (VMT) growth and autonomous operations) will be essential for consumer and societal acceptance.
- **Infrastructure:** *Invest in Infrastructure to Ensure Safety, Mobility and Accessibility and to Stimulate Economic Growth, Productivity and Competitiveness for American Workers and Businesses.* Cooperative automation is essential a digital overlay to the physical infrastructure enabling substantial increases in capacity and efficiency, and additional gains in the baseline safety from HAVs.
- **Innovation:** *Lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation’s Transportation System.* This capability fills a gap recognized by industry and state and local governments ensure long-term public mobility.

- **Accountability:** *Serve the Nation with Reduced Regulatory Burden and Greater Efficiency, Effectiveness and Accountability.*

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Data Access and Exchanges

Program Description/Activities/ Objectives:

This research area will focus on cultivating the unified USDOT approach to Data. For example, the Work Zone Data Exchange project, which is co-managed by ITS JPO and FHWA, will help drive ubiquitous access to harmonized work zone data across the nation. As part of this mission to increase access to data through exchanges, this research area will also incubate and drive the adoption of modern technology best practices and consistent data access and evaluation across all USDOT-funded ITS research and deployment projects. This, in turn, will increase return on federal investment in research and demonstration projects and will accelerate multimodal, data-driven, trusted evaluations of potential safety, mobility, and other benefits to inform future policy and investment decisions.

ITS JPO will continue working through the crosscutting, multi-modal Center of Deployment Excellence (CoDE)⁹ to support consistent data access and evaluation for all USDOT-funded ITS research and demonstration projects. It will continue to operate in collaboration with the Office of the Chief Information Officers (OCIO's) Digital Transformation initiative and the Department's professional capacity building programs to help government program managers at the federal, state, and local level overseeing ITS projects effectively procure and manage projects that use innovative practices and methodologies. These methodologies include machine learning, agile development, and collaborative source code development which are foundational to the next generation of ITS projects and data management needed to evaluate the effectiveness of new ITS technologies.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation, Accountability, and Safety:

- **Innovation:** Accelerates incorporation of innovative practices and methodologies into the transportation enterprise that are foundational to the next generation of ITS projects, and accelerates deployment of innovative technologies in the transportation sector.
- **Accountability:** Improves oversight and return on investment of federally-funded research and demonstration projects.
- **Safety:** Supports evaluation of the safety benefits of new technologies in the transportation system and accelerates their safe deployment.

⁹ A "Center of Excellence" is generally described as a team (or entity) that provides leadership, best practices, research activities, and/or support/training in a specific focus area. A COE is a coordinating function that ensures that initiatives related to the topic are delivered consistently, well, and through standard processes and via subject matter experts. A COE also brings together difference disciplines to focus on one area and offer a comprehensive set of services, capabilities, and collaboration.

Cybersecurity for Intelligent Transportation Systems (ITS)

Program Description/Activities/ Objectives:

The overall objective for USDOT Cybersecurity research is to establish a transportation system that is resistant to, and resilient after cyber-attacks. The FY2020 research leads toward this goal by providing transportation professionals information to advance their awareness, knowledge, and participation in cyber monitoring, information sharing, and event response and recovery. Establishing a cyber culture, and the capacity to support cyber activities will take time to develop and continued vigilance to maintain. FY2021 research will continue to support the establishment of cyber-attack resilient transportation system by developing tools and equipment that increase the capacity of cyber transportation professions.

Advancing Assessment and Monitoring Capabilities: The FHWA in coordination with the ITS JPO will undertake research that will enhance cyber transportation professional's assessments and the monitoring of their systems. The assessment tool prototyped will be refined based on user input and updated in consultation with other cyber experts such as the National Institute for Science and Technology (NIST). In coordination with DHS, cyber exercises will be staged to test and evaluate interaction protocols and interfaces that would be used to monitor, report on, and recover from cyber events. Participants can gain experience and understanding under event simulated conditions. Other efforts will investigate the development of reference hardware that support monitoring communication to identify any anomalies that may be cyber related.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation:

- **Innovation:** The Cybersecurity research program facilitates the development and deployment of innovative practices and technologies to improve the safety and performance of the Nation's transportation system by managing the risk of cybersecurity. This targeted research will advance transportation sector assessment and monitoring capabilities and provide a working introduction to cyber coordination at the national level. The outputs of this research will help us move toward a cyber-attack resilient transportation systems building from prior research and pushing toward establishing effective cybersecurity practices and a sustainable cyber culture. The research will start aligning all levels of government and industry cooperatively and collaboratively protecting against and proactively responding to transportation related cyber events to maintain transportation resiliency.

Emerging /Enabling Technologies

Program Description/Activities/ Objectives:

The Emerging/Enabling Technology Program focuses on cultivating the next generation of transportation systems. As the scale of ITS increases, vehicle manufacturers, infrastructure providers, innovators, and entrepreneurs discover new opportunities to use technology and the data that will be generated. These technological advances, new functionality, new applications, new operational concepts, and disruptive innovations need to be tracked by the USDOT to determine technological, market, and demographic trends throughout the globe and across industries to seek, evaluate and sometimes incubate emerging capabilities that demonstrate the potential to transform transportation. As this happens, the USDOT will be positioned and engaged as a partner to guide research, development, and technology adoption in a systematic manner.

As an example, communications technologies are critical to the safe, secure, and efficient operations of transportation systems across the Nation. Transportation agencies have incorporated communications into their operational environments (i.e., field systems, management centers, and public fleets), and vehicle manufacturers are increasingly including multiples types of communications into their vehicles. While much research has been conducted with Wi-Fi, Dedicated Short Range Communications (DSRC), cellular, and satellite communications, there are emerging communications technologies such as Cellular-Vehicle-to-Everything (C-V2X) and 5G which could also have significant impacts on transportation systems. For example, the 5G capabilities are relatively undefined at this time and it is not clear if transportation needs and requirements are being taken into consideration. Cellular-V2X technology is being designed and developed by an industry led group as a potential replacement technology for DSRC.

The USDOT has an important role to play in pursuing research and analysis in the area of transportation technologies and their use of telecommunications to deliver public benefit. Federal leadership offers State and local agencies an opportunity to express their needs and have Federal telecommunications experts translate into use cases and requirements that cross market boundaries and ensure interoperability among vehicles, infrastructure equipment, and portable devices. State and local agencies tend not to have this type of expertise nor do they have the time or funding to pursue initiatives that are important but tangential to their daily operational mission.

ITS JPO research is conducted in coordination with five USDOT modal administrations (FHWA, FMCSA, FTA, MARAD, and NHTSA). Through multi-modal coordination, the ITS JPO works to avoid duplicative ITS work and to ensure the efficient allocation of ITS resources.

Artificial Intelligence (AI) has been identified as an area of prioritization, both for the benefits it promises and the opportunity to extend those benefits across modes within USDOT. Attention to AI has grown significantly over the last several years and has accelerated within the U.S. government after the release of the White House Executive Order, Maintaining American Leadership in Artificial Intelligence.

Meanwhile, efforts related to AI within USDOT have largely been conducted at the project level. As individual modes make investments in projects that leverage AI technologies, ITS JPO is uniquely positioned to help accelerate knowledge transfer and investment opportunities between these modes. The benefits realized by AI-enabled technologies in one particular mode might be extended across multiple modes, if coordinated properly.

Through this program, ITS JPO seeks to coordinate and synchronize AI research, development, and deployment activities across modes. ITS JPO will work with agency modes to identify AI applications that could be leveraged across the transportation system. A draft baseline report on Artificial Intelligence and Machine Learning¹⁰ canvassed artificial intelligence activities throughout USDOT and identified immediate impact areas for potential research coordination, such as computer vision, natural language processing, and decision support tools. ITS JPO will inventory AI-related projects already underway, explore possibilities for multi-modal coordination, as well as identify new areas of research where multiple modes can benefit from emerging technologies.

In our multi-modal coordinator capacity, the ITS JPO also supports operating administrations (OAs), for example, the FTA on Mobility on Demand (MOD). MOD research looks to address the needs of an increasingly complex and coordinated transportation environment and leverage the benefits of emerging mobility models and technologies. New mobility operational concepts, coupled with the right enabling technologies (e.g., trip planning platforms, integrated payment applications, real-time data processing, rapid communications, etc.) are enabling innovative multimodal service solutions like ride sharing, demand-responsive bus service, microtransit, small package and goods delivery, corridor optimization and other concepts of operation that are providing travelers with new and improved transportation options. These new service approaches are transforming current business and service models offering enormous potential for new forms of multimodal surface travel as well as partnerships between the public and private transportation sectors. MOD research explores these models, their implementation and the way they expand mobility and reduce operational costs.

In a collaborative environment, the OAs and the ITS JPO work together in a coordinated way to describe and identify potential operational service models (primarily the responsibility of the modes who know their sectors and constituencies), and explore enabling technologies that make the new service models possible – a particular strength of the ITS JPO.

Evaluation of the targeted research is also critical and an important outcome of the collaboration between the ITS JPO and the various OAs. By defining the key objectives and measurable parameters of the research projects, both ITS JPO and the modal agency can gauge the effectiveness of the new business and service models while also determining if the technology is performing, as it

¹⁰ *ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING BASELINING: Findings and Recommendations on Defining AI and Machine Learning for U.S. DOT and Identifying Current Activities, Future Priorities, and Needs.* Report to the Office of the Chief Information Officer and the Office of the Under Secretary for Transportation Policy Draft – December 6, 2018

should to support them. This two-leveled approach to evaluation is the most efficient way of monitoring practical research and demonstrations.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation:

- **Innovation:** This research priority aligns with the USDOT strategic goal of innovation by supporting the development and deployment of innovative technologies such as 5G communications.

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Complete Trip

Program Description/Activities/ Objectives:

Complete Trip is a joint USDOT initiative, co-led by FTA, FHWA, and the ITS JPO. It is exploring emerging technologies to enhance travel that includes opportunities for people with mobility challenges by providing travel opportunities that are seamlessly integrated into their daily lives. This seamless integration will be the “Complete Trips for All” effort highlighted by the USDOT Topical Research Area – Mobility Innovation working group. The Complete Trips for All vision leverages innovative technologies and facilitates public private partnerships to allow for a traveler-centric approach that improves mobility options for all travelers, including travelers with disabilities, travelers from rural areas, and lower income travelers. Internal to USDOT this effort will reach beyond the research team to include at a minimum the planning and civil rights disciplines. This multidisciplinary connection is critical to the success of the technology transfer efforts under this program area. This effort would also glean input from a range of interagency Federal partners including the Departments of Health and Human Services (DHHS), Labor (DOL), Defense (DOD), and others.

The USDOT Topical Research Area – Mobility Innovation working group is leading departmental efforts at defining what elements make up a complete trip, and working to identify gaps within related efforts. By working collaboratively, the USDOT will bridge the gap between current USDOT efforts and the realization of “Complete Trips for All”. The Complete Trip Program focuses on identifying opportunities to leverage and combine existing technologies into new and complete solutions that can be implemented to meet the needs of all travelers. The Accessible Transportation Technologies Research Initiative (ATTRI) helped define the complete trip and developed pieces of technology that would enable the complete trip. However, not all elements of the complete trip are fully defined or developed yet. The current ATCMTD Grants Program, the FTA’s Integrated Mobility Innovation (IMI) demonstration projects, and the ADS NOFO are providing the USDOT with real world deployments and demonstrations of emerging capabilities. By working closely with and aligning our research to support these Programs, the Complete Trip Program will avoid duplication, and will be able to ensure the USDOT is moving forward on improving mobility for all travelers.

The flagship effort will support the demonstration of “Complete Trips for All” for one or more of the travelers with disabilities, travelers from rural areas, and/or lower income travelers. An Independent Evaluation of the demonstration will run concurrent with the program.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation, Infrastructure and Safety:

- **Innovation:** The Program is developing innovative technology applications to enable an integrated multimodal environment that will provide fully accessible complete trip options to all travelers.

- **Infrastructure:** The Program is developing innovative technology applications to improve the mobility and accessibility of all travelers. Investments in technology infrastructure for transit stations, surface networks, and other infrastructure would enable the success and scalability of mobility and accessibility applications currently being prototyped and stimulate economic growth in the impacted regions.
- **Safety:** The Program is prototyping applications that provide safer and more reliable travel for all, including a safe intersection crossing application and remote monitoring and assistance applications for people with disabilities.

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Accelerating ITS Deployment

Program Description/Activities/ Objectives:

As new Intelligent Transportation Systems (ITS) technologies and systems evolve into market-ready products, the ITS Accelerating Deployment Program is addressing questions associated with adoption and deployment. The goal of the Accelerating Deployment Program is to speed up the transformation of ITS research and prototypes into market-ready technologies that are commercially viable and adopted by the transportation community. This Program provides communication and education support to facilitate awareness, understanding, acceptance, adoption, and deployment of ITS technologies across stakeholder groups; and ensures effective partnerships are fostered and developed at various levels – executive, program, and project. The ITS JPO seeks to spur adoption of technology, and help stakeholders and localities deploy maturing ITS systems. The Program provides knowledge transfer, and supports technical assistance, training, outreach, program evaluation, and other stakeholder engagement. The Program supports advancing ITS research, to initial adoption, and subsequently on to wider scale deployment in coordination with other stakeholders at the federal, state, regional and local levels.

Program Alignment with Strategic Goals:

This research priority aligns with the USDOT strategic goal for Innovation:

- **Innovation:** The Program supports the strategic goal of innovation by working to accelerate and expand the deployment of new technologies and practices across the Nation to enable safety benefits to be realized rapidly.

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)

Program Description/Activities/Objectives:

The ATCMTD is statutorily required in the FAST Act Section 6004, 23 U.S.C. 503(c)(4). The ITS JPO contributes a mandated percentage of funding through FHWA to annually satisfy the requirement. The ATCMTD grants are managed by FHWA.

The USDOT provides a total of \$60,000,000 for ATCMTD, with \$39,000,000 coming from FHWA and \$21,000,000 from the ITS JPO. The ITS JPO has a role in coordinating USDOT's overall ITS research program to ensure multimodal collaboration and avoid duplication of efforts. Staff from ITS JPO and modal agencies work jointly to accomplish the defined ITS research program and avoid duplication. FHWA administers the ATCMTD program.

The language provided here duplicates the language provided in the FHWA AMRP for consistency.

The Advanced Transportation and Congestion Management Technologies Deployment Initiative (ATCMTD) Program is intended to provide funding for eligible entities to develop model deployment sites for large scale implementation and operation of a diverse set of technologies in various geographic regions. As the Program is aimed at the rapid deployment of advanced technologies, limited expenditures for infrastructure construction is anticipated in grant application. The stated purpose is to reduce costs and improve return on investments; deliver environmental benefits through increased mobility; improve transportation system operations; improve safety; improve collection and dissemination of real-time information; monitor transportation assets; deliver economic benefits; and accelerate deployment of connected and autonomous vehicle technologies. Successful proposals will contain quantifiable system performance objectives, use innovative technologies and strategies, and a plan for long term operation and maintenance of the deployed technologies. Partnering between the private sector, public agencies, research institutions, technology leaders, and other transportation stakeholders is encouraged.

Program Alignment with Strategic Goals:

Goals for the ATCMTD Program are directly linked to USDOT's Strategic Goals and USDOT RD&T Critical Transportation Topics and include:

- Reduced costs and improved return on investments, including through the enhanced use of existing transportation capacity (Infrastructure)
- Delivery of environmental benefits that alleviate congestion and streamline traffic flow (Preserving the Environment)
- Measurement and improvement of the operational performance of the applicable transportation networks (Improving Mobility)

- Reduction in the number and severity of traffic crashes and an increase in driver, passenger, and pedestrian safety (Safety)
- Collection, dissemination, and use of real time transportation related information to improve mobility, reduce congestion, and provide for more efficient and accessible transportation, including access to safe, reliable, and affordable connections to employment, education, healthcare, freight facilities, and other services (Improving Mobility)
- Monitoring transportation assets to improve infrastructure management, reduce maintenance costs, prioritize investment decisions, and ensure a state of good repair (Improving Infrastructure)
- Delivery of economic benefits by reducing delays, improving system performance and throughput, and providing for the efficient and reliable movement of people, goods, and services (Improving Mobility)
- Accelerated deployment of vehicle-to-vehicle, vehicle-to-infrastructure, and automated vehicle applications, and autonomous vehicles and other advanced technologies (Innovation)
- Integration of advanced technologies into transportation system management and operations (Innovation)
- Demonstration, quantification, and evaluation of the impact of these advanced technologies, strategies, and applications towards improved safety, efficiency, and sustainable movement of people and goods (Safety, Improving Mobility)
- Reproducibility of successful systems and services for technology and knowledge transfer to other locations facing similar challenges (Innovation)

Small Business Innovation Research (SBIR)

Program Description/Activities/ Objectives:

The SBIR Program is a highly competitive, awards-based program that encourages domestic small businesses to engage in research and development addressing high priority research areas within USDOT. The SBIR Program favors research that has the potential for commercialization through products and applications sold to the private sector transportation industry, State DOTs, USDOT, or other federal agencies.

The Program is administered by the Volpe Transportation Center. The SBIR Program Office publishes one or two solicitations each fiscal year for proposals on specific research topics of interest to USDOT operating administrations, including the FHWA.

Planned 2021 SBIR Program activities, and their relationship to FY20 activities are presented in the table below.

Key FY 2021 SBIR Program Activities:

Activity	Relationship to FY20 Activities
Review and prioritize funding for the most promising SBIR innovations	Projects funded in FY20 will be reviewed and considered for further funding in FY21 to advance the technology or innovation toward commercialization.
Implement a formalized Technology Readiness Level (TRL) assessment program	Following a review of the FY19 TRL pilot program, a formalized, on-going program will be implemented.

Program Alignment with Strategic Goals:

The SBIR Program solicits research and technology topics from all FHWA R&T offices annually, including the ITS Joint Program Office. Topics are selected based on the merit, suitability for the SBIR Program, as well as consideration of alignment with Agency and Departmental goals. As a result, the SBIR Program supports all of the FHWA R&T program offices and, by extension, all of the USDOT Strategic goals.

Additional Information About Planned FY 2021 SBIR Investments:

Activities	Others Conducting Research in this Area	Findings from Past Investment	Projected Delivery Date for Tangible Outcomes

Review and prioritize funding for the most promising SBIR innovations	N/A	The phased approach for funding SBIR projects has been shown to be successful at moving technologies toward commercialization	On-Going
Implement a formalized TRL assessment program	N/A	Other programs, including the FHWA EAR program, have noted beneficial impacts on the development of technologies through an independent assessment of technological maturity.	On-Going

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