U.S. Department of Transportation

Office of the Secretary of Transportation

Deputy Assistant Secretary for Research and Technology

1200 New Jersey Avenue, S.E.
Washington, DC 20590

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TO: Dr. Michael Walsh, Technology Partnerships Office
National Institute of Standards and Technology

FROM: Diana Furchtgott-Roth DFR
Deputy Assistant Secretary for Research and Technology

SUBJECT: Fiscal Year 2019 Technology Transfer (T2) Annual Summary Report

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Every year, the Department of Commerce (DOC) submits a Federal Laboratory T2 Fiscal Year Summary Report to the President and the Congress in accordance with 15 U.S.C. 3710(g)(2). The report summarizes the implementation of technology transfer authorities established by the Technology Transfer Commercialization Act of 2000 (Pub. L. 106-404) and other legislation.

This report summarizes U.S. DOT's information for DOC's Fiscal Year 2019 Summary Report.

Please submit questions pertaining to this report to Santiago Navarro at Santiago.Navarro@dot.gov or 202-366-0849.

Attachment:

Fiscal Year 2019 Technology Transfer (T2) Annual Summary Report

U.S. Department of Transportation

Office of the Assistant Secretary for Research and Technology

Annual Technology Transfer Report

FY 2019

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Introduction

The U.S. Department of Transportation (U.S. DOT) is the Federal steward of the Nation's transportation system. U.S. DOT consists of multiple modal operating administrations (OAs) that carry out mission-related research, development, and technology (RD&T) programs in support of their goals. U.S. DOT's Technology Transfer (T2) Program, which is housed in the Office of the Assistant Secretary for Research and Technology (OST-R), is responsible for coordinating, documenting, and supporting T2 activities across the Department. This report summarizes the implementation of technology transfer authorities established by the Technology Transfer Commercialization Act of 2000 (Pub. L. 106-404) and other legislation.

U.S. DOT continues to increase coordination and collaboration efforts among its OAs and Federal laboratories, as evidenced through the collection and submission of this T2 Annual Summary Report to U.S. DOT's budget examiner in the Office of Management and Budget. This report is also provided to the Department of Commerce's (DOC's) National Institute of Standards and Technology in support of the Commerce Secretary's Annual Summary Report to the President, the Congress, and to the U.S. Trade Representative on the status of technology transfer by Federal laboratories.

U.S. DOT defines T2 as the process by which the transportation community receives and applies the results of research through dissemination and deployment activities. U.S. DOT's current approach to T2 is diverse and unique to each mode of transportation. Each modal OA conducts mission-specific deployment activities tailored to its mode and type of research. U.S. DOT's annual T2 reports are available online here.

T2 activities are executed by U.S. DOT agencies and their research centers:

- Federal Aviation Administration (FAA): William J. Hughes Technical Center (WJHTC), Atlantic City, NJ, and Civil Aerospace Medical Institute, Oklahoma City, OK
- Federal Highway Administration (FHWA): Turner-Fairbank Highway Research Center (TFHRC), McLean, VA
- Office of the Assistant Secretary for Research and Technology (OST-R): John A. Volpe National Transportation Systems Center (Volpe Center), Cambridge, MA
- National Highway Traffic Safety Administration (NHTSA): Vehicle Research and Test Center (VRTC), East Liberty, OH
- Federal Railroad Administration (FRA): Transportation Technology Center, Pueblo, CO

More information about U.S. DOT's T2 activities and research centers is available on the following websites:

- FAA: https://www.faa.gov/go/techtran/
- FHWA: https://www.fhwa.dot.gov/innovation/ and https://www.fhwa.dot.gov/goshrp2
- OST-R: https://www.volpe.dot.gov/work-with-us/technology-transfer
- FRA: https://www.fra.dot.gov/Page/P0153

U.S. DOT Invention Disclosures, Patenting, Licensing, and Other Measures

The following tables provide data on U.S. DOT's T2 activities from Fiscal Year (FY) 2015 to FY 2019. These tables conform to the guidance that DOC has provided to Federal agencies. Tables 6 and 7 contain other metrics that U.S. DOT tracks.

Table 1. Invention disclosures and patents.

		FY15	FY16	FY17	FY18	FY19
	Invention Disclosures					
1	New inventions disclosed	0	0	3	12	2
	Patents					
2	Patent applications filed	5	0	7	0	2
3	Patents received	1	1	0	0	0
4	Foreign patents filed	0	0	0	0	0
5	Foreign patents received	0	0	0	0	0

Table 2. Income-bearing licenses.

		FY15	FY16	FY17	FY18	FY19
	Licenses					
6	Total active licenses	2	2	5	5	5
7	Total new licenses	1	2	1	1	0
	Income-Bearing Licenses					
8	Total active income-bearing licenses	2	2	5	6	5
9	New income-bearing licenses	0	0	1	1	0
10	Total active invention licenses	2	0	0	1	0
11	New invention licenses	0	0	0	0	0
12	Exclusive licenses	0	0	0	0	1
13	Partially exclusive licenses	0	0	0	0	0

		FY15	FY16	FY17	FY18	FY19
14	Non-exclusive licenses	2	2	5	5	4
	Note: FAA licenses are non-exclusive.					
	Elapsed Amount of Time to Grant Licenses					
15	Average (months)	N/A	N/A	N/A	N/A	N/A
16	Minimum (months)	N/A	N/A	N/A	N/A	N/A
17	Maximum (months)	N/A	N/A	N/A	N/A	N/A
	License Income					
18	Total license income	N/A	N/A	19.8	13.7	8.2
19	Total invention license income	N/A	N/A	N/A	0	0

Table 3. Licensing income.

		FY15	FY16	FY17	FY18	FY19
	Earned Royalty Income					
20	Earned royalty income from top 1% of licenses	N/A	N/A	N/A	0	0
21	Earned royalty income from top 5% of licenses	N/A	N/A	N/A	0	0
22	Earned royalty income from top 20% of licenses	N/A	N/A	N/A	0	0
23	Minimum earned royalty income	N/A	N/A	N/A	0	0
24	Maximum earned royalty income	N/A	N/A	N/A	0	0
25	Median earned royalty income	N/A	N/A	N/A	0	0
	Disposition of Earned Royalty Income ($ thousands)					
26	Earned royalty income received	$11.8	$15.3	$19.8	$13.1	8.2
27	Percent of earned royalty income distributed to inventors	42	32	33	37	25
28	Percent of earned royalty income distributed to the agency or laboratory	58	68	67	64	75
29	Licenses terminated for cause	0	0	0	0	0

Table 4. Cooperative research and development agreements.

		FY15	FY16	FY17	FY18	FY19
	Cooperative Research and Development Agreements (CRADAs)					
30	Active CRADAs	48	68	65	63	44
31	Newly executed CRADAs	9	22	6	7	10
32	Active CRADAs with small businesses involvement	11	12	12	11	8
33	Small businesses involved in active CRADAs	10	12	12	11	8
	Traditional CRADAs					
34	Active traditional CRADAs	48	62	66	63	43
35	Newly executed traditional CRADAs	9	22	6	7	10
	Non-traditional CRADAs					
36	Active non-traditional CRADAs	0	1	1	0	0
37	Newly executed non-traditional CRADAs	0	1	0	0	0

Table 5. Small businesses, startups, and young companies.

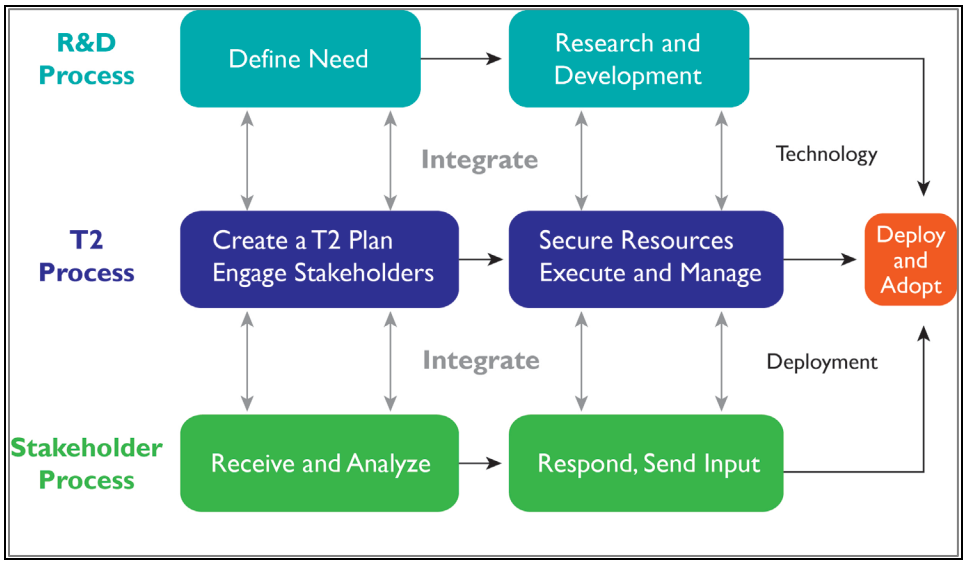
		FY15	FY16	FY17	FY18	FY19
	Others					
38	Small businesses supported	35	65	148	63	7
39	Startups and young companies supported	N/A	N/A	N/A	N/A	N/A

U.S. DOT's Efforts to Streamline Technology Transfer

U.S. DOT's Strategic Objective for Deployment of Innovation

Technology Transfer: Strengthen the technology transfer process to facilitate adoption and commercialization of market-ready transportation technologies.

The importance of T2 within U.S. DOT is reflected in its Strategic Plan for FY 2018 to FY 2022, which was released in February 2018. Citing Innovation as one of the four main strategic goals in the plan, U.S. DOT strives to lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the Nation's transportation system. Under that strategic goal, Deployment of Innovation is a key objective, and the Strategic Plan identifies T2 as one of the strategies to be used to accomplish that objective. Figure 1 shows the relationship of T2 to the Department's research and development (R&D) process and to stakeholder engagement.



Source: U.S. DOT.

Figure 1. Relationships among research and development (R&D), T2, and stakeholders.

The T2 activities of OST-R and the different OAs within the Department are described in more detail below.

The Office of the Assistant Secretary for Research and Technology

OST-R is responsible for coordinating, documenting, and supporting T2 activities across the Department. The T2 activities of OST-R focus on research collaboration, knowledge transfer, and information dissemination, which all lead to the practical application of research.

Specific efforts include:

- Improving public access to the results of research funded by U.S. DOT. As detailed further below, OST-R accomplishes this task through the National Transportation Library

(NTL), the Repository and Open Science Access Portal (ROSA P), and the U.S. DOT Research Hub.

- Tracking the progress of the Department's R&D and T2 activities through key performance indicators for research outcomes and their use, as well as through the collection and sharing of T2 success stories.

- Developing T2 training materials to help R&D personnel incorporate various T2 practices into their research programs.

- Aligning U.S. DOT's R&D budget, research, and T2 processes by incorporating T2 deliverables into R&D funding agreements.

- Coordinating the Department's response to the President's Management Agenda, Cross-Agency Priority Goal #14—Lab to Market—by creating and chairing a working group for T2 and Evaluation.

Highlights of specific programs or offices within OST-R that are crucial to its T2 efforts are provided below.

Bureau of Transportation Statistics

The Bureau of Transportation Statistics (BTS) is the preeminent source of statistics on commercial aviation, multimodal freight activity, and transportation economics. BTS provides context to decision makers and the public for understanding statistics on transportation. BTS assures the credibility of its products and services through rigorous analysis, transparent data quality, and independence from political influence. BTS promotes innovative methods of data collection, analysis, visualization, and dissemination to improve operational efficiency, to examine emerging topics, and to create relevant and timely information products that foster understanding of transportation and its transformational role in society. The BTS Director is by law the senior advisor to the Secretary of Transportation on data and statistics.

National Transportation Library

Administered by BTS, the National Transportation Library (NTL) serves as a central clearinghouse for transportation data and information of the Federal Government. Since 2013, NTL has been the centerpiece of U.S. DOT's response to the White House Office of Science & Technology Policy's memorandum titled, "Increasing Access to the Results of Federally Funded Scientific Research," by serving as the public repository and point of access for research funded by U.S. DOT. NTL also collects and shares transportation data and information produced by other agencies.

The NTL is the permanent, publicly accessible home for research publications from throughout the transportation community; the gateway to all DOT data; and the help line for the Congress, researchers, and the public for information about transportation

NTL has created an all-digital collection of transportation resources called ROSA P. The Department's Public Access Plan identifies this repository as the full-text repository for research funded by the Department. Content types found in ROSA P include text, links to websites, datasets, images, video, other multimedia, and maps.

Source: U.S. DOT.

Figure 2. The ROSA P logo.

Lab to Market

In his "President's Management Agenda," President Trump established Cross-Agency Priority (CAP) Goals to tackle critical government-wide challenges that cut across agencies. One of these CAP Goals is to "Improve Transfer of Federally Funded Technologies from Lab to Market." Within U.S. DOT, OST-R leads cross-modal efforts to collaborate with the White House's Office of Science and Technology Policy in support of the Lab-to-Market (L2M) CAP Goal. As part of this effort, OST-R has created a T2 Evaluation Working Group composed of representatives from the Department's OAs. The Working Group is assessing the effectiveness of past T2 efforts and developing recommendations for future T2 efforts.

Research, Development, and Technology

Housed in DOT's Office of the Secretary, the Office of the Assistant Secretary for Research and Technology (OST-R) plays a lead role in research coordination within the Department and with a wide range of national and international stakeholders. OST-R focuses on collecting, synthesizing, and disseminating information and statistics on the Department's RD&T activities and its products to ensure that all Open Science, Public Access, and other research funding and product transparency mandates are met.

Research Hub

The U.S. DOT's Research Hub is an online, searchable database and contains all of U.S. DOT's sponsored RD&T projects. The database acts as a central repository for information on active and recently completed projects from U.S. DOT's OAs. It provides a comprehensive account of the Department's research portfolio at the project level. The database also provides links to research reports and other products generated by completed projects.

The Fixing America's Surface Transportation (FAST) Act (Pub. L. 114-94) requires U.S. DOT to have a consolidated research database that lists the research abstracts, activities, and outputs of U.S. DOT's research portfolio at the project level. U.S. DOT has met this requirement by expanding the Research Hub database, adding new content, and improving functionality to provide the required comprehensive account of the Department's research.

University Transportation Centers

U.S. DOT invests in the future of transportation through its University Transportation Centers (UTC) Program, which awards and administers grants to consortia of colleges and universities across the United States. Each UTC is a consortium of two- and four-year colleges and

universities that come together to form a unique center of transportation excellence for transportation research, education and workforce development, and T2. In FY18, the Department implemented a T2 requirement for the UTCs. As a result, all UTC grant recipients have active T2 plans.

Annual Modal Research Plans

The FAST Act requires each OA and joint program office within the Department to submit an Annual Modal Research Plan (AMRP) to the Assistant Secretary for Research and Technology for review and approval. The plans are required to provide a comprehensive research plan for the upcoming fiscal year and a detailed outlook for the following fiscal year. The AMRP template that OST-R has provided to the OAs includes sections on T2/Deployment and Evaluation. In its AMRP, each OA must describe its planned research and T2 activities.

Volpe National Transportation Systems Center

Housed within OST-R, the John A. Volpe National Transportation Systems Center (Volpe Center) provides multidisciplinary and multimodal transportation expertise on behalf of U.S. DOT's OAs, U.S. DOT's Office of the Secretary, and external organizations. The Volpe Center provides OST-R with a broad range of assistance, including research and implementation, process analysis, process design, and communication. Within the Volpe Center, the Innovative Research Program Office is heavily involved in U.S. DOT's T2 activities by administering U.S. DOT's Small Business Innovation Research (SBIR) program and supporting the T2 Program Office in OST-R. Other offices within the Volpe Center support the T2 efforts of the OAs.

Small Business Innovation Research Program

U.S. DOT's SBIR program is a highly competitive award system that provides qualified domestic small businesses with opportunities to pursue research on, and develop innovative solutions to, our Nation's transportation challenges. The SBIR program favors research that has the potential for commercialization through products and applications sold to the private-sector transportation industry, State DOTs, U.S. DOT, or other Federal agencies. The SBIR Program also provides commercialization services to the small businesses—market research, intellectual property protection assistance, and consulting—to promote the commercial value of innovations and technologies. The Volpe Center administers the Department's SBIR program on behalf of the Office of the Secretary.

Source: U.S. DOT.

Figure 3. The logo of U.S. DOT's SBIR program.

Transportation Safety Institute (TSI)

For over 40 years, the Transportation Safety Institute (TSI) has provided training for safety professionals in Federal, state, and local government agencies, as well as those in private industry. TSI has courses for all modes of travel, covering the transport of either people or freight. With a small staff and adjunct faculty, TSI offers face-to-face instruction, live virtual courses, and web-based training to more than 25,000 people each year.

Federal Aviation Administration (FAA)

FAA supports multiple pathways to deployment and operational transition of research results and new technologies to advance aviation safety, efficiency, and environmental objectives. Many of these deployment pathways are created by research partnerships. FAA enhances and expands its R&D capabilities through partnerships with other government, industry, academic, and international organizations. By partnering with other organizations, FAA gains access to both internal and external innovators, promotes the transfer of FAA technologies to the private sector for other civil and commercial applications, and expands the U.S. technology base. Other T2 mechanisms used by FAA are described below.

Deployment of New Airport Technology to Improve Infrastructure (AIP)

Often helped by financial assistance grants from the FAA's Airport Improvement Program (AIP), airport operators design and implement capital improvements to their airport infrastructure. The FAA provides technical and engineering design guidance to airport operators by issuing advisory circulars and engineering specifications. Airport technology research is reflected in the engineering guidance and technical instructions contained in advisory circulars, as well as in airport compliance inspections and certification procedures. To facilitate the deployment of beneficial technologies resulting from airport technology research, the FAA's airport line of business can enable AIP grant eligibility for those technologies. The AIP grant promotes operator adoption and implementation, and thus serves as a deployment strategy for research products.

Cooperative Research and Development Agreements (CRADAs)

The Technology Transfer Program at FAA's WJHTC uses CRADAs to facilitate the operational transition of research products. Research transition support is an important characteristic of CRADAs because they provide an initial validation of the operational suitability and potential effectiveness of a particular technology solution. This initial validation increases the likelihood of eventual commercialization of the technology. In FY 2018, FAA had 56 active CRADAs, including 5 new CRADAs that were established during the fiscal year.

Centers of Excellence (COE)

FAA's Centers of Excellence (COE) program conducts and transfers research in specific mission-critical topics. The FAA establishes COEs through cooperative agreements with the Nation's premier universities, members, and affiliates to conduct focused R&D and related activities over a period of 5 to 10 years. The COE program facilitates collaboration and coordination between government, academia, and industry to advance aviation technologies and expand FAA research capabilities through matching contributions. Over the life of the program, the COE universities, with their non-Federal affiliates, have provided more than $300 million in matching contributions to augment FAA's research efforts. Through long-term cost-sharing activities, the FAA uses its RD&T resources while educating and training the next generation of aviation scientists and professionals.

Federal Highway Administration (FHWA)

The Federal Highway Administration (FHWA) has embraced a culture of innovation and actively supports and advances innovation across the entire breadth of its activities. FHWA has woven innovation into its organizational structure and business practices. For example, the Office of Innovative Program Delivery works across FHWA and with its partners to identify and promote innovations for implementation. In addition, FHWA's Office of Technical Services and its Division Offices in each State provide technical assistance to FHWA's State and local partners to deploy innovations. FHWA's Federal Lands Highway program works with Federal partners (e.g., National Park Service) to deploy innovations on transportation assets on Federal lands.

FHWA works through multiple programs and initiatives to transfer technological improvements and innovative practices to State and local DOTs, which are responsible for much of the actual construction and maintenance of the Nation's highways. These programs, some of which are described below, reach every State and thousands of stakeholders annually.

Across the agency, FHWA advances innovation through two primary methods: 1) the identification and development of innovative technologies and practices; and 2) the transfer of innovation at the Federal, State, and local levels. *FHWA devotes approximately 10 percent of its staff-years to conducting T2 activities.*

Highlights of FHWA's T2 activities include:

- **Office of Research, Development, and Technology (RD&T):** The FHWA's Office of RD&T is located at TFHRC, a federally owned and operated national research facility. The center houses more than 20 laboratories, data centers, and support facilities, and conducts applied and exploratory advanced research in vehicle-highway interaction, nanotechnology, and a host of other types of transportation research in safety, pavements, highway structures and bridges, human-centered systems, operations and intelligent transportation systems (ITS), and materials.

- **Every Day Counts (EDC):** The EDC program identifies and rapidly transfers and deploys proven-but-underutilized innovations to shorten the project delivery process, enhance roadway safety, reduce congestion, and improve environmental outcomes. Every two years, FHWA works with State, local, and tribal transportation departments to identify a new collection of innovations to champion. FHWA then provides technical assistance, training, and other resources to support the implementation and widespread adoption of the chosen innovations. Through FY19, there have been five EDC rounds. Since the inception of EDC, each State has used 19 or more of the 52 EDC innovations, and some States have adopted more than 40 of them. Many of these innovations have become mainstream practices across the country.

- **Advanced Transportation and Congestion Management Technologies Deployment Program (ATCMTD):** ATCMTD awards competitive grants to develop model deployment sites for the implementation of cutting-edge transportation technologies. In FY 2018, the program awarded 10 grants totaling $53.2 million for projects ranging from advanced real-time traveler information to integrated corridor management and vehicle

communications technologies. From FY 2016 to FY 2018, the program provided $163 million to 28 projects in 19 States. FHWA announced opened the competition for the fourth round of awards in June 2019.

- **Accelerated Innovation Deployment (AID) Demonstrations:** The AID Demonstration program provides incentive funding to State DOTs, Federal land management agencies, tribal governments, metropolitan planning organizations, and local governments to offset the risks associated with deployment of an innovation on a project. Funds are available to cover the full cost of implementation of an innovation on a project (up to $1 million) in areas such as planning, financing, operations, pavements, structures, materials, environment, and construction. Through FY 2019, FHWA has awarded a total of 92 AID Demonstration grants worth over $66 million.

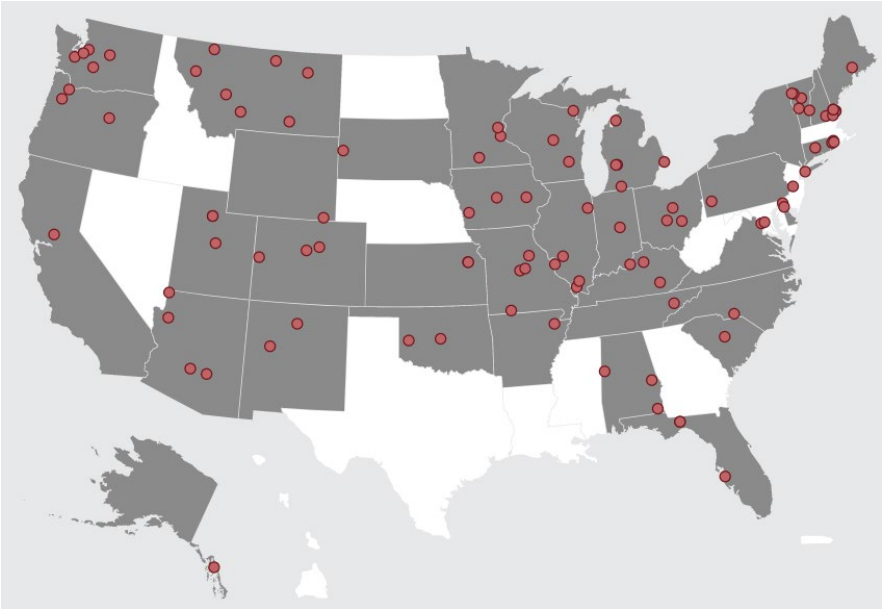


Figure 4. Map of locations of AID demonstration projects. Source: FHWA.

- **State Transportation Innovation Council (STIC) Incentive program:** FHWA fosters collaboration between stakeholders within the transportation community through the STICs, which bring together public and private transportation stakeholders in each State to evaluate innovations and spearhead their deployment. The STIC Incentive program makes available up to $100,000 per State each year to support or offset the costs of standardizing innovative practices in a State transportation agency or another public-sector STIC stakeholder.

Intelligent Transportation Systems Joint Program Office (ITS JPO)

The ITS Joint Program Office (ITS JPO) is responsible for conducting research on behalf of U.S. DOT and all major modes to advance transportation safety, mobility, and environmental sustainability through electronic and information technology applications, known as ITS. As new

ITS technologies and systems evolve into market-ready products, ITS JPO addresses issues associated with adoption and deployment. The office works closely with those deploying ITS technologies to ensure a smooth transition from initial adoption (seen as part of the overall R&D lifecycle) to widespread deployment. The main goal of the adoption phase is to improve market understanding of and commitment to the new technologies. ITS JPO's primary mechanism for educating the public sector's transportation workforce about ITS is the Professional Capacity Building (PCB) Program.

ITS Professional Capacity Building Program (ITS PCB)

The ITS PCB Program designs, develops, and delivers educational opportunities that spur the deployment of ITS technologies. These activities keep public and private entities informed about advances in ITS technologies and their applications for solving real-world transportation challenges. The ITS PCB Program works with the managers of U.S. DOT's ITS research programs to devise, coordinate, and implement outreach and technology transfer activities. The PCB Program also partners with professional associations, universities, and the training programs of U.S. DOT's modal administrations to engage the technical and organizational expertise needed to develop and deliver ITS learning. Some performance metrics of the ITS PCB's activities in FY 2017 and FY 2019 are shown in Table 8.

Table 6. Performance metrics for the ITS PCB Program, FY 2017, 2018, and 2019.

ITS PCB Activity	FY 2017	FY 2018	FY 2019
ITS PCB website	92,541 sessions (daily average: 254)	141,313 sessions (daily average: 387)	77,698 sessions (daily average: 213)
Webinars, online courses, and workshops	37 (3,032 attendees)	41 (3,972 attendees)	41 (4,512 attendees)
Archived and on-demand training content	46,042 users	42,131 users	25,372 users

Increasingly, the PCB Program partners with academic institutions to train the future workforce in new transportation technologies and applications. The program holds workshops with representatives from university, community college, and technical and trade school programs to discuss how best to incorporate relevant topics into curricula.

A newer offering of the PCB Program, known as the Connected Vehicle Deployment Technical Assistance Program, is designed to assist participants in U.S. DOT's three Connected Vehicle Pilots with interoperability. Recently, the Connected Vehicle Pilot recipients gathered at Turner-Fairbank Highway Research Center's (TFHRC) to test interoperability in staged scenarios on TFHRC's closed road course. More recently, the PCB Program worked with the CV Pilot sites to prepare a draft document with information and best practices for deploying onboard units (OBUs) in vehicles. Sharing this knowledge will assist future deployers in understanding some of the technical challenges related to deployment so that they can more easily deploy consistent and interoperable systems. The PCB Program is also offering a Help Desk that provides technical assistance during testing and deployments of connected and automated vehicles.

Federal Transit Administration (FTA)

The Federal Transit Administration's (FTA's) research activities are designed to respond to issues facing public transit systems today and in the future. FTA continues to focus on three broad research program areas: safety, infrastructure, and mobility innovation.

FTA prioritizes research spending on demonstration and deployment activities—usually approximately 70 percent of available research funds. This enables FTA to test promising research findings with public transit agencies. The evaluation of demonstration programs provides information that helps encourage transit agencies to implement potential solutions.

An essential part of FTA's national leadership role is to ensure that promising research findings and technologies benefit public transportation. FTA uses a variety of mechanisms to cultivate relationships with key parties and disseminate research results. Speakers share information about research findings at key industry events. FTA also publishes research reports and posts them on its website. FTA conducts webinars both in-house and through partner organizations. Additionally, in the mobility innovation research program, FTA funds the Shared-Use Mobility Center for a project called the Innovation and Knowledge Accelerator (IKA), which is a structured, supported learning and information exchange system. The IKA also includes an initiative to enable colleagues to exchange information via communities of practice. Similarly, FTA is phasing in a standardized approach for disseminating research results in the safety and infrastructure program areas.

Federal Railroad Administration (FRA)

The mission of FRA's RD&T program is to ensure the safe, efficient, and reliable movement of people and goods by rail through basic and applied research, and to develop innovations and solutions to rail transit problems Safety is U.S. DOT's primary strategic goal and the principal driver of FRA's RD&T program. FRA develops technology that its inspectors use to enforce safety regulations. Other technology developed by FRA is adopted by the railroad industry. In both cases, the agency funds research projects through all levels of technology readiness from basic principles to system deployment. Most funding goes toward moving projects from proof of concept to prototype demonstration in the railway environment. Suppliers to the rail industry usually take the prototype to implementation of a commercial product.

FRA encourages industry involvement in its R&D program and coordinates its technology development and deployment activities with the rail industry, in part through its relationship with the Association of American Railroads (AAR). FRA's R&D program is coordinated with the AAR's Strategic Research Initiatives to avoid duplication and to cosponsor research when appropriate. In addition, FRA's Transportation Technology Center in Pueblo, CO, is managed and maintained by a wholly owned subsidiary of AAR. This Center has nearly 50 miles of test track and numerous test facilities for conducting R&D. Since its dedication as the High-Speed Ground Test Center in 1971, the Center has played an important part in research, development, and testing of rail infrastructure and equipment.

Most of FRA's RD&T research results are described in in technical reports published on FRA's eLibrary. This makes the results accessible to the railroad industry and the American public. Some RD&T contracts include funding for vendors to disseminate the RD&T research results at various events. Information regarding RD&T's work can also be found on OST-R's Research Hub. In FY18, FRA RD&T amended its process and began publishing research to the NTL to ensure that research results are widely available and searchable. In FY19, FRA began formalizing its T2 methodology by piloting T2 plans throughout its divisions. RD&T created program-level T2 plans for each division which include business cases, operational needs, Technology Readiness Level assessments, resource strategies, risk assessments, communications/stakeholder engagement strategies, and integration strategies

National Highway Traffic Safety Administration (NHTSA)

Within NHTSA, the Office of Vehicle Safety Research supports U.S. DOT's and NHTSA's safety goals by conducting research and safety testing of motor vehicles and motor vehicle equipment. It also supports advanced vehicle safety technologies to address human behavioral concerns, including distracted and impaired driving. In addition, the Office conducts testing and research on the reliability and security of complex safety-critical electronic control systems, vehicle cybersecurity, and new and emerging technologies, including advanced driver assistance systems and automated vehicle technologies. NHTSA uses several strategies for deploying its research and technology results into practice. These range from technology demonstrations and field tests to consumer education programs. In 2019, NHTSA revamped its process for the dissemination of research products. It now includes dedicated personnel to ensure work products are placed into the U.S. DOT Research Hub and NTL Digital Library. Currently, NHTSA's reports are not available through these resources, but new personnel have started making the most recent work products available and will work to post older research products.

Technology Demonstrations and Field Tests

NHTSA has a long history of deploying new technology developments into the field to collect data on their real-world performance and consumer acceptance. One example is the Vehicle-to-Vehicle (V2V) Model Deployment in Ann Arbor, MI, where thousands of vehicles were equipped with dedicated short-range communications (DSRC) technology. The purpose of the deployment was to test how well V2V technology performed, how it supported safety applications, and how consumers received it. The findings from this deployment have given NHTSA important data to use when developing regulatory guidelines for V2V technology. Building on the success of the first deployment, from 2015 to 2018, the University of Michigan and its partners (with support from U.S. DOT) expanded the existing infrastructure footprint from northeast Ann Arbor to the entire 27-square miles of the City of Ann Arbor and have deployed thousands of additional connected vehicles. This new deployment, called the Ann Arbor Connected Vehicle Test Environment (AACVTE), is the world's largest operational, real-world deployment of connected vehicles and connected infrastructure.

Behavioral Safety Research

The purpose of the behavioral research conducted by NHTSA is to find ways to change the behavior of drivers and other roadway users to increase safe behavior (e.g., seat belt use) and reduce unsafe behaviors (e.g., alcohol- and drug-impaired driving). This research provides the scientific basis for State and community traffic safety programs. Behavioral safety research has contributed significantly to the widespread adoption of numerous programs proven to reduce crashes. Examples include the national Click It or Ticket program, the adoption of standardized field sobriety tests by law enforcement officers, and passage of primary seat belt and distracted-driving laws, the advancement of graduated driver licensing laws, a greater understanding of older-driver issues, and the development and testing of effective pedestrian and bicyclist safety programs..

In FY 2018, NHTSA completed the first phase of an initiative on fatigue in Emergency Medical Service (EMS) workers. The overall goal of this project is to develop, test, and disseminate evidence-based guidelines for fatigue risk management tailored to the EMS setting. As the project enters its second phase, researchers will test the impact of one or more evidence-based recommendations. In the third phase, the project team will develop a biomathematical model tailored to the scheduling of shifts for EMS personnel.

Vehicle Research and Test Center (VRTC)

Staff at the VRTC, NHTSA's in-house laboratory, conduct research and vehicle testing supporting NHTSA's mission to save lives, prevent injuries, and reduce traffic-related health care costs and other economic costs. Research and testing activities conducted at the VRTC support agency decisions and actions with respect to: new vehicle systems and issues; consumer information programs; development of test dummies; injury criteria development; and safety issues that require quick reaction or are sensitive in nature (e.g., defect investigations). The full range of testing and research capabilities available at VRTC allows the agency to study emerging safety issues more rapidly and provide benefits to the American public more quickly. In FY 2018, NHTSA initiated a series of postmortem human subject tests to evaluate occupant kinematics for non-standard driving postures anticipated in automated vehicles. In FY2019, NHTSA used the test data to update human body models to better reflect the kinematics of humans in reclined and rotated seating postures.

Federal Motor Carrier Safety Administration (FMCSA)

The primary mission of the Federal Motor Carrier Safety Administration (FMCSA) is to reduce crashes, injuries, and fatalities involving large trucks and buses. In support of that mission, FMCSA invests in the development, testing, and transfer of innovative technologies through the following programs and activities:

- **Research and Technology (R&T) Program:** FMCSA's R&T program develops the knowledge, practices, and technologies to improve enforcement technologies and the safety of commercial drivers, vehicles, and carriers. Each year, the R&T program sponsors and conducts numerous technology-focused projects designed to:

  - Improve the safety and efficiency of commercial motor vehicles (CMVs) through technological innovation and improvement;
  - Improve the technology used by enforcement officers when conducting roadside inspections and compliance reviews; and
  - Facilitate the training or education of CMV safety personnel.

- **Innovative Technology Deployment (ITD) Grant Program:** The ITD program is FMCSA's key mechanism for transferring proven enforcement technologies into operational systems for the States. Each year, ITD provides up to $20 million in funding for States to deploy, support, and maintain ITS and commercial vehicle information systems and networks. Grant priorities included deploying a work-zone and incident electronic notification system, deploying a CMV truck parking notification system, and deploying thermal imaging technology to detect inoperable, defective, or deficient brakes, tires, or exhaust systems that may cause unsafe conditions. One example of ITD efforts is the deployment of infrared screening tools that identify CMVs with unsafe brakes by measuring the temperature of wheels of CMVs in motion. As another example, ITD helped to implement a communications and data exchange mechanism to facilitate communicating safety and credentials within and among States, Federal agencies, and motor carriers. ITD also assisted in the implementation of cameras that can help identify noncompliant trucks by reading license plates and U.S. DOT numbers on trucks while they are traveling at highway speeds.
- **Automated CMV Research:** FMCSA conducts research to accelerate the testing and deployment of proven safety technologies (e.g., automatic emergency braking systems) and partners with industry associations, original equipment manufacturers, and motor carriers to promote the acceptance and adoption of these technologies. FMCSA also promotes safe pilot testing of automated CMVs and truck platoons to further validate the safety of these technologies and support their deployment.

Pipeline and Hazardous Materials Safety Administration (PHMSA)

The Pipeline and Hazardous Materials Safety Administration (PHMSA) sponsors R&D projects focused on providing near-term solutions that will increase the safety and reliability of the nation's pipelines and the transportation of hazardous materials. PHMSA has a consensus-based, collaborative RD&T program that is bringing new technology to market and is helping to strengthen pipeline integrity in the United States. PHMSA investment continues beyond proof of concept and concludes when the pre-commercial technology is effectively demonstrated in the intended operating environment.

Through its R&D awards, PHMSA mandates several steps for researchers to undertake to promote project results. Mandated actions include promoting commercialization at the end of the contract, such as by demonstrating a technology in front of pipeline operators, equipment vendors, standards organizations, and pipeline safety officials. PHMSA considers a demonstration to be just one stage in the T2 process, but it is a major milestone along the path to achieving an ultimate research goal.

In addition, all technical reports produced through PHMSA-sponsored research are promoted to decision makers and key entities via trade journals, public conferences, or other industry events. PHMSA also publishes pipeline research on the website for its research program, as well as in the U.S. DOT Research Hub and NTL Digital Library.

Maritime Administration (MARAD)

Through its Maritime Environmental and Technical Assistance (META) program, the Maritime Administration (MARAD) partners with Federal, State, and local agencies, the maritime industry, and academia to execute projects that provide all concerned parties with useful information and insight on maritime environmental issues. For the most part, this research is carried out using contracts or cooperative agreements with industry partners and academia. MARAD works closely with industry to identify research needs, formulate research initiatives to address specific issues, and transfer research findings to the industry. MARAD is also partnering with ITS JPO for joint T2 activities to assist ports in the planning, funding, and deployment of ITS applications.

Technology testing, validation, and verification is a fundamental part of the META program. These activities generate information about the costs, benefits, and performance of technologies, which assists industry in choosing among technology options and making decisions regarding capital investments. At the same time, META provides opportunities that are otherwise unavailable to innovators to perform R&D outside of the laboratory in real or near-real operations.

MARAD makes test results, reports, studies and industry guidelines available through its website, the Research Hub, and most partners' websites. Technical papers from the projects are regularly presented to journals, industry magazines, the Transportation Research Board, and other public venues.

Success Stories

The following success stories show how U.S. DOT-funded research results are being deployed in a wide range of transportation settings and are producing public benefits.

Federal Highway Administration (FHWA)

Unmanned Aircraft Systems Enhance Safety and Efficiency of Highway Agencies

An unmanned aircraft system (UAS) equipped with cameras can be an effective tool that reduces safety risks to inspectors working in hard-to-reach areas and lessens the burden on motorists by eliminating lane closures. It provides a high level of detail that can only be replicated using under-bridge inspection vehicles, while saving an average of 40 percent compared to traditional methods. A UAS is also useful in emergency response operations after roadway disturbances such as rockslides, avalanches, and floods and damage assessments following earthquakes, fires, and bridge hits. This relatively low-cost method enables agencies to obtain high-quality data quickly, leading to better-informed decisions.

> FHWA's Every Day Counts (EDC) initiative is a State-based model that accelerates deployment of proven-but-underutilized innovations. FHWA works with State transportation departments and other stakeholders to identify a new collection of innovations to champion every two years. The fifth round of EDC (EDC-5) is currently underway through the end of 2020.

UAS will benefit nearly all aspects of highway transportation by collecting high-quality data safely and efficiently at reduced costs. FHWA's EDC-5 team is promoting UAS technology, coupled with high-definition cameras and sensors, to improve data gathering for structural and construction inspections and to assist with emergency response.

The EDC-5 team is focused on five UAS applications for structural inspections: bridges, high-mast lighting, confined spaces, retaining walls, and tunnels. Structural inspection enhanced by UAS improves safety for the inspection team and the traveling public by reducing the need for temporary work zones. UAS can aid construction inspection tasks such as surveying, project scoping, and monitoring traffic in work zones. UAS allows for an overhead view of a project's progress and the development of three-dimensional (3D) models to document construction processes and assist in earthwork quantity measurement.

To date, 46 States have set goals to demonstrate, assess, or standardize the use of UAS in transportation applications. Minnesota DOT implemented UAS to support its bridge inspection program, particularly for bridges with difficult-to-access elements. Utah DOT (UDOT) uses UAS technology for rapid, high-quality data gathering. On its State Route 20 construction project, UDOT was the first agency to use a 3D-engineered model as the contract document. Combining UAS with 3D modeling and "e-Construction" tools (for inspection documentation) resulted in overall project savings of about $83,000, increased workforce productivity by 45 percent, and enabled UDOT to complete the project 25 days ahead of schedule.

Figure 5. UAS technology can help agencies quickly and inexpensively survey damage during emergencies.

Using Data-Driven Safety Analysis to Target Investments and Save Lives (DDSA)

Traditional safety analyses have relied on subjective or limited quantitative measures of safety performance. Instead, data-driven safety analysis (DDSA) applies modern software tools and methods to analyze crash, roadway, and traffic volume data. DDSA quantifies the expected safety impacts of each decision in the project development process, allowing agencies to make informed choices and optimize investments. The result is fewer serious injuries and fatal crashes.

The focus of FHWA's EDC initiative on DDSA has nearly doubled the number of States that use advanced tools to more accurately predict the impacts of highway projects on safety and target future investment decisions more effectively. DDSA became widespread during the third and fourth rounds of EDC, with 49 States attaining the demonstration, assessment, or institutionalized stages of implementation by December 2018. Previously, only 25 States used DDSA in project development.

Agencies like Colorado DOT (CDOT) are advancing DDSA at the State and local levels. CDOT conducted predictive analysis to estimate future safety performance of various transportation projects. In addition, CDOT, the Colorado Local Technical Assistance Program, and six local agencies participated in a pilot to develop local road safety plans (LRSPs). This effort helped the agencies identify locations at risk for crashes and select low-cost countermeasures. Colorado also hosted an LRSP peer exchange to share information learned in the pilot with other cities and counties across the State. CDOT is offering technical support for additional agencies to develop LRSPs.

Figure 6. Diagram explaining how data-driven safety analysis can result in fewer fatalities and serious injuries. Source: FHWA.

An early adopter of DDSA, Missouri DOT (MoDOT) used analysis tools to identify 31 locations with safety concerns as part of its Toward Zero Deaths strategy. Five design-build teams competed to offer MoDOT cost-effective countermeasures for high-risk areas based on Highway Safety Manual analyses. The winning bid included safety treatments and countermeasures that are expected to prevent 73 fatal and serious injury crashes over 10 years.

Reducing Rural Roadway Departures

Rural roadway departures make up a third (34 percent) of all U.S. traffic fatalities—nearly 12,000 annually or about 30 deaths *per day*. A fundamental challenge on rural roads is that the locations of roadway departure crashes change from year to year. This makes it challenging for State and local transportation agencies to choose the highest-risk locations to install countermeasures.

There are multiple analysis tools available to help agencies identify locations that are at the highest risk of future roadway departure crashes. Once agencies know which locations and corridors are at high risk of roadway departures, they can install countermeasures systemically across the network. Systemic analysis identifies safety countermeasures based on high-risk roadway features that correlate with severe crash types, rather than relying on crash data alone.

Through its EDC initiative, FHWA is encouraging State and local transportation agencies to conduct systemic analyses of rural roadway departures, develop safety action plans, and install proven countermeasures at the highest-risk locations. The countermeasures lower crash risk by keeping vehicles in their lanes and reducing the severity of crashes that do occur. As part of EDC-5, 32 State Transportation Innovation Councils have set goals to reduce rural roadway departures by demonstrating, assessing, or applying systemic safety countermeasures on rural roads as standard practice.

Figure 7. Roadway departure countermeasures applied at this curve include wider lane separation to prevent head-on collisions in the curve, raised pavement markers, widened shoulders, and a guardrail. Credit: FHWA.

In Washington State, 35 of 39 counties completed LRSPs to identify priorities for Highway Safety Improvement Program funding. Thurston County, WA, (county seat is Olympia—state capital) used FHWA's Systemic Safety Project Selection Tool to determine risk factors and prioritize rural safety investments. One area of concern targeted in the county's LRSP was curves, where 45 percent of fatal and serious injury crashes occurred from 2006 to 2010. The county implemented countermeasures such as improved signage, raised pavement markers, rumble strips, and guardrail delineation. As a result, between 2012 and 2016 Thurston County showed a 35 percent reduction in fatal and serious injury crashes at curves.

Ultra-High Performance Concrete

In the early 2000s, FHWA recognized the potential of ultra-high performance concrete (UHPC) to speed up bridge projects and decrease maintenance costs. The EDC UHPC team promoted UHPC for connecting prefabricated bridge elements (PBEs) by offering technical assistance and training to transportation agencies through peer exchanges, webinars, and workshops in 33 States. As a result, the number of agencies demonstrating, assessing, or using UHPC as a standard practice increased from 12 in January 2015 to 33 in December 2018.

In the third and fourth rounds of EDC, the use of UHPC quadrupled from 50 bridges to more than 200 structures nationwide. UHPC is used to create simple, strong, long-lasting connections for pre-fabricated bridge elements and it performs far better than conventional concrete. Pre-fabricated bridge elements are built offsite and then moved to a project location for installation. This innovative building practice shortens construction time, enhances safety, and provides superior durability.

The New York State Department of Transportation (NYSDOT) has used the technology more than any other agency, incorporating UHPC into 76 bridge projects. In addition to connecting deck panels, girders, beams, and other components with UHPC, NYSDOT pioneered the use of UHPC link slabs to connect bridge decks across expansion joint locations, improving overall bridge durability.

Iowa DOT's project in Buchanan County in 2016 was the first to apply a UHPC overlay to extend the life of a deteriorating bridge deck and minimize maintenance costs. New Jersey's Pulaski Skyway deck replacement featured precast deck panels connected with UHPC, stainless steel rebar, and a polyester concrete overlay to improve durability. Using 5,000 cubic yards of UHPC to connect 1 million square feet of deck panels, the project is the largest application of UHPC to date and serves as an example for other agencies.

Figure 8. Delaware DOT combined precast elements with UHPC connections and a UHPC overlay on an Accelerated Innovation Deployment Demonstration project.

The mechanical properties of UHPC allow planners and engineers to redesign common bridge connections that are easier and faster to install than standard construction practices. UHPC connections are also simple to fabricate and assemble, saving both time and money. Field-cast UHPC bridge elements offer robust connections that provide better long-term performance compared to conventional construction methods.

Federal Aviation Administration (FAA)

William J. Hughes Technical Center's Airframe Structural Beam Test (ABST)

Established in 2018 in collaboration with Boeing, the Airframe Beam Structural Test (ABST) fixture is one of the FAA's core capabilities for structural testing of aircraft wings and components under realistic flight conditions. Engineers use the data from ABST testing to address safety concerns and structural integrity issues.

The ABST is a national resource for research and development activities used by researchers to evaluate the design, certification, and continued airworthiness of airframe structures in current and future generation aircraft. The ABST fixture effectively leverages resources through partnerships with other government agencies, industry, and academia. It provides critical data to engineers in order to calibrate, verify, and validate methodologies used for fatigue and damage testing of aircraft structural components.

Figure 9. Engineers calibrate the ABST fixture to test an aircraft structural component. Source: Michael Gross.

William J. Hughes Technical Center's Cockpit Simulation Laboratory

To reduce the number of helicopter accidents, the FAA operates the S76-D helicopter simulator located at the William J. Hughes Technical Center in Atlantic City, NJ. Built from the front end of a decommissioned Sikorsky S-76 helicopter, the simulator provides realistic, high-fidelity modelling of the S76-D's aerodynamics, avionics, and controls. It also serves as a low-cost tool for conducting research to improve rotorcraft safety. Research projects using the S76-D simulator help develop safety-enhancing technologies (electronic flight bags, flight data monitoring systems, vision systems, augmented/virtual reality displays, etc.) that reduce the risks posed by bad weather, poor visibility, low altitude, and loss of control.

Figure 10. Helicopter pilots perform routine operations using the S76-D flight simulator. Source: Michael Gross.

Federal Transit Administration (FTA)

Mobility on Demand is a Vision for the Future (MOD)

Mobility on Demand (MOD) envisions a transportation system that is multimodal, integrated, automated, accessible, and connected. Emerging solutions such as bike and car sharing and on-demand bus services are providing travelers with flexible and personalized transportation options. MOD uses on-demand information, real-time data, and predictive analysis to provide travelers with choices that best serve their transportation needs and circumstances.

In April 2019, the Intelligent Transportation Society of America, a key FTA research partner on mobility innovation, officially launched its Mobility on Demand Alliance to help determine what the future of mobility should look like, with participation from both the public and private sectors.

FTA's MOD Sandbox Demonstration Program provides a venue through which integrated concepts and solutions–supported through local partnerships–are demonstrated in real-world settings. Two of MOD Sandbox grantees—TriMet and the Vermont Agency of Transportation—launched OpenTripPlanner apps that incorporate fixed and flexible-route/MOD modes. These options draw on international best practices and create shared mobility marketplaces within their apps in which bike/scooter-sharing and ride-sourcing are operated by the same company.

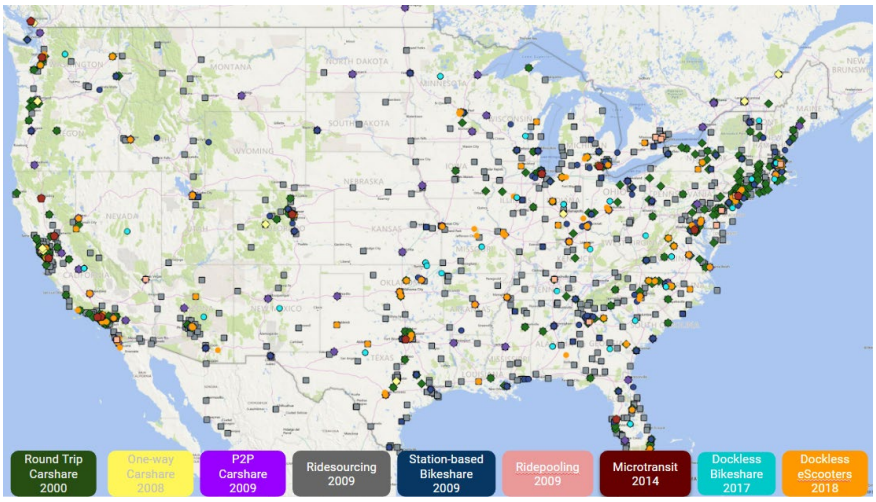


Figure 11. Shared mobility is being widely implemented across the U.S. Source: FTA.

While the shared mobility market has grown and local governments are taking a proactive regulatory role, expedited knowledge and information sharing are imperative as cities and transit agencies work to understand the evolving mobility marketplace. For example, the annual Shared Mobility Summit in March 2019 convened its largest gathering to date, with over 700 attendees representing shared mobility private operators; transit agencies; and Federal, State, and local governments. The MOD Learning Center website has had nearly 1,000 visitors since its launch in March 2019 at the Shared Mobility Summit. The high number of visitors to the MOD Learning Center website helps underscore the need for timely and accurate information on shared mobility so that jurisdictions and agencies can effectively plan for a shared mobility future.

Intelligent Transportation Systems Joint Program Office (ITS JPO)

Cars Successfully Communicate with Each Other in Tampa Hillsborough Expressway Authority's (THEA) Connected Vehicle Tests

In 2019, the Tampa Hillsborough Expressway Authority (THEA) successfully demonstrated two key elements of the connected vehicle technology being deployed in Tampa, FL as part of the THEA Connected Vehicle (CV) Pilot. During live testing on a closed section of the Lee Roy Selmon Expressway, eight vehicles fitted with connected vehicle technology received alerts that could assist in real-life collision avoidance. THEA also effectively used a roadside unit to upload connected vehicle information via wireless communication.

During the first test, eight vehicles equipped with onboard units traveled in a line behind a lead vehicle in rush hour conditions. The driver of the lead vehicle slammed on the brakes. In a real-world situation, a sudden stop could cause a costly, dangerous, and time-consuming pileup. During the test, every driver behind the hard-braking lead vehicle received an alert in time to take action and avoid a collision, thanks to a CV application called Emergency Electronic Brake Light.

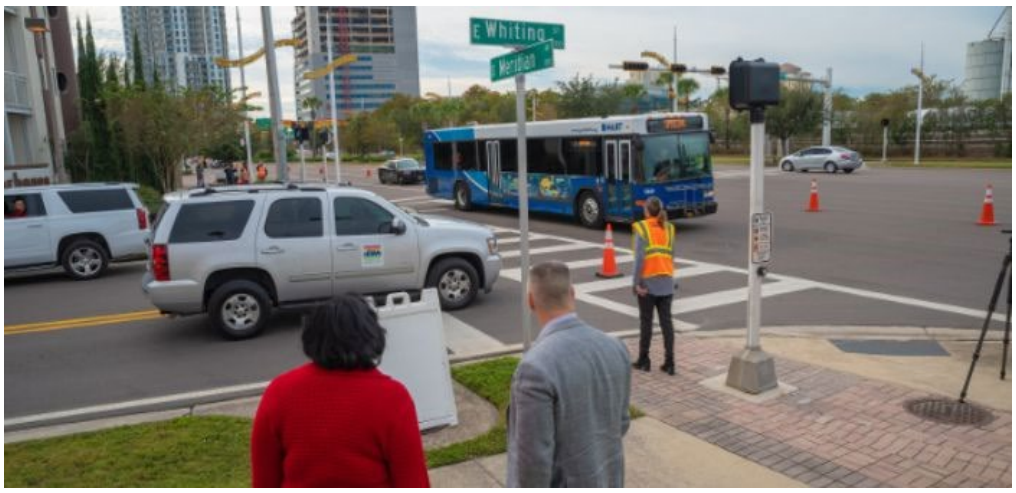


Figure 12. THEA staff observe the full-scale CV pilot conducted on a closed section of the Lee Roy Selmon Expressway. Source: THEA.

In the second CV test, a single roadside unit uploaded data from multiple cars traveling at 40 mph. THEA and its partners were pleased to learn the system can reliably collect data that will improve safety, enhance traffic flow, and help evaluate the effectiveness of CV technology.

The THEA CV Pilot Program installed more than 1,000 onboard units in the cars of area residents who volunteered to participate in the program, which is sponsored by U.S. DOT. Tampa is one of only three cities in the country to receive a grant from U.S. DOT to test CV technology and is the only site in the country to test this technology on private vehicles.

The success of the tests is a defining moment for the THEA CV Pilot Program and offers critical insight into how this innovative technology can improve safety conditions for Tampa drivers.

Federal Railroad Administration (FRA)

Railroaders' Guide to Healthy Sleep Website Project

The railroad industry involves safety-critical work and around-the-clock operations, placing demands on employees to perform during times that interrupt normal sleep-wake cycles. Railroaders who work unpredictable schedules have difficulty getting enough sleep, and when compared to the general population, are at increased risk for fatigue and sleep-related disorders. For train and engine employees in particular, the sedentary nature of their work is an additional known risk factor for sleep apnea.

The Federal Railroad Administration (FRA) launched the Railroaders' Guide to Healthy Sleep website in 2012 as a non-regulatory, educational resource for safety-critical rail employees. The website was created by the U.S. DOT Volpe Center in collaboration with experts in sleep science and health from the Harvard Medical School Division of Sleep Medicine—with railroad employees and their support networks in mind. The project team fully redesigned the website in 2015 in partnership with the railroad industry and

used best practices from educational technology and web design.

The website features articles, videos, illustrations, and interactive options aimed at increasing awareness of the importance of sleep for personal health and safe performance on the job. Tailored, proven behavioral strategies are provided to help individuals improve sleep habits, increase alertness while awake, and achieve a healthy work/life balance. Additional resources are available to help railroaders assess sleep habits and health and to download alertness scales, a sleep-wake diary, and a zip-code feature to locate nearby accredited sleep disorder specialists.

The project team employed real-time demonstrations, in-person promotion, and digital communications to targeted (self-selected) subscribers, and collected website use statistics. The main focus of the website is to promote good sleep habits for railroad employees, which can improve safety and health both on and off the job.

Figure 13. Railroaders' Guide to Healthy Sleep website. Source: FRA.

Acronyms and Abbreviations

AACVTE	Ann Arbor Connected Vehicle Test Environment
AAR	Association of American Railroads
ABST	Airframe Beam Structural Test
AID	Accelerated Innovation Deployment Demonstration
AIP	Airport Improvement Program
AMRP	Annual Modal Research Plan
ATCMTD	Advanced Transportation and Congestion Management Technologies Deployment
CAMI	Civil Aerospace Medical Institute
CAP	Cross-Agency Priority
CMV	Commercial motor vehicle
CDOT	Colorado DOT
COE	Center of Excellence
CRADA	Cooperative research and development agreement
CV	Connected vehicle
DDSA	Data-driven safety analysis
DOC	Department of Commerce
DOT	Department of Transportation
DSRC	Dedicated short-range communications
EDC	Every Day Counts
EMS	Emergency Medical Services
FAST Act	Fixing America's Surface Transportation Act
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FlexSim	Flexible Aircraft Cabin Simulator
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FY	Fiscal year
IKA	Innovation and knowledge accelerator

ITD	Innovative Technology Deployment program
ITS JPO	Intelligent Transportation Systems Joint Program Office
ITS	Intelligent transportation systems
ITS PCB	Intelligent Transportation Systems Professional Capacity Building Program
JPO	Joint Program Office
L2M	Lab-to-Market
LRSP	Local road safety plan
MARAD	Maritime Administration
META	Maritime Environmental and Technical Assistance
MoDOT	Missouri DOT
MOD	Mobility on demand
NHTSA	National Highway Traffic Safety Administration
NRL	Naval Research Laboratory
NTL	National Transportation Library
NYSDOT	New York State DOT
OA	Operating administration
OBU	On-board unit
OST-R	Office of the Assistant Secretary for Research and Technology
PBE	Prefabricated bridge element
PCB	Professional capacity building
PHMSA	Pipeline and Hazardous Material Safety Administration
R&D	Research and development
R&T	Research and technology
RD&T	Research, development, and technology
ROSA P	Repository and Open Science Access Portal
SBIR	Small Business Innovation Research Program
STIC	State Transportation Innovation Council
T2	Technology transfer
TFHRC	Turner-Fairbank Highway Research Center
THEA	Tampa Hillsborough Expressway Authority
UAS	Unmanned aircraft system

UDOT	Utah DOT
UHPC	Ultra-high performance concrete
U.S. DOT	United States Department of Transportation
U.S.C.	United States Code
UTC	University Transportation Centers
V2V	Vehicle-to-vehicle
Volpe Center	John A. Volpe National Transportation Systems Center
VRTC	Vehicle Research and Test Center
WJHTC	William J. Hughes Technical Center