United States Department of Transportation
Annual Modal Research Plans

Intelligent Transportation Systems Joint Program Office (ITS JPO)

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Table of Contents

Executive Summary

1. 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 the 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 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 **Vision** of the ITS JPO is to "Transform the way society moves." That vision is executed through our **Mission** to "Conduct research, development, and education activities to facilitate the adoption of information and communication technology to enable society to move more safely and efficiently." 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 agnostic 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 agnostic 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, and 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 mobility and safety 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 Accessible Transportation Technologies Research Initiative (ATTRI). 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.

In the near term, vehicles with various levels of driving automation systems that enter the market offer potentially new benefits in comfort, convenience, and affordable accessibility. There is a clear government role in 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." These vehicles will behave in a way that works best for their own travel needs without consideration for wider impacts to the transportation 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 as well as 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 efficiently and safely integrate these vehicles into the transportation system. USDOT has heard from stakeholders that access to data is a critical enabler for the safe deployment of AVs, while lack of data access could impede actions to accommodate AVs and may delay their introduction. This need is consistent across all modes of transportation, and within the many aspects of AV deployment in the USDOT research portfolio, including 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.

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 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 the cybersecurity risk of their ecosystems. *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. Federal leadership offers State and local agencies an opportunity to express their needs and have cybersecurity experts translate those 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. The research 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 such as the adaptation of the NIST Cybersecurity Framework for the transportation sector. The research will facilitate developing the capacity of our partners and 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.

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 community 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 communication technologies 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 translate use cases and requirements that can 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 such as 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, assist with purchasing decisions, and support procurement designs. As a result of technology transfer events provided by the ITS JPO, evaluators have identified a reassessment by State and local agencies of their infrastructure vulnerability to now include information technology and data management areas.

The ITS JPO maintains and evolves a reference system architecture and supports the development of ITS standards to enable efficient, safe and interoperable ITS deployments. In order to facilitate expedited safe, efficient and interoperable Nationwide – and preferably North American – implementation of ITS technologies, ITS JPO maintains and evolves system architecture toolsets as well as a reference ITS architecture with 130+ user services. ITS JPO cooperates with stakeholders to develop needed ITS 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 adoption of automation and connectivity technologies. ITS JPO works closely with the Office of the Assistant Secretary for Aviation and International Affairs (OST-X) to enable the use of U.S. architecture and standards products in other nations (notably, Brazil and Turkey), and to continue support of cross-border and North American interoperability efforts. The ITS JPO Automation Program's collaborative and multi-modal research portfolio provides cross-cutting support to the USDOT Research Priorities, including economic impact of regulatory reform, safety and performance based rules, improving the mobility of freight, feasibility of microtransit, 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.

The ITS for Underserved Communities 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 underserved communities. 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.

ITS JPO research efforts focuses on market failures and avoids research already being undertaken by private actors by constantly engaging with the transportation industry and maintaining ties with national and international practitioners. 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	ITS for Underserved Communities	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

Technology Transfer

Deployment and Research Technical Assistance

The ITS JPO 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 the 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	***Transportation System Users***
-Executives and General Managers	-Commercial Vehicles/Freight -General Public
Technical Development/Device	***Transportation Management***
-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 Center Operations -Transportation Operations/Traffic Engineers -ITS Project Manager -Transit Professionals
Policy and Planning	***Specialized Operations***
-Legal and Legislative -Planners -Public Safety Professionals	-Incident Management Operators -Maintenance Engineers -Safety Analysts/ Engineers

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

To ensure that these identified audiences are given the 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 JPO PCB Program receives information on educational and training needs and also as a distribution channel through which the PCB Program disseminates various ITS educational materials or training courses developed. The PCB Program will continue to enhance coordination efforts with all USDOT modal partners in FY2019. Through the implementation of the PCB Strategic Plan, the ITS JPO 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:

- 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 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 educational 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. Annual ITS University and Community College Workshops, 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. These activities 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 JPO PCB materials to presentations before other audiences further providing additional knowledge sharing.

During the first 15 years of the ITS JPO 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 and 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 the early months of 2018, the PCB Program presented information at two large industry events including 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, which had over 16,000

attendees, 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 assistance with interoperability. In 2018, the Connected Vehicle Pilot recipients 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 is essential for the safe, secure and efficient operation of the transportation system. 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. 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+ 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.

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 ITS evolves from primarily infrastructure systems – for example traffic signal coordination or ramp metering – 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, become part of the ITS system, multi-regional interoperability becomes a requirement rather than merely a benefit. Beyond interoperability, standards-based ITS deployments can facilitate more competitive procurement of ITS components and systems and incentivize innovation. Open, interoperable and secure systems will reduce life-cycle cost and increase performance.

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 current architecture reference and toolsets released in 2017 and updated in 2018, 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+ user 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 user services, (2) better adapting existing user 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 a high-level optional interface architecture between automated vehicles and

the infrastructure, (4) continuing to increase the level of detail in key architecture views including more detailed standards and profile recommendations based on results of internationally cooperative analyses, (5) continuing support of US implementation assistance, including enhanced outreach to the transportation planning community, and (6) 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 additional 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) completing development of an initial set of performance standards for connectivity services between vehicles and infrastructure (V2I), (2) identifying and initiating development of standards to support interoperable integration of automated driving systems with the infrastructure, (3) maintaining

and updating current ITS standards including adaptations to improve cybersecurity, (4) development efforts to fill ITS standards gaps identified by an internationally cooperative effort to identify architecture-wide standards recommendations, and (5) initiating testing of additional standards in the Center-to-Center (C2C) and Center-to-Field (C2F) family. 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 only when it is beneficial to US interests. The Programs have developed extensive cooperative relationships with SDOs (which tend to be international in their focus), 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 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 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 ITE and SAE International, as well as contractual means to directly engage in IEEE activity. For ITS architecture activity and standards testing and reference implementations, USDOT relies primarily on competitively awarded contracts and/or tasks. International cooperation is conducted via "twinning" and similar cooperative structures. 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 processes 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.

Evaluation / Performance Measurement

The ITS JPO engages in Evaluation/Performance Measurement in two ways:

1. The ITS JPO works with independent evaluators to assess the performance of individual demonstrations and/or deployment projects that the ITS JPO has invested in, as to ensure that the technologies, applications, and processes in these deployments performed as expected and achieved results; and
2. The ITS JPO collects benefits, costs and lessons learned data to maintain a longitudinal repository of information to assist deployers in their decision making, and conducts detailed surveys of ITS deployments across the nation in representative geographical areas 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 track the overall effectiveness of ITS deployment investments.

The ITS Deployment Evaluation Program is engaged in two areas of evaluation – (1) support for the conduct of independent evaluations of ITS JPO-funded model deployments, demonstrations, pilots, and other projects that use ITS JPO funds, including grants, and (2) tracking, reporting on, and analyzing the overall effectiveness and impact of the ITS JPO's research and deployment investments across the United States.

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.

An IE will be expected to work with the site's deployment team to develop a Performance Measurement Plan and Evaluation Support Plan, and develop its own plans to conduct evaluation of the deployment.

An IE is expected to produce a suite of activities and related deliverables that clearly articulate the approach to the following evaluation-related activities, that could include but are not limited to:

1. Conduct comprehensive assessment of specific articulated factors specific to the deployment site and project;
2. Apply quantitative and qualitative evaluation methodologies to conduct cost-benefit assessments of these deployment programs;
3. Assess user acceptance/satisfaction of deployment programs; document lessons learned, challenges and approaches for overcoming them;
4. Develop guidance documents on evaluation;
5. Conduct surveys of the site related to tracking technology deployment, benefit, costs, customer satisfaction, socio-economic variables, or other factors
6. Conduct national-level evaluation if applicable;
7. Evaluate the deployment program's effectiveness overall, including ROI (not only for the deployment, but also for USDOT); and
8. Support coordination with other deployment programs across all modes.

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.

With respect to supporting research and development activities across all Departmental modes and in support of the Department as a whole, IE activities can often include:

- Conducting data fusion, aggregation, storage, management, and leveraging of data and data streams;
- Refining and applying methodologies and tools identified in other deployment evaluations (as applicable) to evaluate and understand potential impacts of the current deployments under evaluation;
- Comparing and leveraging results, lessons learned, and relevant experiences at these other sites;
- Surveying sites to glean additional information;
- Comparing deployment and operational costs and benefits of the project compared to the benefits, costs, and savings the other projects provide;

- Comparing how differences in project site setup, finance, operation, management and other factors affect the site's ability to effectively meet the original performance measures/performance expectations projected in the deployment, including data to support comparisons on:
    - How the project helped address the Department's strategic priorities and performance goals;
    - The effect of measuring and improving transportation system performance through the deployment of advanced technologies;
    - The effectiveness of ITS; and
    - How best to measure the socio-economic/efficiency benefits of the systems deployed;
- Developing and documenting best practices and recommendations for future deployment strategies to optimize transportation efficiency and multimodal system performance.
- Developing guidance documents on evaluation, including data collection, and evaluation methodologies and best practices.

It is important to note that the ITS JPO also prefers to use an IE to maintain the absolute objectivity of the 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.

The second way the ITS Deployment Evaluation Program engages in performance measurement is to help determine the extent, effectiveness and benefits of deployed ITS across the nation, and ultimately, 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 the ITS Program activities and to allow for the continual refinement of the ITS Program's strategic plan and direction.

The overall objectives of this program 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.

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 website and published as an update 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.

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 and 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, and the cost/benefit/lessons learned databases themselves are also completely 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.

The 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 survey and actively seeking stakeholder input into new questions and topics. The program is also conducting its activities in very close cooperation with the ITS PCB work to leverage these partnerships and ensure continued value of these data resources.

The Program is gearing up to reexamine the IE aspect of deployment evaluation and integrate it far deeper into the ITS JPO research program overall, and especially with our modal partners and across the Department as a whole. In 2019, the focus of the ITS Deployment Evaluation Program will not only be to revamp and modernize how the JPO collects data on ITS deployments nationwide, but also how it brings all the elements of successful individual deployment evaluations together with its partners across the Department. The ITS JPO would like to work toward development of this integrated function, perhaps by creating a "Center of Excellence (COE),"[1] or something similar, to accomplish this function and 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.

The initial vision is to coordinate across the entire Department and with all modes to provide integrated and leveraged evaluation support, guidance, best practices and analysis to show quantitatively and qualitatively the ROI of ITS deployments and technologies to the nation and to the Department.

[1] 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.

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, this makes it difficult to parse differences in performance results.
- There is not yet a common set of best practices or guidance 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 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 KPIs.

The expectation is that all surface modes will participate/lead in the development, maintenance and technology transfer of the "core" elements, and for the Department's Office of the Chief Information Officer (OCIO) to play an important role. The effort is expected to mesh well with and bolster the performance-based approach of the Department overall.

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.

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 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.

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

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 purpose

The Fixing America's Surface Transportation Act (FAST Act) continues the ITS program, which provides for the research, development, and operational testing of ITS aimed at solving congestion and safety problems, improving operating efficiencies in transit and commercial vehicles, and reducing the environmental impact of growing travel demand. Guided by the required five-year ITS Strategic Plan, the program is currently focused on significantly reducing crashes through advanced safety systems based on interoperable wireless communications among surface transportation vehicles of all types, traffic signals, other infrastructure systems, pedestrians, wireless devices, and automated vehicle systems.

Statutory citations

FAST Act § 6002, 6005-6010; 23 U.S.C. 512-519

Funding features

Type of budget authority

Contract authority from the Highway Account of the Highway Trust Fund. Funds are available until expended. Funds are subject to the overall Federal-aid obligation limitation and the obligation limitation associated with these funds is available for four fiscal years. Funds are not transferrable except as otherwise provided in the FAST Act. [FAST Act § 6002(c)]

Set-asides

Of the total authorized for the ITS Program, the FAST Act requires USDOT to set aside an unspecified amount for each of FYs 2016-2020 as one component of the $60 million in funding for the Advanced Transportation and Congestion Management Technologies Deployment Program. [FAST Act § 6004]

Federal share

The Federal share of a project or activity carried out with funds authorized under section 6002 of the FAST Act shall be 80% unless expressly specified by the FAST Act (including amendments by the FAST Act) or otherwise determined by the Secretary. [FAST Act § 6002(c)(1)]

Eligible activities

The FAST Act continues without change the activities eligible under the ITS Program but limits the ability to use program funds for the construction of physical surface transportation infrastructure (see below).

Program features & Project selection

Freight-related program goal

The FAST Act adds to the ITS Program a new goal: enhancement of the national freight system and support to national freight policy goals. [FAST Act § 6005; 23 U.S.C. 514(a)(6)]

Research related to disruption of connected and automated vehicles

The FAST Act requires USDOT, under the ITS Program, to implement activities that assist in the development of cybersecurity research to help prevent hacking, spoofing, and disruption of connected and automated transportation vehicles. [FAST Act § 6006; 23 U.S.C. 514(b) (10)]

Infrastructure development

The FAST Act states that funds made available for operational tests of ITS under the ITS Program—

- shall be used primarily for the development of ITS infrastructure, equipment, and systems; and
- to the maximum extent practicable, shall not be used for the construction of physical surface transportation infrastructure unless the construction is incidental and critically necessary to the implementation of an ITS project. [FAST Act § 6010; 23 U.S.C. 519]

New High-Priority Research Projects for FY 2019:

1) Automation:

The development of Automated Vehicle (AV) technology is occurring at a rapid pace, with industry investing billions of dollars a year. Several states have enacted legislation regarding AVs, and testing is currently occurring on public roads across the country. Partially automated vehicles are already available in the market today and heavy vehicle automation technologies are approaching commercialization. The speeds of these developments are challenging our existing institutional frameworks and Federal investment is required to ensure the safe development and deployment of this technology.

Automation is a key component of the ITS JPO's *ITS Strategic Plan 2015-2019*. 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	Impact Assessment of Automated Vehicle Operations
Total Funding in FY19	$350,000
Period of Performance	2019-2020
AMRP Program	Automation

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

A clear understanding of the benefits and other impacts of automated vehicles is needed to reduce the likelihood of alarmist policy-making at the Federal, State or local level that would stifle innovation. Although we expect to leverage private sector research, this research should be funded by the government for the following reasons:

- 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. State and local governments are looking for USDOT leadership in this area.
- USDOT should be positioned to leverage major transportation deployment grants to develop a deeper and broader public understanding of AV impacts.
- Given that USDOT's mission to serve the public interest, USDOT-sponsored research will directly address the needs of public sector policy-makers, and may have more credibility with these policy-makers than privately funded research would.
- Most privately-funded research in this domain is commercially sensitive, so we rarely have access to detailed results. However, where appropriate, this research includes execution of agreements with private-sector researchers to share results as appropriate.

Who else is researching this issue?

The evaluation of research by others has increased the importance of assessing system impacts. Several other USDOT projects will produce data and methodologies relevant to

this work, in particular the connected/automated vehicle (C/AV) analysis modeling and simulation project, and the FHWA Cooperative Adaptive Cruise Control testing and workforce impacts research that is required in the 2018 Consolidated Appropriations Act. Academia and various think tanks are developing traffic models and simulations, making travel forecasts, and attempting to model longer-term socioeconomic impacts of automated vehicles.

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; and developed and tested preliminary models of travel behavior. Safety, vehicle operations, and socio-economic impacts (economy and jobs).

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. Our collaboration with Volvo Cars has given us exposure to their methodology for assessing safety impacts.
4. We have integrated a traffic simulation model (Vissim) with the Environmental Protection Agency (EPA) MOVES energy/emissions model, producing mobility/energy/emission results for several CACC freeway scenarios.
5. We have outlined impact mechanisms for auto ownership and vehicle/ride sharing, and are engaging with researchers in system dynamics on these topics. 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 and innovation goals for the Department. The research will provide USDOT with:

- Identification of important research by others, and how it can inform USDOT understanding and decision-making.
- Baseline crash scenarios, which will provide a rigorous foundation for analyzing the safety impacts of automated vehicle functions, thus enabling an improved estimate of the safety benefits of automation.
- Evaluation of vehicle operations models developed by others, which will improve our understanding of the highway capacity effects of connected and automated vehicles, and thus infrastructure needs.

- Access to ideas, data and methods from other researchers and automation field tests.

This research will provide USDOT with a better understanding of the expected impacts of automated vehicles, which will enable USDOT to foster innovation in a way that serves the public interest.

Alignment with DOT Strategic goals?

This research priority aligns with three of the DOT strategic goals:

- **Innovation:** quantitative evaluation and forecasting of system aspects can enable accelerated deployment of innovative AV technologies in the transportation sector.
- **Accountability:** improves USDOT ability to evaluation and ensure 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.

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

The ITS JPO expects to continue to partner with private sector firms and non-Federal public sector organizations for in-kind data and modeling technologies. We do not expect direct financial contribution from non-federal partners.

2) Data Access and Exchanges:

This research area will focus on enabling data access across the automated vehicle (AV) ecosystem by cultivating the unified USDOT approach to Data for AV Integration, and exploring the potential for similar approaches in other emerging ITS areas. 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 which AVs need to navigate safely. 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.

Research Project Name/Topic Area	Data for AV Integration
Total Funding in FY19	$2,500,000
Period of Performance	2019-2020
AMRP Program	Data Access and Exchanges

Why should we pursue (or invest in) this research?
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. Other emerging ITS areas such as shared mobility face similar challenges, and research focused on increasing access to data for AV integration can be applied across the ITS portfolio.
Who else is researching this issue?
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.
Have we invested in this topic in the past and what have we learned to date?
In the past three years, 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, and Advanced Transportation and Congestion Management Technologies Deployment Program, which have pushed the limits of current the 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.

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

ITS JPO proposes establishing a cross-cutting, multi-modal effort that would operate in collaboration with the 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 such as machine learning, agile development, and collaborative source code development that are foundational to the next generation of ITS projects. Activities would be conducted in formal collaboration with the modes, OCIO, OST-P, and OST-R and include:

- 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.
- At the end of this research project, 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.

Alignment with DOT Strategic goals?

This research priority aligns with three of the USDOT strategic goals:

- **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.

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

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

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 multiples 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 the transportation system. 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 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
Total Funding in FY19	$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?

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.

4) Cybersecurity for Intelligent Transportation Systems:

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.

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.

Research Project Name/Topic Area	NIST CSF Profile for ITS Deployments
Total Funding in FY19	$250,000
Period of Performance	2019-2020
AMRP Program	Cybersecurity for Intelligent Transportation Systems

Why should we pursue (or invest in) this research?
The research project will allow the ITS JPO to work with the experts from NIST to develop a customized profile of the NIST cybersecurity framework that can be utilized by ITS deployers to address the urgent security concerns of today's deployments while preparing for the needs of the next generation of deployments. This research project will analyze the cybersecurity needs of ITS deployments across the various modes of transportations. This project will also support OCIO and OST-P activities to develop a transportation-specific cybersecurity framework for the Department.
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 leverage the expertise and developments in these other sectors for ITS.
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. The biggest challenge to the ITS ecosystem is a result of increased value of ITS data and connectivity. Concerns about cybersecurity for ITS and traffic management deployments are related to both current technologies as well as 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. Because of this, there is a need to adapt the expertise and developments from other sectors for the ITS ecosystem.

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

ITS JPO proposes establishing a cross-cutting, multi-modal effort to develop a customized profile of the NIST cybersecurity framework for ITS deployments. Activities would be conducted in formal collaboration with the modes, OCIO, OST-P, and OST-R and include:

- **Baseline** – Developing a comprehensive baseline of ITS cybersecurity activities across the USDOT and analyze this baseline to identify the needs within individual modes as well as across the range of ITS deployments.
- **Profile Development** – Apply the CSF across all deployments of intelligent transportation systems to develop a common ITS profile.
- **Technology Transfer** – Support the technology transfer from other sectors that accelerate adoption of cybersecurity technologies within ITS deployments.

Alignment with DOT Strategic goals?

This research priority aligns with the USDOT strategic goal for the development of innovation for cybersecurity by developing modal cyber threat models for transportation critical infrastructure. This project also supports the strategy to encourage the adoption of the National Institute of Standards and Technology Cybersecurity Framework by transportation ecosystem stakeholders.

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 (ITS America, OmniAir) and public-sector organizations in a manner that provides technical contributions with a financial value. For instance:

- ITS JPO participated in a task force led by ITS America which generated a well-received summary report on cybersecurity issues in ITS.
- NIST supported the ITS JPO in applying their cybersecurity framework to deployments of connected vehicles and infrastructure.
- Deployers of connected vehicles and infrastructure agreed to meet with ITS JPO and NIST staff to describe the systems being deployed and help develop best practices for future deployments.

5) ITS for Underserved Communities:

The ITS for Underserved Communities 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. The program resources will be used to support defining the Complete Trips for All vision. Internal to USDOT, this effort will reach beyond the researchers 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. The ITS for Underserved Communities 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 ITS for Underserved Communities 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	ITS for Underserved Communities - Technical Support
Total Funding in FY19	$ 988,938
Period of Performance	2019-2020
AMRP Program	ITS for Underserved Communities

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

The ITS for Underserved Communities 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.

Who else is researching this issue?

On-going research into technologies and services for travelers with disabilities are being funded by the private and public sectors, as well as academia.

- **Federal Government:** The Program has partnered with several Federal agencies that are actively researching and developing accessible transportation technologies:
  - 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 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.

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

Ensure effective program planning and efficient program execution, assess and mitigate program-level risks associated with unexpected technical/schedule/budget issues. Coordinate activity among the federal team, site staff, evaluators, and other stakeholders. Technical support under this project will support ITS for Underserved, Complete Trip and related mobility innovation activities. Areas of technical support includes strategic program management and out-year budget planning, program roadmap development and maintenance, technical review of deployer/contractor deliverables, systems engineering/other deployment support, outreach coordination, federal team coordination, performance measurement and evaluation support/coordination, standards support, and procurement support.

Alignment with DOT Strategic goals?

This project supports the following near term and long term goals. Near-Term: Demonstrate complete trip for ITS for Underserved Communities 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.

Two High Priority projects that were completed in FY 2017 or FY 2018:

***1) CV Pilot Deployment Program*:** The CV Pilot Deployment Program will complete Phase 2 (Design, Test & Build) in three locations (New York City, Tampa and Wyoming) in FY18. These CV Pilot deployments utilize new forms of CV and mobile device data to improve multi-modal surface transportation system performance and enable enhanced performance-based systems management. In FY16, the three participating sites completed Phase 1 (Concept Development). Deliverables from Phase 1 were used to create a cooperative agreement that covered the remaining phases of the deployment: Phase 2 (Design/Build/Test) and Phase 3 (Operate and Maintain). The objective of Phase 2 is to demonstrate that their systems are operational, tested, and safe before moving on to Phase 3. In Phase 3, the sites will operate and maintain their deployments, report on performance against safety, mobility and other objectives, support independent evaluation, share lessons learned, and prepare to transition to a post-deployment phase maintaining successful aspects of their pilot deployment concept.

The CV Pilots aligns with the USDOT Strategic Goals of Innovation and Safety.

- Strategic Objective 1: 'Develop Innovation', the CV Pilots are serving as a national example of both how to coordinate large scale CV deployments as well as by providing best practices that advance the technology and promote safety and efficiency.
- Strategic Objective 2: 'Deployment of Innovation' the CV Pilots is accelerating and expanding the deployment of technologies, in this case CV research by actively promoting innovations that enhance the safety and performance of the Nation's transportation system. Documented lessons learned include the importance of interoperability, collaboration and the value of partnerships.
    - Near-Term: Demonstrate that early CV concepts 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.

All three Pilot sites are required to match at 20% the cost of Phase 2 and 3. The total cost of the CV Pilots, for all three Phases, is $44M. Phase 2 and 3 were funded at $38MM and 20% of that is $7.6MM.

Through a collaborative effort, the Connected Vehicle Pilot sites – New York City, Tampa, and Wyoming – worked with the USDOT to conduct an Interoperability Test at the Turner-Fairbank Highway Research Center (TFHRC) on June 25-28, 2018. The test of interoperability was conducted among connected vehicle devices from the three sites and multiple technology vendors as well as to

identify potential interoperability issues that may require resolution prior to the sites advancing to an operational phase of the CV Pilot Deployment Program later in 2018.

In total, 102 interoperability test runs were conducted for three test cases – Forward Collision Warning, Intersection Movement Assist, and Emergency Electronic Brake Lights. Results of the testing indicated successful transfer of messages between the six vehicles from five different vendors using two forms of communication. All devices used for the test were enrolled with a commercial security credential management system (SCMS).

2) 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.

For this reason, the USDOT partnered with the automotive industry and industry security experts through the Crash Avoidance Metrics Partnership (CAMP) to design and develop a state-of-the-art **Security Credential Management System proof-of-concept (SCMS POC)**. Authorized system participants use digital certificates issued by the SCMS POC to authenticate and validate the safety and mobility messages that form the foundation for connected vehicle technologies.

The purpose of this effort was to prove that a Public Key Infrastructure (PKI)-based security system was feasible, deployable, and scalable (up to 17 million devices), all of which were demonstrated through the research conducted in support of the SCMS POC. The proof-of-concept system was originally intended to operate up to five years in length (in support of the CV Pilot sites), but due to the successful transfer of the technology to the marketplace, viable commercial services have been established faster than anticipated. Therefore, the ongoing work related to the SCMS will focus on facilitating the establishment of a large-scale, National system, operated by private industry.

The successful build of the SCMS POC aligns with the USDOT Strategic Goals of Innovation and Safety:

- Strategic Objective 1: 'Develop Innovation', the SCMS POC utilizes a Public Key Infrastructure (PKI)-based approach that employs highly innovative methods of encryption and certificate management to facilitate trusted communication.

- Strategic Objective 2: 'Deployment of Innovation' through the lessons learned from the SCMS POC, deployment efforts are underway that leverage the technology developed from this effort. The design and build of the SCMS POC stimulated the marketing of new highway safety related technology that is now being serviced by private industry.

When the USDOT started this project, a clear path for establishing an industry-based security system did not exist. Today, there are three technology companies who are leveraging the technological lessons from the SCMS POC to provide commercial services to automotive companies

deploying V2X technology (General Motors, Toyota, Volkswagen), as well as two FHWA-funded deployments of V2X (ATCMTD grants & CV Pilots).

The technical and policy research from this effort provides government and private stakeholders with a detailed blueprint of several viable options for standing up a National-level SCMS. One promising path that USDOT will continue to explore is that of working with a private sector, multi-stakeholder entity that could serve as an SCMS Manager to deploy, govern, and coordinate operation of a fully operational V2X SCMS, in which USDOT would only need to play a limited role. The USDOT expects industry to take the lead on establishing the governing policies and procedures around the operations of the system.

The total cost of the research is $30 million (with $6 million non-federal dollars leveraged from CAMP).

Section 1 – Program Descriptions, FY 2019

FY 2019 RD&T Program Funding Details

RD&T Program Name	FY 2019 Pres. Budget ($000)	FY 2019 Basic ($000)	FY 2019 Applied ($000)	FY 2019 Development ($000)	FY 2019 Technology ($000)
Automation			$17,488		
Data Access and Exchanges			$11,761		
Cybersecurity for Intelligent Transportation Systems			$4,516		
Emerging/Enabling Technologies			$19,389		
ITS for Underserved Communities			$3,146		
Accelerating Deployment			$26,215		
Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)					$21,000
Small Business Innovation Research (SBIR)			$2,000		
ITS Program Support			$5,375		
Totals			**$89,890**		**$21,000**

FY 2019 amounts are authorized amounts prior to any "lop-off" being determined (approximately -7.5%)

FY 2019 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2019 Pres. Budget ($000)	SAFETY ($000)	INFRA-STRUCTURE ($000)	INNOVATION ($000)	ACCOUNT-ABILITY ($000)
Automation		$5,215		$10,338	$1,935
Data Access and Exchanges				$11,761	
Cybersecurity for Intelligent Transportation Systems				$4,516	
Emerging/Enabling Technologies				$19,389	
ITS for Underserved Communities				$3,146	
Accelerating Deployment				$26,215	
Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)				$21,000	
Small Business Innovation Research (SBIR)				$2,000	
ITS Program Support					$5,375
Totals		**$5,215**		**$98,365**	**$7,310**

FY 2019 amounts are authorized amounts prior to any "lop-off" being determined (approximately -7.5%)

Automation Program
Funding Request ($17,488,000)

Program Description/Activities:
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, decreased travel times, improved travel time reliability, multi-modal connectivity, 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 assurance, infrastructure interoperability, and policy analyses.

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:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

This research priority aligns with the USDOT strategic goals for safety, infrastructure, and innovation.

- **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 potential 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, 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 to ensure long-term public mobility.

Program Objectives:
As automated vehicles increasingly enter the broad transportation system, 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 assurance, infrastructure interoperability, and policy analyses, including:

Safety Assurance

- 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.
- Adverse weather conditions affect the performance of automated vehicles. ITS JPO will conduct research in how road weather conditions negatively affect the abilities of HAVs to operate safely. Outcomes will include actionable data and decision support results for infrastructure owner/operators and information providers.

Infrastructure 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 vehicles 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 and operations impacts of in-service truck platoon systems. We will also partner 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 safely operate in in work zones, around incidents, and to enable speed harmonization on freeways.

Policy Analyses

- A clear understanding of AV impacts, and how AV adoption will affect the public interest, is of great important 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.

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 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.
- FHWA – Connected Automated Research and Mobility Applications (CARMA) reusable software platform.
- ITS JPO and FHWA – Development and testing of cooperative adaptive cruise control (CACC), speed harmonization and land/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.

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.

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.

Technology Transfer (T2):
The Program ensures technology transfer to accelerate deployment through the Professional Capacity Building (PCB) efforts. PCB is the primary mechanism for educating the public sector's transportation workforce about ITS. The program will be supported by the ITS PCB Program that 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. Academic institutions have become an ever-increasing partner with the PCB Program, especially in an effort to train the future workforce in new disruptive transportation technologies and applications. The PCB Program holds workshops with representatives from University, Community College and Technical and Trade School programs to discuss how to best incorporate relevant topics into their curriculum and products the PCB Program can provide the instructors to aid in teaching on next generation technologies. The Program monitors and tracks attendance, participation levels and training course reviews. These performance reports are monitored within the ITS JPO.

Evaluation / Performance Measurement:
The ITS JPO engages in Evaluation/Performance Measurement in two ways:

1. The ITS JPO works with independent evaluators to assess the performance of individual demonstration and/or deployment projects that the ITS JPO has invested in as to ensure that the technologies, applications, and processes in these deployments performed as expected and achieved results; and
2. The ITS JPO collects benefits, costs, and lessons learned data to maintain a longitudinal repository of information to assist deployers in their decision making, and conducts detailed

surveys of ITS deployments across the nation in representative geographical areas 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 track the overall effectiveness of ITS deployment investments.

***Performance Measures**:*

- *Quantitative demonstrations of system performance benefits from cooperative automation applications.*
- *Complementary industry investments in cooperative automation research and development.*
- *Capability gap closed as public and private sectors support long-term investment in these technologies and systems.*

Tracking:

- *Assessment via ITS Deployment Tracking Survey(s).*

Data Access and Exchanges
Funding Request ($11,761,000)

Program Description/Activities:
This research area will focus on enabling data access across the automated vehicle (AV) ecosystem by cultivating a unified USDOT approach to Data for AV Integration, and exploring the potential for similar approaches in other emerging ITS areas. 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 which AVs need to navigate safely. 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.

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. Other emerging ITS areas such as shared mobility face similar challenges, and research focused on increasing access to data for AV integration can be applied across the ITS portfolio.

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:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

This research priority aligns with the USDOT strategic goals 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.

Program Objectives:
ITS JPO proposes establishing a crosscutting, multi-modal center of excellence[3] to support consistent data access and evaluation for all USDOT-funded ITS research and demonstration projects. It will 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. This collaboration will enable stakeholders to effectively procure and manage projects that use innovative practices and methodologies such as machine learning, agile development, and collaborative source code development that are foundational to the next generation of ITS projects and manage the data needed to evaluate the effectiveness of new ITS technologies. Activities would be conducted in formal collaboration with the USDOT 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.

- Convene multimodal stakeholders to refine our understanding of priorities for data exchange and appropriate federal role, and launce 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.

[3] 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.

- At the end of this research project, 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.

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[4] 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

[4] https://www.transportation.gov/sites/dot.gov/files/docs/Official%20DOT%20Public%20Access%20Plan.pdf

velocity data and require new approaches to data management and analysis that go beyond the current capabilities of these broader programs.

In the past three years, 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 would not have direct non-Federal financial contribution in year one, 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.

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.

Technology Transfer (T2):
The Program ensures technology transfer to accelerate deployment through the Professional Capacity Building (PCB) efforts. PCB is the primary mechanism for educating the public sector's transportation workforce about ITS. 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 ITS PCB Program has developed a number of data management live and on-demand training courses to support knowledge sharing and the transfer of best practices to a wide range of stakeholders. The PCB Program likewise brings deployers and operators of these data generating and data application systems together with agencies looking to do similar deployments to discuss their experiences (the events are known as Deployers' Roundtable). The Program monitors and tracks attendance, participation levels and training course reviews. These performance reports are monitored within the ITS JPO.

Evaluation / Performance Measurement:
The ITS JPO engages in Evaluation/Performance Measurement in two ways:

1. The ITS JPO works with independent evaluators to assess the performance of individual demonstration and/or deployment projects that the ITS JPO has invested in as to ensure that the technologies, applications, and processes in these deployments performed as expected and achieved results; and
2. The ITS JPO collects benefits, costs and lessons learned data to maintain a longitudinal repository of information to assist deployers in their decision making, and conducts detailed surveys of ITS deployments across the nation in representative geographical areas 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 track the overall effectiveness of ITS deployment investments.

Performance Measures:

- *Public and private sector invest in innovative data management technologies and practices.*
- *Quantitative assessment of* return on investment *(ROI).*
- *Quantitative assessment of safety benefits.*

Tracking*:*

- *Via the ITS Deployment Tracking Survey(s).*

Cybersecurity for Intelligent Transportation Systems (ITS)
Funding Request ($4,516,000)

Program Description/Activities:
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.

Presidential Executive Order 13800 (issued May 11, 2017) on Cybersecurity of Federal Networks and Critical Infrastructure holds heads of Departments accountable for managing the cybersecurity risk of their ecosystem. 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."

Furthermore, this research should be conducted by the ITS JPO because it is uniquely positioned to work across the USDOT modes to develop and coordinate multimodal projects that are central to this research, which includes 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, while eliminating "silo" activities.

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 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.

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:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

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

- **Innovation:** This research priority aligns with the USDOT strategic goal for the development of innovation for cybersecurity by developing modal cyber threat models for transportation critical infrastructure.

Program Objectives:
This research will allow the ITS sector to develop a strategic framework that addresses the urgent security concerns of today's systems while preparing for the needs of tomorrow. By 2028, this is expected to result in resilient Intelligent Transportation Systems that are designed, installed, operated, and maintained to survive a cyber-incident while sustaining critical functions. The work will be organized and conducted in a collaborative process with the modal administrations and validated with external stakeholders. It will encompass:

- Intelligent Transportation Systems
- Public and private sector assets and activities
- 10-year timeframe divided into near-, mid-, and long-term efforts
- Risk as a function of threat, vulnerability, and consequences consistent with the NIST Cybersecurity Framework (CSF)
- Prevention, detection, response, and recovery efforts
- Cyber disruptions caused by unintentional incidents, intentional cyber-attacks, and attacks against the cyber-physical interface

Achieving the vision is a sizable challenge. But as our understanding of ITS risks evolves, so too have the methods used in other sectors and industries to measure, assess, and manage risk. The following four research strategies are offered as a logical path forward for industry, government, and academia to realize and sustain the vision. Projects would be developed that support each of these four strategies.

- **Assess and Monitor Risk.** Continuous cyber risk monitoring of all ITS architecture levels and across cyber-physical domains is conducted by Transportation sector asset owners and operators.
- **Adapt and Implement Protective Measures to Reduce Risk Preferentially.** Next-generation ITS architectures provide "defense in depth" and employ components that are interoperable, extensible, and able to continue operating in a degraded condition during a cyber incident.
- **Manage Incidents.** Transportation sector stakeholders are able to mitigate a cyber incident as it unfolds, sustain critical operations during the incident, return to normal operations quickly, and derive lessons learned from incidents and changes in the Intelligent Transportation Systems environment.
- **Creating an Organizational Culture of Security.** Cybersecurity practices are reflexive and expected among all transportation sector stakeholders.

Research Collaboration Partners:
There is extensive research sponsored by the private sector and other Federal agencies including the National Institute of Standards and Technology (NIST), Department of Homeland Security (DHS) and the Department of Defense (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 leverage the expertise and developments in these other sectors for ITS.

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. 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 as well as legacy systems, coupled with the growing trend to integrate ITS deployments with other networks. This combination has introduced new threat categories which 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. Because of this, there is a need to adapt the expertise and developments from other sectors for the ITS ecosystem.

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

- ITS JPO has partnered with the Connected Vehicle Pilot sites to adapt the NIST CSF for connected vehicle environments. They have provided expertise from public and private firms on user requirements and countermeasures that are critical to establishing CSF guidance for the connected vehicle environment.

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.

Technology Transfer (T2):
The Program ensures technology transfer to accelerate deployment through the Professional Capacity Building (PCB) efforts. PCB is the primary mechanism for educating the public sector's transportation workforce about ITS. 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. These performance reports are monitored within the ITS JPO.

Evaluation / Performance Measurement:
The ITS JPO engages in Evaluation/Performance Measurement in two ways:

1. The ITS JPO works with independent evaluators to assess the performance of individual demonstration and/or deployment projects that the ITS JPO has invested in as to ensure that the technologies, applications, and processes in these deployments performed as expected and achieved results; and
2. The ITS JPO collects benefits, costs and lessons learned data to maintain a longitudinal repository of information to assist deployers in their decision making, and conducts detailed surveys of ITS deployments across the nation in representative geographical areas 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 track the overall effectiveness of ITS deployment investments.

Performance Measures:

- *Majority of ITS asset owners baseline their security posture using ITS specific metrics.*
- *Capabilities to evaluate the robustness and survivability of ITS assets are available.*
- *Incident reporting and information sharing guidance accepted and implemented.*
- *Cyber threats, vulnerabilities, mitigation strategies and incidents timely shared among appropriate ITS stakeholders.*

Tracking:

- *Via ITS Deployment Tracking Survey(s).*

Emerging /Enabling Technologies
Funding Request ($19,389,000)

Program Description/Activities:
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 the transportation system. 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 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.

Through multi-modal coordination the ITS JPO works to avoid duplicative ITS work and ensures the efficient allocation of ITS resources especially for emerging technologies. In our multi-modal coordinator capacity, the ITS JPO supports operating administrations (OAs), for example, the FTA on a major initiative such as 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 a 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 the ITS JPO and the modal agency can gauge the effectiveness of new business and service models while also determining if the technology is performing, as it should to support them. This two-leveled approach to evaluation is the most efficient way of monitoring practical research and demonstrations.

In 2016, the USDOT pledged $40 million to Columbus, Ohio as the winner of the Smart City Challenge (SCC). With this funding, Columbus was tasked to demonstrate how advanced technologies can be integrated into other operational areas within the city, utilizing advancements in Intelligent Transportation System (ITS), connected vehicles (CV), autonomous vehicles (AV), and electric vehicles (EV) to meet specific challenges, while integrating data from various sectors and sources to simultaneously power these technologies, and leverage the new information they provide. Community and customer engagement was present throughout the program, driving the requirements and outcomes for each project. The effort was proposed to reinforce the idea that the residents of Columbus were ultimately the owner and co-creator of the program. The program was intended to define what it means to be a “Smart City” and serve as a model for other cities wishing to fully integrate innovative technologies and community development that will be deployed in the program. The program includes eight projects grouped into three overarching themes: Enabling Technologies; Enhanced Human Services (EHS); and Emerging Technologies. The program also includes an Operating System meant to be the integral backbone and heart of all current and future smart city projects.

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:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic

Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

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.

Program Objectives:
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 their 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 next generation communications systems.

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 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 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.

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.

Technology Transfer (T2):
The Program ensures technology transfer to accelerate deployment through the Professional Capacity Building (PCB) efforts. PCB is the primary mechanism for educating the public sector's transportation workforce about ITS. 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 PCB Program has made a concerted effort over the past decade to further expand its reach to new types of stakeholders to ensure that those now included with the new technologies are included in the PCB trainings and other knowledge transfer efforts. Over the course of its two-decade existence, telecommunications has been a top cross-cutting topic for the ITS PCB Program. Educating the current and future workforce on the communications options available to utilize for emerging and enabling technologies, at varying levels of details, continues to be a key pursuit of the PCB Program. The Program monitors and tracks attendance, participation levels and training course reviews. These performance reports are monitored within the ITS JPO.

Evaluation / Performance Measurement:
The ITS JPO engages in Evaluation/Performance Measurement in two ways:

1. The ITS JPO works with independent evaluators to assess the performance of individual demonstration and/or deployment projects that the ITS JPO has invested in as to ensure that the technologies, applications, and processes in these deployments performed as expected and achieved results; and
2. The ITS JPO collects benefits, costs and lessons learned data to maintain a longitudinal repository of information to assist deployers in their decision making, and conducts detailed surveys of ITS deployments across the nation in representative geographical areas 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 track the overall effectiveness of ITS deployment investments.

***Performance Measure**:*

- *Deployment of innovative communications technologies.*

Tracking:

- *Via ITS Deployment Tracking Survey(s).*

ITS for Underserved Communities
Funding Request ($3,146,000)

Program Description/Activities:
The ITS for Underserved Communities 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. The program resources will be used to support defining the Complete Trips for All vision. Internal to USDOT this effort will reach beyond the researchers 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. The ITS for Underserved Communities 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 ITS for Underserved Communities Program will avoid duplication, and will be able to ensure the USDOT is moving forward on improving mobility for all travelers.

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:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

The mission of the program is to transform the mobility options for all travelers, including travelers with disabilities, travelers from rural areas, and lower income travelers, by providing the capability to reliably, safely, and independently plan and execute their travel. The program identifies, collaborates, coordinates, develops, and implements transformative solutions in advancing accessible transportation and independent mobility.

This research priority aligns with the USDOT strategic goals 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 people with mobility challenges by providing travel opportunities that are seamlessly integrated into their daily lives.

Program Objectives:
The lack of transportation options for all travelers, including travelers with disabilities, travelers in rural areas, and lower income travelers in transportation deserts is a persistent challenge for access to jobs, education, healthcare and other activities. The ITS for Underserved Communities 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 a 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 with 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.

This effort will develop criteria for demonstrating the “Complete Trip for All” for one or more of the travelers with disabilities, travelers from rural areas, and/or lower income travelers.

Research Collaboration Partners:
The Program is a collaborative effort co-led by FHWA, FTA and ITS JPO. 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.

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.

Technology Transfer (T2):
The Program ensures technology transfer to accelerate deployment through the Professional Capacity Building (PCB) efforts. PCB is the primary mechanism for educating the public sector's transportation workforce about ITS. 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. These performance reports are monitored within the ITS JPO.

Evaluation / Performance Measurement:
The ITS JPO engages in Evaluation/Performance Measurement in two ways:

3. The ITS JPO works with independent evaluators to assess the performance of individual demonstration and/or deployment projects that the ITS JPO has invested in as to ensure that the technologies, applications, and processes in these deployments performed as expected and achieved results; and
4. The ITS JPO collects benefits, costs and lessons learned data to maintain a longitudinal repository of information to assist deployers in their decision making, and conducts detailed surveys of ITS deployments across the nation in representative geographical areas 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 track the overall effectiveness of ITS deployment investments.

Performance Measures:

- *Majority of ITS asset owners baseline their security posture using ITS specific metrics.*
- *Capabilities to evaluate the robustness and survivability of ITS assets are available.*

- *Incident reporting and information sharing guidance accepted and implemented.*
- *Cyber threats, vulnerabilities, mitigation strategies and incidents timely shared among appropriate ITS stakeholders.*

Tracking:

- *Via ITS Deployment Tracking Survey(s).*

Accelerating Deployment
Funding Request ($26,215,000)

Program Description/Activities:
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 educational 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 key stake holders such as the FHWA's Vehicle to Infrastructure (V2I) Deployment as well as the joint American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), and ITS America (ITSA) effort to engage stakeholder through the V2I Deployment Coalition.
- 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 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.

As ITS evolves from primarily infrastructure systems – for example traffic signal coordination or ramp metering – towards a nationwide or preferably North American, complex "system of systems" including connected and automated vehicles, secure system-wide interoperability becomes far more critical. Incorporating vehicles via Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) – collectively Connected Vehicle (CV) - capabilities offers great promise to improve safety and mobility while reducing environmental impact. However, once vehicles, which can easily travel across North America, become part of the ITS system, multi-regional interoperability becomes a requirement rather than merely a benefit.

The ITS JPO supports interoperability via funding and program execution in cross-modal cooperation with FHWA on V2I deployment, NHTSA on V2V rulemaking, as well as, with other surface transportation modes and with state, local, international, industry and academic partners.

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.

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:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

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

- **Innovation:** The Program supports 'Innovation Strategic Objective 2: Deployment 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.

Program Objectives:
The objectives of the Accelerating Deployment Program are to define 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).

Research Collaboration Partners:
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 FY2019. 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.

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.

Technology Transfer (T2):
The Program ensures technology transfer to accelerate deployment through the Professional Capacity Building (PCB) efforts. PCB is the primary mechanism for educating the public sector's transportation workforce about ITS. 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 PCB Program has made a concerted effort over the past decade to further expand its reach to new types of stakeholders to ensure that those now included with the new technologies are included in the PCB trainings and other knowledge transfer efforts that will aid in accelerating deployments. The Program monitors and tracks attendance, participation levels and training course reviews. These performance reports are monitored within the ITS JPO.

Through its knowledge sharing and technology transfers of products, training, and peer events, the PCB Program seeks to speed the assimilation of the new technologies and systems into the existing transportation network. Interoperability, or lack thereof, of these new systems with legacy systems is a major deterrent to quick assimilation. The PCB Program provides many training products, including standards on-line modules and procurement courses, that strive to improve the implementer's knowledge, skills and abilities (KSAs) on how to best identify and overcome issues such as interoperability when deploying new technologies.

Evaluation / Performance Measurement:
The ITS JPO engages in Evaluation/Performance Measurement in two ways:

1. The ITS JPO works with independent evaluators to assess the performance of individual demonstration and/or deployment projects that the ITS JPO has invested in as to ensure that the technologies, applications, and processes in these deployments performed as expected and achieved results; and
2. The ITS JPO collects benefits, costs and lessons learned data to maintain a longitudinal repository of information to assist deployers in their decision making, and conducts detailed surveys of ITS deployments across the nation in representative geographical areas 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 track the overall effectiveness of ITS deployment investments.

***Performance Measures**:*

- *Deployment of innovative transportation technologies.*

Tracking:

- *Via ITS Deployment Tracking Survey(s).*

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)

Funding Request ($21,000,000)

Program Description/Activities:

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 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:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Infrastructure	Improving Infrastructure

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.

Program Objectives:

The USDOT's vision for the ATCMTD initiative is the deployment of advanced technologies and related strategies to address issues and challenges in safety, mobility, sustainability, economic vitality, and air quality that are confronted by transportation systems owners and operators. The advanced technologies are integrated into the routine functions of the location or jurisdiction, and play a critical role in helping agencies and the public address their challenges. Management systems within transportation and across other sectors (e.g., human services, energy, and logistics) share information and data to communicate between agencies and with the public. These management systems provide benefits by maximizing efficiencies based on the intelligent management of assets and the sharing of information using integrated technology solutions. The advanced technology solutions and the lessons learned from their deployment are used in other locations, scaled in scope and size, to increase successful deployments and provide widespread benefits to the public and agencies.

Although proposals are not limited to USDOT priorities, the Department is particularly interested in deployment programs and projects in the following Focus Areas:

- Multimodal Integrated Corridor Management (ICM): ICM is the coordination of individual transportation network operations of adjacent facilities across all government or other operations agencies that creates a unified, interconnected, and multimodal system capable of sharing cross-network travel management to safely and efficiently improve the movement of people and goods. All corridor transportation assets and information services (i.e., local, county, regional, State) are brought to bear when prevailing or predicted transportation conditions trigger alerts. Through an ICM approach, transportation agencies manage the corridor as a multimodal system and make operational and safety decisions for the benefit of the entire corridor. The USDOT is interested in increasing deployment of ICM.

- Installation of connected vehicle technologies at intersections and pedestrian crossing locations: Deployment of connected vehicle wireless communications technologies at intersections to enhance motorized and non-motorized traveler safety, or actively improve the management, operation, and maintenance of traffic signal systems through real-time data collection and signal control. Example technologies include vehicle-to-infrastructure (V2I) and vehicle-to-pedestrian (V2P) deployments, such as at intersections or midblock pedestrian crossings, to support activities and initiatives of the V2I Deployment Coalition and non-motorized traveler applications, or technologies to support automated traffic signal performance measures. Such technologies should provide information, notifications, and alerts in accessible formats to help all users navigate safely through intersections including providing contextual information for situational awareness and localization. The USDOT has been working to accelerate the implementation of technologies that advance these strategies.

- Unified fare collection and payment systems across transportation modes and jurisdictions: Technological advancements in payment systems allow convergence across both publicly-delivered and privately-delivered mobility services. However, field implementations have been achieved only sparingly and in small projects. Convergence will enhance consumer payment options and mode choices and forge partnerships among providers to achieve a seamless, accessible, and flexible transportation network across the Nation. USDOT is engaged in efforts that will assist in identifying technical, institutional, and policy solutions to achieve unified transportation payment systems.

- Freight Community System: A Freight Community System (sometimes called Port Community System) is an electronic platform that connects the multiple systems operated by a variety of organizations that make up a freight transportation community, including seaports, airports, rail yards, inland ports, and distribution centers. It is shared in the sense that it is set up, organized and used by firms in the same sector – in this case, a freight community – to provide a neutral and open electronic platform enabling an intelligent and secure exchange of information between public and private stakeholders to improve the

efficiency and competitive position of the ports' community(ies). It optimizes, manages, and automates smooth port and logistics processes through a single submission of data by connecting transport and logistics chains. This focus area is important to the departmental goal of integrating freight infrastructure within the surface transportation system, particularly maritime ports, while at the same time providing a platform to reduce the impacts of national freight movement on local communities.

- Technologies to support connected communities: Deployment of technologies for a multimodal transportation system provides Americans with safe, reliable, and affordable connections to employment, education, healthcare, and other essential services. Examples include dynamic ridesharing through the latest communications technologies and social network structures to bring drivers and riders together quickly and efficiently, technologies to mitigate the negative impacts of freight movement on communities, or technologies that support workforce development, particularly for disadvantaged groups, which include persons with visible and hidden disabilities and elderly individuals. These example technologies should consider the elements of universal design and inclusive information and communication technology solutions, and may include deployment of autonomous vehicles through geographically contained ridesharing pilot programs, including the benefits of the technology with groups that might otherwise have limited transportation options, such as older Americans who no longer drive or those with disabilities or no driver's license. The USDOT is interested in using advanced technologies to improve the public's connections to employment, education, healthcare, and other essential services.

- Infrastructure Maintenance, Monitoring, and Condition Assessment: Timely, accurate and efficient assessment of infrastructure condition is critical to effective infrastructure asset management. Current state-of-the-practice technologies for condition assessment represent a good start, but have a variety of limitations. Opportunities for advancement include: implementation of friction management programs founded on highway-speed friction testing; highway speed deflection monitoring for pavement structural evaluation; sensor systems for infrastructure condition monitoring; use of unmanned aerial systems (UAS) for condition inspection; development of holistic and virtual data visualization technologies; and advancement of bridge load rating technologies. Implementation of these emerging technologies will enable improved highway safety and more timely intervention to address structural deficiencies and infrastructure deterioration with relatively low-cost solutions.

- Rural technology deployments: Deployment of advanced technologies to enhance safety, mobility, or economic vitality. Example technologies include improved access to transportation services, corridor freight platooning, mobile work zone alerts, improved roadway weather management, improved emergency response services and traffic incident management, curve warning systems, or animal intrusion detection and warning. The USDOT is interested in geographically diverse application of technologies to include rural deployments.

The 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. 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.

Key FY19 Program activities are identified below:

Activity	**Period of Performance**	**Partners/Notes**
Selection of FY19 grant awards and timely implementation of projects	FY19 to project closeout	Work with grantees to ensure timely implementation of grant awards
Continue award of FY 18 grants and manage FY16, FY17, and FY18 projects	To project closeout (varies)	Work with grantees to ensure timely implementation of grant awards

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					

Acquisition/Assistance:

As a discretionary grant program, the technical review of grant applications and project selections by the Secretary may be considered acquisition methods. The technical review and project selection process is described in the annual Notice of Funding Opportunity (NOFO). The ATCMTD Program anticipates two sole source acquisitions with USDOT's Volpe Center for technical assistance in the application review process and annual report mandated by the FAST Act. Sole source acquisition is proposed because both these activities are inherently government functions. The technical assistance for the application review process is a single-year acquisition. The technical assistance for publishing the annual ATCMTD report is multi-year as the first report is due in May of 2020. As specified in Section 6004 of the FAST Act, the Federal share is up to 50% of the cost of the project. Leveraging of non-Federal funds above the 50% minimum is considered in the award selection process.

Technology Transfer (T2):

- Annual ATCMTD grant awardees are involved and are the primary beneficiaries. In addition, through publication of the USDOT annual report, information on the awards (e.g. best practices, etc. will be shared on a nationwide level). USDOT's first annual report is due May 2020.

- Technology transfer reports are not applicable, as ATCMTD is a discretionary grant program to deploy advanced technologies and related strategies to address issues and challenges in safety, mobility, sustainability, economic vitality, and air quality that are confronted by transportation systems owners and operators.

Key 2019 ATCMTD Program Outputs:

Program Objective	**Key 2019 Outputs**
Provide funding to develop model deployment sites for large scale implementation and operation of advanced congestion management technologies.	Selection of FY19 grant awards and timely implementation of projects

Evaluation / Performance Measurement:

Per 23 U.S.C. 503(c)(4)(F), not later than 1 year after receiving an ATCMTD grant, and each year thereafter, the recipient shall submit a report to the Secretary that describes:

i. Deployment and operational costs of the project compared to the benefits and savings the project provides; and

ii. How the project has met the original expectations projected in the deployment plan submitted with the application, such as:

a. data on how the project has helped reduce traffic crashes, congestion, costs, and other benefits of the deployed systems
b. data on the effect of measuring and improving transportation system performance through the deployment of advanced technologies
c. the effectiveness of providing real time integrated traffic, transit, and multimodal transportation information to the public to make informed travel decisions
d. lessons learned and recommendations for future deployment strategies to optimize transportation efficiency and multimodal system performance

This Program directly supports both the Infrastructure and Innovation objectives of the 2019-2022 FHWA Strategic Plan. The ATCMTD Program outputs enable our partners to maintain transportation networks mobility, which also directly backs Infrastructure Strategic Objective 3 (System Operations and Performance) and the related Alleviate Urban Congestion performance goal. This Program facilitates the deployment of advanced technologies solutions to maintain a more reliable transportation system under challenging environments in both urban and rural areas. Likewise, the Program promotes transportation systems management in a proactive, integrated, and effective manner to use existing transportation facilities more efficiently.

USDOT Strategic Objectives are provided next to the ATCMTD Program goals below.

- Reduced costs and improved return on investments, including through the enhanced use of existing transportation capacity (Infrastructure, Strategic Objective 1: Project Delivery, Planning, Environment, Funding and Finance)

- Delivery of environmental benefits that alleviate congestion and streamline traffic flow (Infrastructure, Strategic Objective 1: Project Delivery, Planning, Environment, Funding and Finance)
- Measurement and improvement of the operational performance of the applicable transportation networks (Infrastructure, Strategic Objective 3: System Operations and Performance)
- Reduction in the number and severity of traffic crashes and an increase in driver, passenger, and pedestrian safety (Safety, Strategic Objective 1: Systemic Safety Approach)
- 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 (Infrastructure, Strategic Objective 3: System Operations and Performance)
- Monitoring transportation assets to improve infrastructure management, reduce maintenance costs, prioritize investment decisions, and ensure a state of good repair (Infrastructure, Strategic Objective 2: Life Cycle and Preventive Maintenance)
- 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 (Infrastructure, Strategic Objective 4: Economic Competitiveness and Workforce)
- Accelerated deployment of vehicle-to-vehicle, vehicle-to-infrastructure, and automated vehicle applications, and autonomous vehicles and other advanced technologies (Innovation, Strategic Objective 2: Deployment of Innovation)
- Integration of advanced technologies into transportation system management and operations (Infrastructure, Strategic Objective 3: System Operations and Performance)
- 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 (Infrastructure, Strategic Objective 1: Project Delivery, Planning, Environment, Funding and Finance)
- Reproducibility of successful systems and services for technology and knowledge transfer to other locations facing similar challenges (Innovation, Strategic Objective 2: Deployment of Innovation)
- Trend data is not yet available. FY 2016 and 2017 grantees are just beginning to provide their quarterly reports (annual report deadlines have not yet occurred). This information will be published in the first U.S. DOT report to be published by May 2020.

Small Business Innovation Research (SBIR)

Funding Request ($2,000,000)

Program Description/Activities:

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.

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.

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting Safety
Innovation	Promoting Safety
Innovation	Improving Infrastructure
Innovation	Improving mobility

Innovation	Preserving the environment

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 FY19 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

Acquisition/Assistance:

The SBIR Program competitively awards contracts to small businesses through an annual or semi-annual solicitation, which is posted on the FedBizOpps.gov website. The SBIR Program does not utilize cooperative agreements or grants. All proposals are subject to review by a panel of technical experts. Small businesses may utilize internal or external funds to supplement the Federal contributions. The SBIR Program does not utilize sole source acquisitions.

Phase I projects are generally given a period-of-performance of 6 months. Phase II projects, which are optional, are generally given a period-of-performance of up to 2 years. The period-of-performance for Phase IIB projects, which are also optional, varies but is no more than 2 years.

Small businesses are able to solicit and contribute internal or external funds to supplement the Federal contribution, particularly during the Phase IIB phase. However, there is no requirement for matching funds.

Technology Transfer (T2):

Technology transfer in the SBIR Program is accomplished through the development of innovations and technologies by the small businesses. A primary goal of the SBIR Program is to provide funding to small businesses to develop innovations and technologies that have commercial value and meet a strategic need for the department. The intellectual property for the innovations and technologies resides with the small business and thus serves as the motivation for the business to bring it to market. As a result, the SBIR Program does not utilize the internal USDOT technology transfer tools used to promote and deploy other innovations.

Through the Commercialization Assistance Program, the USDOT SBIR Program provides commercialization services to the small businesses to provide market research, intellectual property protection assistance, and other consulting options to promote the commercial value and discovery of the innovations and technologies. Additionally, the SBIR Program is piloting a new Technology Readiness Level (TRL) assessment service for completed Phase II projects to provide an independent assessment of the maturity level of a particular technology.

Specific Program outputs anticipated in 2019 are identified below.

Program Objective	**Key 2019 Outputs**
Identify and fund technologies and innovations that have commercial value and support Agency and Departmental goals	Select Phase II and Phase IIB projects that show significant promise for commercialization and technology readiness
Pilot a Technology Readiness Level (TRL) program	Independent assessment of technology maturity to aid in identifying and funding promising technologies and provide the contractor with a review of technology development needs.

Evaluation / Performance Measurement:

The SBIR Program tracks the performance of innovations and technologies by implementing a phased funding approach. The objective of Phase I is to establish the technical merit, feasibility, and commercial potential of the proposed R/R&D efforts and to determine the quality of performance of the small business awardee organization prior to providing further Federal support in Phase II. The objective of Phase II is to continue the R/R&D efforts initiated in Phase I. Funding is based on the results achieved in Phase I and the scientific and technical merit and commercial potential of the project proposed in Phase II. Only Phase I awardees are eligible for a Phase II award. A Phase II awardee may receive one additional, sequential Phase II award to continue the work of an initial Phase II award. These awards are referred to as Phase IIB awards. The intent of the Phase IIB awards is to advance and/or accelerate Phase II SBIR funded technologies towards commercialization. For each phase, a technical proposal and cost estimate is required from the contractor, which is evaluated by a panel of technical experts to determine the feasibility,

commercial value, and technological maturity. Program performance is assessed primarily on the basis of project milestones.

Outputs of this Program are intended to directly support the USDOT strategic plan by supporting technologies and innovations that show commercial promise and technological maturity in pursuit of those goals.

Section 2 – Program Descriptions, FY 2020

Automation Program

Program Description/Activities:

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, increased multi-modal connectivity, improved transportation system efficiency and increased accessibility, particularly for persons with disabilities and the growing aging population. ITS JPO automation research will support the federal role in automation safety assurance, infrastructure interoperability, and policy analyses.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

- **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.
    - ***Performance Measure****: Quantitative demonstrations of system performance benefits from cooperative automation applications.*
    - ***Tracking:*** *Via ITS Deployment Tracking Survey(s).*
- **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.
    - ***Performance Measure:*** *Complementary industry investments in cooperative automation research and development.*
    - ***Tracking:*** *Via ITS Deployment Tracking Survey(s).*
- **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.
    - ***Performance Measure****: Capability gap closed as public and private sectors support long-term investment in these technologies and systems.*
    - ***Tracking****: Via ITS Deployment Tracking Survey(s).*

Data Access and Exchanges

Program Description/Activities:
This research area will focus on enabling data access across the automated vehicle (AV) ecosystem by cultivating the unified USDOT approach to Data for AV Integration, and exploring the potential for similar approaches in other emerging ITS areas. 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 which AVs need to navigate safely. 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.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

- **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.
    - ***Performance Measure:*** *Public and private sector invest in innovative data management technologies and practices.*
    - ***Tracking****: Via the ITS Deployment Tracking Survey(s).*
- **Accountability:** improves oversight and return on investment of federally-funded research and demonstration projects.
    - ***Performance measure:*** *Quantitative assessment of* return on investment *(ROI).*
    - ***Tracking****: Via ITS Deployment Tracking Survey(s).*
- **Safety:** supports evaluation of the safety benefits of new technologies in the transportation system and accelerates their safe deployment.
    - ***Performance Measure:*** *Quantitative assessment of safety benefits.*
    - ***Tracking****: Via ITS Deployment Tracking Survey(s).*

Cybersecurity for Intelligent Transportation Systems (ITS)

Program Description/Activities:

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.

Presidential Executive Order 13800 (issued May 11, 2017) on Cybersecurity of Federal Networks and Critical Infrastructure holds heads of Departments accountable for managing the 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 Cybersecurity Framework by transportation ecosystem stakeholders."

Furthermore, this research should be conducted by the ITS JPO because it is uniquely positioned to work across the USDOT modes and with their modal partners to develop and coordinate multimodal projects that are central to this research, which includes 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, while eliminating "silo" activities.

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 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.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

- **Innovation:** This research priority aligns with the USDOT strategic goal for the development of innovation for cybersecurity by developing modal cyber threat models for transportation critical infrastructure.
    - ***Performance Measures:***
        - *Majority of ITS asset owners baseline their security posture using ITS specific metrics.*

- *Capabilities to evaluate the robustness and survivability of ITS assets are available.*
- *Incident reporting and information sharing guidance accepted and implemented.*
- *Cyber threats, vulnerabilities, mitigation strategies and incidents timely shared among appropriate ITS stakeholders.*

- ***Tracking:*** *Via ITS Deployment Tracking Survey(s).*

Emerging /Enabling Technologies

Program Description/Activities:

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.

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 those needs 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.

Through multi-modal coordination the ITS JPO works to avoid duplicative ITS work and ensures the efficient allocation of ITS resources especially for emerging technologies. In our multi-modal coordinator capacity, the ITS JPO supports operating administrations (OAs), for example, the FTA on major initiative such as 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 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:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

- **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.
    - ***Performance Measure****: Deployment of innovative communications technologies.*
    - ***Tracking:*** *Via ITS Deployment Tracking Survey(s).*

ITS for Underserved Communities

Program Description/Activities:
The ITS for Underserved Communities 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 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 a "Complete Trips for All." The ITS for Underserved Communities 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 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 ITS for Underserved Communities 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 ITS for Underserved Communities 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 a 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 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.

Program Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

- **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.
  - ***Performance Measure:*** *Number of accessible transportation deployments*
  - ***Tracking:*** *Via ITS Deployment Tracking Survey(s).*
- **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.
  - ***Performance Measures****:*
    - *Industry investment in accessible transportation*
    - *State and Local government investment in accessible transportation*
    - *Assessment of effectiveness of complete trip deployments*
  - ***Tracking:*** *Via ITS Deployment Tracking Survey(s).*
- **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.
  - ***Performance Measures****:*
    - *State and Local government investment in accessible transportation*
    - *Assessment of effectiveness of complete trip deployments*
  - ***Tracking:*** *Via ITS Deployment Tracking Survey(s).*

Accelerating Deployment

Program Description/Activities:

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 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 key stake holders such as the FHWA's Vehicle to Infrastructure (V2I) Deployment as well as the joint American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), and ITS America (ITSA) effort to engage stakeholder through the V2I Deployment Coalition.
- 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 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 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.

As ITS evolves from primarily infrastructure systems – for example traffic signal coordination or ramp metering – towards a nationwide or preferably North American, complex "system of systems" including connected and automated vehicles, secure system-wide interoperability becomes far more critical. Incorporating vehicles via Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) – collectively Connected Vehicle (CV) - capabilities offers great promise to improve safety and mobility while reducing environmental impact. However, once vehicles, which can easily travel across North America, become part of the ITS system, multi-regional interoperability becomes a requirement rather than merely a benefit.

The ITS JPO supports interoperability via funding and program execution in cross-modal cooperation with FHWA on V2I deployment, NHTSA on V2V rulemaking, as well as, with other surface transportation modes and with state, local, international, industry and academic partners.

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 Alignment with Strategic Goals:

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

- **Innovation:** The Program supports 'Innovation Strategic Objective 2: Deployment 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.
    - ***Performance Measure****: Deployment of innovative technologies.*
    - ***Tracking:*** *Via ITS Deployment Tracking Survey(s).*

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)

Program Description/Activities:

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 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.

Key FY20 ATCMTD Program Activities

Activity	**Relationship to FY19 Activities**
Selection of FY20 grant awards and timely implementation of projects	Continuation of the Program with new funding opportunity
Continue award of FY 19 grants and manage FY16, FY17, FY18, and FY19 projects	Implementation of the ATCMTD Program for FY16 – FY20

Program Alignment with Strategic Goals:

DOT Strategic Goal	**DOT RD&T Critical Transportation Topic**
Safety	Promoting Safety
Infrastructure	Improving Infrastructure
Innovation	Improving mobility

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)

Per the FAST Act, awards have been made for FY 2016 and 2017 and grantees are just beginning to provide their quarterly reports (annual report deadlines have not yet occurred). The ATCMTD Program is funded for FY 2016 – 2020.

Additional Information About Planned FY20 Structures R&T Investments

Activities	Others Conducting Research in this Area	Findings from Past Investment	Projected Delivery Date for Tangible Outcomes
N/A	N/A	N/A	FAST Act requires the Secretary to post on the DOT website a report on the effectiveness of grant recipients in meeting their projected deployment plans by May 2020.

Small Business Innovation Research (SBIR)

Program Description/Activities:

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 2020 SBIR Program activities and their relationship to FY19 activities are presented in the table below.

Key FY20 SBIR Program Activities:

Activity	**Relationship to FY19 Activities**
Review and prioritize funding for the most promising SBIR innovations	Projects funded in FY19 will be reviewed and considered for further funding in FY20 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.

DOT Strategic Goal	**DOT RD&T Critical Transportation Topic**
Safety	Promoting Safety
Innovation	Promoting Safety
Innovation	Improving Infrastructure
Innovation	Improving mobility

Innovation	Preserving the environment

Additional Information About Planned FY20 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