FTA

FEDERAL TRANSIT ADMINISTRATION

FTA Annual Report on Public Transportation Innovation Research Projects for FY 2019

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Federal Transit Administration

PREPARED BY
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Federal Transit Administration

FTA Annual Report on Public Transportation Innovation Research Projects for FY 2019

Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^{o}F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^{o}C

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13. ABSTRACT This report provides information on projects funded under Federal public transportation law (49 U.S.C. § 5312). FTA Research priorities are safety, mobility innovation, and infrastructure. Projects in these areas promoted public transportation innovation to improve operations, infrastructure, and traveler experiences. Projects active in FY 2019 promoted research, innovation and development, demonstration and deployment, and evaluation.		
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

U.S. Department
of Transportation

**Federal Transit
Administration**

Dear Colleague:

I am pleased to provide the Federal Transit Administration (FTA) Annual Report on Research. This report describes public transportation research activities that received financial assistance under FTA's Public Transportation Innovation Program (49 U.S.C § 5312) during Fiscal Year (FY) 2019. FTA funds research, development, demonstration, deployment, and evaluation projects of national significance that improve public transportation. During this changing time, public transit agencies and the communities they serve need information on products, processes, and solutions that can reduce operational expenses; expand economic development; and enhance accessible mobility for all travelers. FTA's research into new mobility models, new types of safety systems, and more efficient buses are examples of how FTA's research investments meet FTA's mission to improve public transportation for America's communities.

This report describes the results of the $93 million, appropriated in multiple years, in research programs and projects active in FY 2019. FTA's research priorities of safety, infrastructure, and mobility innovation are consistent with the Department of Transportation's strategic goals of safety, innovation, and infrastructure.

In FY 2019, FTA's research portfolio included $38 million for safety research; $24 million for infrastructure research; $19 million for mobility innovation research; and $12 million for supportive services and other activities such as the $5 million Transportation Cooperative Research Program.

I am proud of the results of FTA's research – mobility on demand projects that increased access to public transportation through public-private partnerships and technologies such as applications on smart phones; innovative technologies that keep workers safe while working on rail systems tested through our safety research development demonstration program; technologies that enable independent travel for people with disabilities funded by the Accessible Transportation Technology Research Program; and many more successes. Thank you for your continued support of public transportation innovation research.

Sincerely,

K. Jane Williams
Acting Administrator

FTA's Public Transportation Innovation Program (49 U.S.C. § 5312) authorizes FTA to make grants and enter into contracts, cooperative agreements, and other agreements for research, development, demonstration, deployment, and evaluation projects that will improve public transportation.

FTA's mission is to improve public transportation for America's communities, and FTA's vision is that the United States has a world-class public transportation system with access and mobility for all. FTA's research mission is to advance public transportation innovation by leading research, development, demonstration, deployment, evaluation, and implementation practices and technologies. FTA's research priorities are to enhance safety; improve accessible mobility; and promote advanced infrastructure. Through these priorities, the primary goals for FTA's research are to improve the traveler's experience; drive economic development; and reduce operational costs.

Eligible projects fall within three areas: research; innovation and development; and demonstration, deployment, and evaluation. Within these areas there can be many types of projects. Examples of eligible research activities include more effective and efficient public transportation service; mobility management; system capacity; advanced vehicle design; asset maintenance; construction and project management; environment and energy efficiency; and safety improvements.

Research activities evolve through a four-phase research-to-practice pipeline process, as seen in Figure 1, moving from the early research of promising ideas to evaluation and implementation.

Figure 1 *FTA Pipeline Phased Approach*
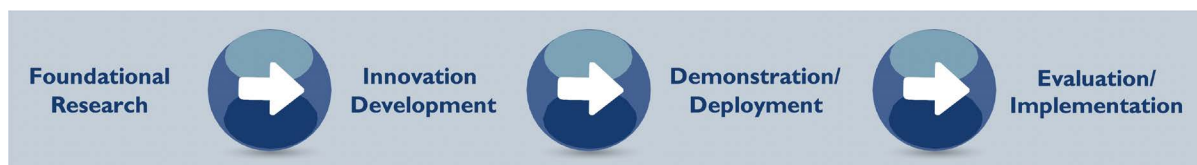
- **Research** – developing and deploying new and innovative ideas, practices, and approaches.
- **Innovative Development** – improving public transportation systems nationwide to provide more efficient and effective delivery of public transportation services including through technology and technological capacity improvements.
- **Demonstration and Deployment** – enabling early deployment and demonstration of innovations in public transportation with broad applicability, including low or no emission vehicle deployment.

- **Evaluation and Implementation** – analyzing project results and plans for broad-based implementation of research findings.

After over three years of consistent focus in the research priority areas of Safety, Infrastructure, and Mobility Innovation, FTA has a solid foundation of significant results and programs of national significance. These research program areas support the strategic goals of the Department of Transportation (DOT) of Safety, Infrastructure, and Innovation. Specifically, FTA's research activities supported DOT's strategic goals in the following ways:

Figure 2

FTA Research Priorities and Goals
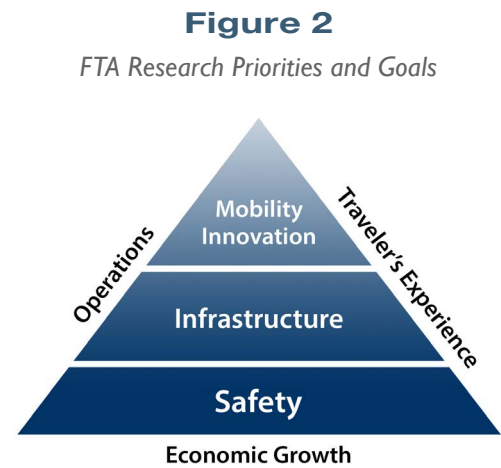
- **Safety** – researching new products, and processes to reduce injuries and fatalities, especially for workers of rail systems.
- **Infrastructure** – stimulating economic growth for the nation's bus industry and reducing operational costs for transit agencies, through low and no emissions public transit vehicles.
- **Mobility Innovation** – increasing accessible mobility options for everyone through new business models, some that leverage public/private partnerships, and others that deploy innovative technologies such as smart phone applications.

FTA's adherence to this four-phased research pipeline process helped to optimize the success of FTA's research program. FTA prioritized research spending on demonstration and deployment activities, enabling FTA to test promising research findings in public transportation environments across the U.S.

FTA's research also supports the DOT's fourth strategic goal of accountability and its two objectives: regulatory reform and mission efficiency. A major area of development for FTA is developing data analytic capacity and outreach to support research to practice. FTA continues to conduct supporting programs and evaluation activities. The statutorily-required Transportation Cooperative Research Program (TCRP), continues developing excellent research with topics chosen by the public transportation industry and is authorized at $5 million annually. A total of 3.2% of discretionary research funds are allocated each year for the statutorily required Small Business Innovation Research (SBIR) (Section 9 of the Small Business Act, 15 U.S.C. § 638). SBIR programs helped to develop solutions for passenger counting and improving safety for pedestrians and bicyclists.

FTA actively managed $93 million in research funding during FY 2019. These funds are from multiple fiscal years and the funding includes $38 million for safety research; $24 million for infrastructure research; $19 million for mobility innovation research; and $12 million for supportive services and other activities.

Table 1 provides a complete list of all FTA research programs and projects that received assistance in FY 2019, and the projects are categorized by research priority area and the type of project.

Table 1 *Complete List of FY 2019 Active FTA Research Programs and Projects*

Research Priority	Type of Project	Project Title	FTA Funding
Safety	Demonstration & Deployment	Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Program	$24,020,135
Safety	Innovation & Development	FTA Employee Safety Reporting Pilot Program	$3,000,000
Safety	Demonstration & Deployment	Safety Research and Demonstration (SRD) Program	$8,516,669
Safety	Evaluation & Implementation	Safety Research and Demonstration (SRD) Program Evaluation	$750,000
Safety	Research	Safety Standards Research	$1,500,000
Mobility Innovation	Innovation & Development	Mobility on Demand (MOD) Sandbox	$7,931,080
Mobility Innovation	Evaluation & Implementation	Mobility on Demand (MOD) Sandbox Evaluation	$250,000
Mobility Innovation	Research	Mobility on Demand (MOD) Metrics and Studies	$750,000
Mobility Innovation	Innovation & Development	Mobility on Demand (MOD) Information and Knowledge Accelerator (IKA)	$600,000
Mobility Innovation	Research	Transit Automation Analysis and Research Plan Development	$950,000
Mobility Innovation	Research	Strategic Transit Automation Research (STAR) Plan Enabling Research and Implementation	$350,000
Mobility Innovation	Research	Transit Bus Automation Strategic Partnerships	$600,000
Mobility Innovation	Research	Accessible Transportation Technologies Research Initiative (ATTRI)	$2,500,000
Mobility Innovation	Research	Mobility Payment Integration (MPI)	$400,000
Mobility Innovation	Research	Transit and Health Access Initiative	$2,355,758
Mobility Innovation	Demonstration & Deployment	Human Services Coordination Research (HSCR) Deployment Program	$2,207,857
Mobility Innovation	Innovation & Development	Mobility Services for All Americans (MSAA)	$333,570
Infrastructure	Research	Low or No (LoNo) Emission Component Assessment Program (LoNo-CAP)	$12,000,000
Infrastructure	Innovation & Development	Low or No (LoNo) Emission Bus Testing Centers	$2,000,000
Infrastructure	Demonstration & Deployment	Track Asset Management Demonstration	$4,225,000
Infrastructure	Research	Best Practices and Research for Lifecycle-Based Management	$200,000
Infrastructure	Research	Bus Propulsion Evaluation and Support	$1,400,000
Infrastructure	Demonstration & Deployment	Bus Efficiency Enhancements Research and Demonstrations (BEERD) Program	$3,000,000

Table 1 (cont'd.) *Complete List of FY 2019 Active FTA Research Programs and Projects*

Research Priority	Type of Project	Project Title	FTA Funding
Supporting Programs	Evaluation & Implementation	Information Dissemination and Evaluation Program	$1,439,692
Supporting Programs	Evaluation & Implementation	Information Dissemination and Outreach Program	$1,100,000
Supporting Programs	Evaluation & Implementation	Research Evaluation Implementation Plan	$480,000
Supporting Programs	Evaluation & Implementation	Transit Data Research Project Secure Data Commons System (SDC)	$100,000
Supporting Programs	Evaluation & Implementation	Workforce Development Program Evaluation and Dissemination	$250,000
Supporting Programs	Research	Transit Cooperative Research Program (TCRP)	$5,000,000
Supporting Programs	Innovative Development	Small Business Innovation Research (SBIR) Program	$3,494,756
		Total	$92,929,382

FTA is currently funding research projects in 32 states and the District of Columbia. Figure 3 shows the location of FTA Research programs and projects by DOT research priority.

Figure 3 *Location of FTA's Research Programs and Projects Recipients*
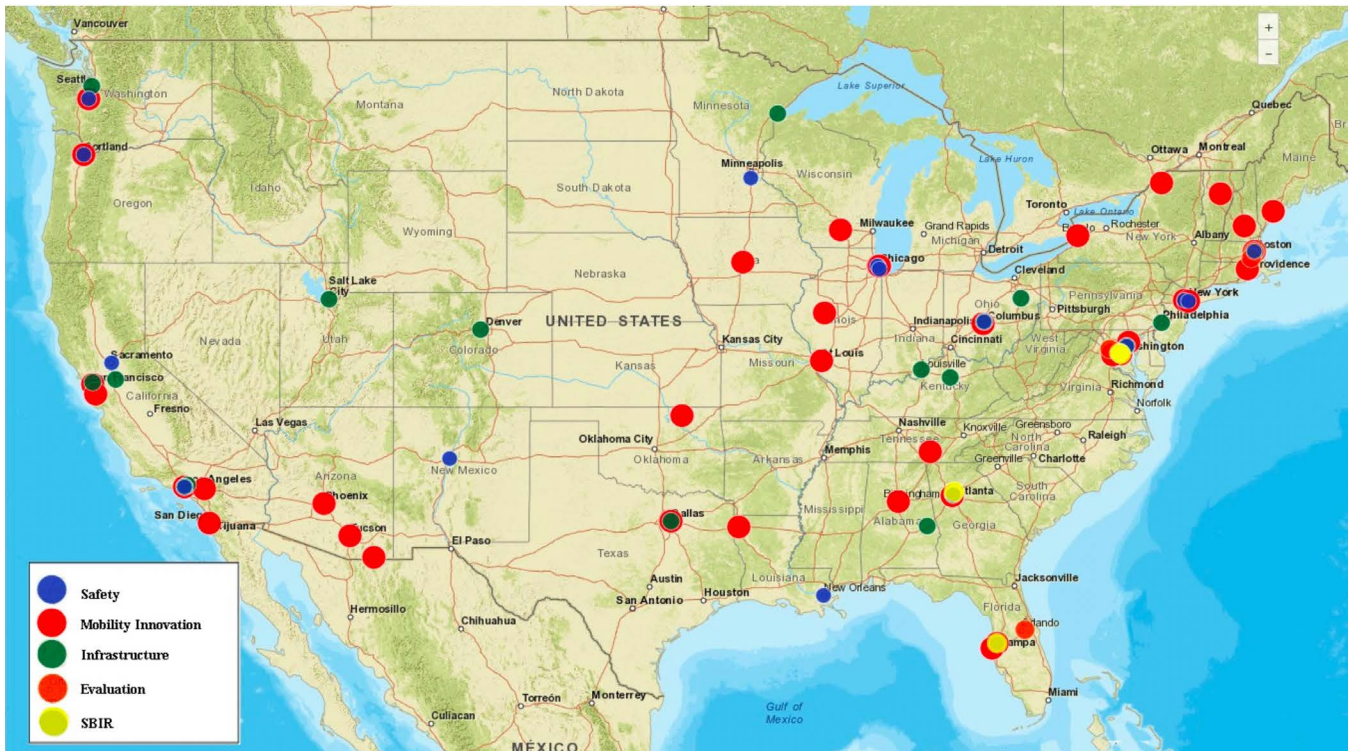
Requirement for This Report

Federal public transportation law (49 U.S.C. § 5312(f)) requires FTA to post an annual report on research available to the public on its website not later than the first Monday in February of each year. This report should include:

- A description of each project that received assistance under this section during the preceding fiscal year.

- An evaluation of each project that received assistance in the preceding year, including any evaluation conducted for demonstration and deployment projects.

Program and Project Descriptions

This section of the report has detailed descriptions of programs and projects that received assistance in FY 2019. Definitions of assistance include the planning and development of a new project, the award of a new project, management of an existing project, or evaluation of a project. Program and project descriptions are categorized by research priority area—Safety, Infrastructure, and Mobility Innovation—and concludes with a section on supporting programs and other initiatives. Each priority section notes the overall objective for that priority and provides a detailed description with objectives and a list of projects. Individual project descriptions include project title, recipient(s), performance indicators (results), evaluation, and FTA funding.

Safety

Description:

FTA's Safety research program continued to provide leadership and vision in the development and management of initiatives that improved the safety of passengers, employees, emergency responders, and all others who encounter the public transportation system. As the steward of the nation's public transportation system, FTA is obligated to provide the resources necessary for safe, efficient, and effective operations for transit customers, employees, and others through safety research, innovation, and/or regulation. The nation's economy depends on a safe public transit system for millions of Americans to get to work every day. FTA supports research on new safety technologies that can reduce fatalities, injuries, and expand American economic and technological leadership.

Objectives:

FTA Safety research sought to:

- Operate systems in a safer manner through improved:
  - Application of advanced technologies, practices, and designs
  - Safety culture
  - Human factors
- Reduce injuries and fatalities by using:
  - Innovative technologies, practices, and designs to improve worker safety
  - Innovative technologies, practices, and designs to improve rider safety

FTA had five active Safety projects in FY 2019, as listed in Table 2.

Table 2 *Safety Programs Receiving Assistance from FTA, FY 2018*

Safety Programs		
Type of Project	**Project Title**	**FTA Funding**
Demonstration & Deployment	Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Program	$24,020,135
Innovation & Development	FTA Employee Safety Reporting Pilot Program	$3,000,000
Demonstration & Deployment	Safety Research and Demonstration (SRD) Program	$8,516,669
Demonstration & Deployment	Safety Research and Demonstration (SRD) Program Evaluation	$750,000
Research	Safety Standards Research	$1,500,000
	Total	**$37,786,669**

In FY 2019, FTA funded 19 recipients located in 14 states to advance DOT's safety research priority. Funding ranged from $500,329 to $4,497,963.

Figure 4 *Location of Safety Program Recipients*
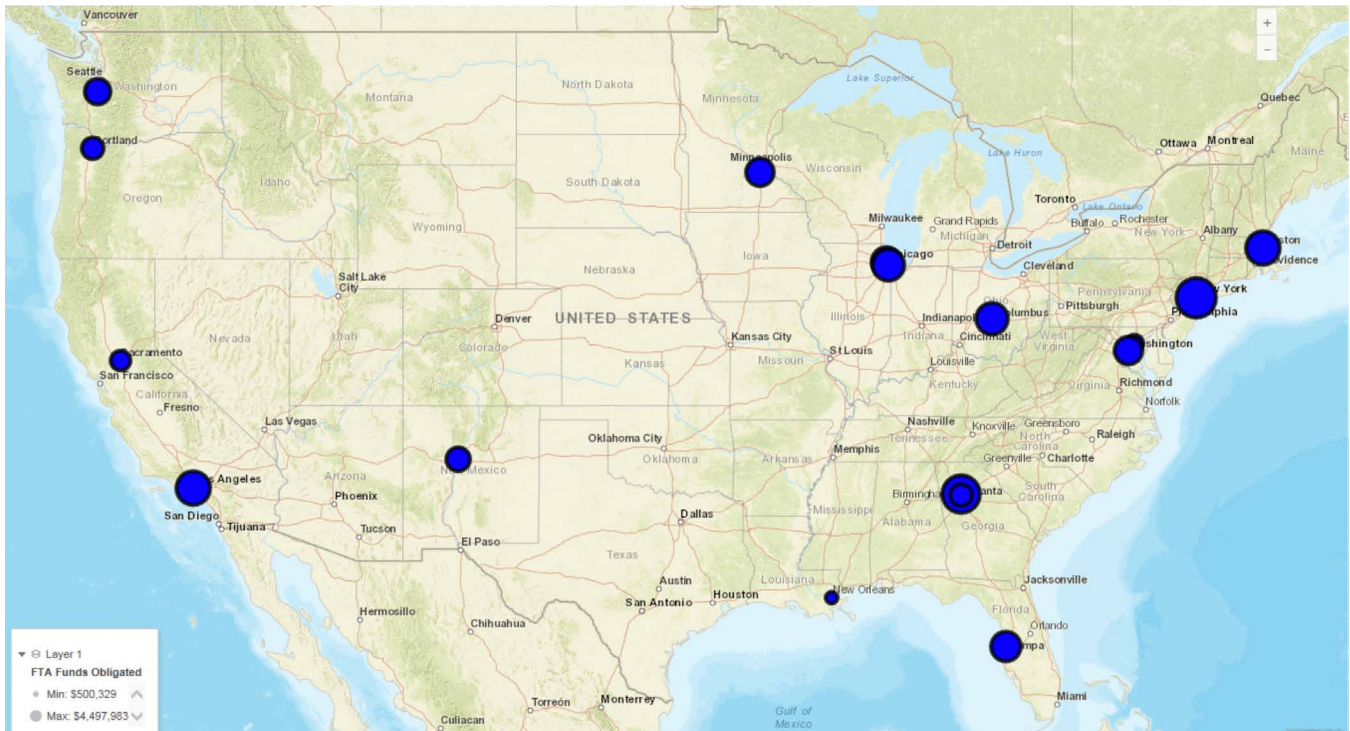
Title: *Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Program*

Recipients: Local governments, transit authorities, educational institutions, and private entities (see Table 3)

Project Description:

The SRER Program pursues innovative approaches to eliminate or mitigate safety hazards, improve infrastructure resiliency, and improve all-hazards emergency response and recovery. FTA is funding 12 projects under SRER in 9 states to explore solutions and improvements with 3 program goals. SRER goals are to: 1) improve operational safety; 2) increase infrastructure or equipment resiliency; and 3) advance all-hazards emergency response and recovery methods. Under operational safety, SRER is developing and testing new or substantially-improved technologies, methods, and practices to reduce the risk of transit-related injuries and fatalities. Resiliency projects are seeking to identify the most promising methods and/or technologies to deploy in a public transit system that can be hardened against natural disasters and/or catastrophic events. Under all-hazards emergency response and recovery, SRER is investigating technologies, methods, and practices to improve communication with emergency responders in the event of emergencies, disruptions, and catastrophic failures.

Results:

All the SRER projects, shown in Table 3, were active in FY 2019. Significant results of SRER projects in FY 2019 include:

- Center for Transportation and Environment (CTE): Together with University of Texas Center for Electromechanics (UT-CEM), BAE Systems and other partners participated in the development of a prototype exportable power system based on fuel cell shuttle bus. The prototype system has 60 KWh power output and had multiple 120 volt and 240 volt outlets built on a fuel cell bus platform. BAE Systems further refined the initial design and showcased the prototype at Pinellas Suncoast Transit Authority and APTA Bus and Paratransit Conference using a 40-foot hybrid-electric bus platform. The project met the SRER goal of advancing all-hazards emergency response and recovery. This technology, if adopted, could bring electric power to first responders much faster during a disaster.
- New York Metropolitan Transportation Authority (NYMTA): This project demonstrates vehicles and wayside technologies to enable schedule-based to condition-based maintenance and improve safety. NYMTA completed the vehicle and track instrumentation deployment and demonstration phase of this project as well as the data collection and analysis phase. The team conducted industry outreach efforts to present the findings on the innovative solutions for improving the effectiveness of rail track maintenance by using state-of-the-art rail vehicle and track instrumentation and computer

analytics. The preliminary data analysis identified an approximate cost savings of $10 million within two years if such system was fully deployed and scaled up in NYMTA. The estimated potential savings was associated with improved wheel service life, better utilization of resources for rail wheel maintenance, improved inspection, and overall improved operations. The project could benefit not only NYMTA, but other rail transit agencies by optimizing the track and vehicle inspection and maintenance process. The team plans to continue this effort, with local funds, in order to capture longer term data to validate the initial results from this pilot program.

- Greater Cleveland Regional Transit Authority (GCRTA): GCRTA completed the Connected Vehicle (CV) Infrastructure - Urban Bus Operational Safety Platform project in May 2019. The final report is available at https://www. transit.dot.gov/research-innovation/connected-vehicle-cv-infrastructure-%E2%80%93-urban-bus-operational-safety-platform. The project team installed CV Technology in 24 GCRTA buses and 3 intersections to provide bus drivers with alerts to avoid likely collisions with pedestrians. The team completed a six-month long revenue service demonstration as well as collected and analyzed data. Key findings indicated that 81% of driver alerts were correct, meaning that the CV technology correctly identified the presence and location of a pedestrian 81% of the time. There was a 10% incorrect alert rate and a 9% false alarm rate. These alerts allowed for a potential reduction in collisions by improving the driver response in braking by 16% and 18%, on average. The research benefits all transit agencies and the traveling public by assisting buses in avoiding collisions with other vehicles and pedestrians crossing the streets. The project met the goal of mitigating safety hazards identified by the transit agency.

- Minnesota Valley Transit Authority (MVTA): MVTA completed the Driver Assist System Technology to Support Bus-on-Shoulder Operations project in June 2019. The final report is available to the public at https://www.transit. dot.gov/research-innovation/driver-assist-system-technology-support-bus-shoulder-operations. The project team installed the second generation (Gen2) driver assist system (DAS) on 11 of MVTA's Gillig buses. The Gen2 DAS is a GPS-based technology suite that provides lane position feedback to bus operators. The team completed a 12-month long revenue service demonstration as well as collected and analyzed data. Key findings included: 1) zero accidents during both the baseline and yearlong demonstration period; 2) One safety incident early in the implementation period that led to a design change to the system; and 3) DAS-equipped buses had slightly better on-time performance. The project met the goal of developing and testing new or substantially-improved technology to reduce the risk of transit-related injuries and fatalities.

Throughout the duration of the program, each recipient was required to conduct outreach and transfer knowledge via workshops, conference presentations, webinars, and other methods. Final reports are expected from each project after

their completion. The quantitative and qualitative results of these projects will enable transit agencies to incorporate lessons learned from the demonstration projects into their own efforts to improve safety, resiliency to natural disasters, and emergency response.

Project/Program Evaluation:

All recipients are required to have an independent evaluator for their project, and each project has its own set of performance metrics within the area of safety improvements, operational and capital efficiency, and return on investment. Evaluations are ongoing and are expected to be completed at the end of each project. Final evaluation reports will be provided to FTA describing the effectiveness of the proposed technology, method, and/or practice. FTA received evaluation reports from completed projects. A final SRER evaluation report will be provided after the completion of all projects.

FTA Funding: $24,000,000

Table 3 *Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Research Demonstration Projects Receiving Assistance from FTA, FY 2019*

Project Title	Project Recipient	City and State	FTA Award
Demonstration and Commercialization of LRV Bumper for Enhanced Safety in Shared Right-of-Way Street Environments	Applied Research Associates	Albuquerque, NM	$1,323,414
TrackSafe Phase II Demonstration Project	Metropolitan Atlanta Rapid Transit Authority	Atlanta, GA	$4,233,865
Development of Bus Exportable Power System for Emergency Response	Center for Transportation and the Environment	Atlanta, GA	$995,098
Coordinated Transit Response Planning and Operations Support Tools for Mitigating Impacts of All-Hazards Emergency Events	University of Chicago	Chicago, IL	$2,890,600
Evacuation and Return: Increasing Safety and Reducing Risk	City of New Orleans	New Orleans, LA	$500,329
Driver Assist System Technology to support Robust, Flexible Bus-on-Shoulder and Narrow-Lane Operations for Robust Transit Service	Minnesota Valley Transit Authority	Burnsville, MN	$1,790,014
New Jersey Transit Critical Infrastructure Storm Surge Warning System	New Jersey Transit Corporation	Newark, NJ	$843,750
Connected Vehicle Infrastructure- Urban Bus Operational Safety Platform	Battelle Memorial Institute	Columbus, OH	$2,761,617
Smart, Shared, and Social: Enhancing All-Hazards Recovery Plans with Demand Management Technologies	Portland State University	Portland, OR	$943,984
Innovative Platform Track Intrusion Detection System Technology: A Demonstration on Los Angeles Metro Rail System	Los Angeles County Metropolitan Transportation Authority	Los Angeles, CA	$1,722,400
Resilient Concrete Crosstie and Fastening System Designs for Light Rail, Heavy Rail, and Commuter Rail Transit Infrastructure	University of Illinois	Urbana, IL	$2,396,981
Integrated Wheel/Rail Characterization and Safety through Advanced Monitoring and Analytics	New York Metropolitan Transportation Authority	New York, NY	$3,617,948
Total			**$24,020,135**

Figure 5 *Example of Impact of Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) on Safety*

The New York Metropolitan Transportation Authority (NYMTA) and its partners, along with FTA, worked to test and develop an information collection system that assesses track and wheel conditions. The system has the potential to make rail operation safer by reducing derailments. It also could improve the effectiveness and efficiency of rail vehicle and track maintenance. The research team used vehicle-borne and wayside technologies to acquire data about track and wheel conditions along New York City Transit's (NYCT) #7 subway line. They equipped a data collection car with accelerometers, acoustic and energy measurement equipment, and instrumented wheel sets. The data collection car was part of a larger vehicle being used in revenue service. The team also outfitted a NYCT track geometry car with data measurement equipment. Both cars were equipped with Radio Frequency Identification (RFID) readers that could position data maps produced by the track geometry car within feet of where data was obtained from the data collection car. This provided a way for the team to overlay the track map on the data collection car's data map to quickly identify potential issues or abnormalities with vehicle and track performance. Meanwhile, truck bogie optical geometry inspection and lateral/vehicle measurement gear was used to collect data from the track and wayside. The project team has completed the demonstration, data collection, and analysis phase.

Title: *FTA Employee Safety Reporting Pilot (ESRP) Program*

Recipient: The Volpe Center

Project Description:

The Public Transportation Agency Safety Plans (PTASP) regulation (49 C.F.R. Part 673) requires recipients and sub-recipients of Urbanized Area Formula funds (49 U.S.C. § 5307) to develop an Agency Safety Plan that is based on Safety Management System (SMS) principles and methods. The PTASP regulation requires agencies to establish an Employee Safety Reporting Program (ESRP). The purpose of program is to provide the transit industry guidance on how to develop an effective ESRP, a program that provides a process for employees, including contract employees, to report safety conditions to senior management. This pilot program includes a demonstration of how three (small, medium and large) transit organizations use and implement employee safety reporting systems and identifies challenges in implementing the ESRP.

Results:

FY 2019 produced the following results:

- Literature Reviews: The Volpe Center conducted a literature review of several demonstrations with small, medium and large transit systems.

Senior managers, employees, and first level supervisors were interviewed to help FTA learn about the organization's structure, culture, and operating environment as well as operations to determine how they manage safety. FTA used the collected examples of best practices in ESRP implementation at these different sized agencies.

- Internal Draft Report: The Volpe Center drafted the report titled *A Guide for Implementation of an Employee Safety Reporting Program (ESRP)*. The draft report was submitted to FTA in July 2019 and is currently under review. This guidance document provides the transit industry with a roadmap on how to design, develop, implement, and operate an effective ESRP.

- Webinar: The Volpe Center and FTA conducted a webinar on July 30, 2019, to provide participating agencies with an overview of the rule requirements for an ESRP and to highlight some best practices for establishing an ESRP.

The PTASP rule establishes parameters for establishing an ESRP, but also provides agencies with the flexibility to create a system that meets their needs. The guidance document developed as a result of this research program, offers best practices and suggested approaches, methodologies, and ideas to consider when designing and implementing an effective ESRP. ESRPs support transit agencies' collection of safety information that can be used to identify safety concerns that might otherwise go unresolved.

FTA Funding: $3,000,000

Title: *Safety Research and Demonstration (SRD) Program*

Recipients: Transit authorities partnering with local governments, educational institutions, and private entities (see Table 4)

Project Description:

The SRD Program provides technical and financial support for transit agencies to pursue innovative approaches to eliminate or mitigate safety hazards. Projects pursue cutting-edge technologies and innovative approaches to safety, focusing on the demonstration of technologies and safer designs. Program goals are to: 1) explore advanced technologies to prevent transit vehicle collisions; 2) enhance the safety of transit services by incorporating safer design elements; and 3) and evaluate the cost-effectiveness and practicability of potential solutions. The SRD Program targets collision avoidance and mitigation, and transit worker safety protection. Funding for the program is intended to assess the practicality and effectiveness of potential solutions to improve safety and influence transit industry guidance and standards. The results of the program will be widely applicable nationwide and will support FTA's efforts to promote safe public transportation systems.

Results:

The seven demonstration projects shown in Table 4 were active in FY 2019. Significant outputs for the program include:

- <u>Maryland Transit Administration Fixed-Mounted Train Detection and Worker Warning System Demonstration</u>: The project team completed the calibration of sensors and validated the communication network on the secondary track worker protection system installed on the Maryland Transit Administration's light rail system. The worker protection system was fully deployed in revenue service. The project team is currently collecting and analyzing data from the pilot demonstration. Efforts under this project are beneficial to the industry as they demonstrate how to make the work environment for track workers safer. This project meets the SRD goals of exploring technologies to prevent transit vehicle collisions with track maintenance workers and evaluating the cost-effectiveness and practicability of the worker protection system. The team plans to document safety improvements to track workers, evaluate system effectiveness, and document the return on investment.

- <u>Washington Metropolitan Area Transit Agency (WMATA) Track Inspector Location Awareness System</u>: The team successfully installed 125 of 182 ranging wayside units at 12 locations throughout the rail system that were identified as high risk for roadway workers. WMATA developed a demonstration schedule that included equipment installation, operational testing, and system evaluation. Challenges included updating equipment firmware and collecting data from the back-end server. In Summer 2019, WMATA is providing additional local funding to purchase extra equipment and expand the awareness system on the entire Red Line of the metro system. An updated pilot phasing plan is being developed that will include an additional 12 months of the demonstration followed by six months of controlled tests. Upon completion, this demonstration project anticipates making WMATA safer in high risk areas, thus lowering the possibility of employee injuries and fatalities. This project meets the SRD goals of exploring technologies to prevent transit vehicle collisions with track maintenance workers as well as evaluating the cost-effectiveness and practicability of the systems.

- <u>New York City Transit (NYCT) Bus Mirror Configuration Project</u>: Using an expert advisory panel and focus groups, the project team established preliminary visibility requirements for transit bus operators. The team completed benchmarking of representative samples of the NYCT bus fleet and completed 3-D laser scan modeling of 4 representative buses (New Flyer, Proterra, NOVA and Orion). In addition, the team completed visibility modeling and dynamic performance on left turns using the 3-D laser scan of the sample buses. NYCT is in the process of validating the optimized mirror configuration based on the previous completed tasks. The safer mirror design improves visibility for bus operators and decreases the possibility of collision with pedestrians due to blind spots. This project meets the SRD goals of

enhancing the safety of transit bus services by incorporating safer design elements and evaluating the cost-effectiveness and practicability of the design.

- Pierce Transit Collision Avoidance and Mitigation Safety Demonstration: The team successfully completed the Alpha testing phase. The team completed the installation of the collision avoidance system in a 40-foot Pierce Transit bus. As part of the Alpha testing, the team completed the validation of the system, with the Light Detection and Ranging (LIDAR)-based collision avoidance and automatic braking system at the Virginia Tech Transportation Institute (VTTI). The early results of the closed course tests are very promising with 100% pedestrian, vehicle detection, and braking. The team will start installing the technology on 30 Pierce Transit buses for non-revenue service and data collection before proceeding to revenue service field demonstration to validate the early results. The potential benefit of this technology is that it could be applicable to all bus transit operators due the fact that the technology is relatively low cost and can be retrofitted to older buses. The project supports the SRD goals of exploring advanced technologies to prevent transit vehicle collisions with pedestrians, cyclists, and other vehicles as well as evaluating the cost-effectiveness and practicability of the system.

Project final reports are expected to be submitted to FTA in FY 2020 and FY 2021. The reports will describe the technical details of the system installed, the deployment phase of the project and any challenges, lessons learned during development, deployment and demonstration, as well as the analysis and evaluation of the data collected for each project.

FTA Funding: $8,516,669

Table 4 *Safety Research and Demonstration (SRD) Projects Receiving Assistance from FTA, FY 2019*

Project Title	Project Recipient	City and State	FTA Award
Pierce Transit Collision Avoidance and Mitigation Safety Demonstration	Pierce County Public Transportation Benefit Area Authority	Lakewood, WA	$1,664,894
Transit Bus Mirror Configuration Research and Development	New York Metropolitan Transit Authority	New York City	$880,035
CTA Operations Control Center Safety Enhancements Project	Chicago Transit Authority	Chicago, IL	$1,078,300
Enhanced Secondary Warning System for Track Worker Protection Pilot	Sacramento Regional Transit District	Sacramento, CA	$870,000
Fixed-Mounted Train Detection and Worker Warning System Demonstration	Maryland Department of Transportation	Baltimore, MD	$688,448
Collision Avoidance and Mitigation Technologies on LA Metro Bus Pilot	Los Angeles County Metropolitan Transportation Authority	Los Angeles, CA	$1,450,000
Track Inspector Location Awareness with Enhanced Transit Worker Protection Pilot	Washington Metropolitan Area Transit Authority	Washington, DC	$1,884,992
		Total	$8,516,669

Figure 6 *Impact of Safety Research and Demonstration (SRD) on Public Transportation Industry*

Nearly 6,000 pedestrians were killed in traffic crashes in 2017, according to data from National Highway Traffic Safety Administration. FTA, working with Pierce Transit, the Virginia Tech Transportation Institute (VTTI), and other industry partners, has funded this project, and other similar projects under the SRD program, to address and mitigate transit buses collision with pedestrian and cyclists. The project seeks to ensure pedestrian and cyclist safety with Light Detection and Ranging (LIDAR)-based detection technology and automatic braking to assist bus operators with more time and distance to bring their buses to a controlled stop. The goal of the project is to demonstrate this technology's potential to significantly reduce the frequency and severity of bus collisions and provide data on return on investment, impact on insurance claims, reductions in collisions and near misses, and operator acceptance. The project plans to install the system on 30 Pierce Transit buses and deploy them on revenue service for 18 months of data collection. The project is estimated to be completed by 2021.

Title: *Safety Research and Demonstration (SRD) Program Evaluation*

Recipient: University of South Florida (USF) Center for Urban Transportation Research (CUTR)

Project Description:

This project supports FTA's SRD Program, and it is necessary to meet the statutory requirement of independent research demonstration evaluation under Federal public transportation law (49 U.S.C. § 5312 (e)(4)). The goals of this project are to: 1) evaluate the SRD projects; 2) assess the contribution of each project towards advancing FTA's SRD programmatic goals of improved collision avoidance and increased worker safety; and 3) estimate the broader, national-level impact of SRD projects. Each project-level evaluation has a set of performance measures established by SRD award recipients in coordination with the SRD evaluation team.

Results

The SRD Program Evaluation was active in FY 2019. The evaluator produced the following relevant outputs:

- Performance Metrics and Data Collection: The SRD Program Evaluation team worked with the SRD recipients and FTA project managers to establish a set of individual performance metrics for all 3 evaluation areas. The three evaluation areas are safety improvements, system effectiveness, and return on investment. The specific performance metrics were revised and updated based on each individual project's scope changes and progress.

- Data Collection Plans: The SRD Program Evaluation team worked with the SRD recipients and FTA project managers to complete seven data collection plans. The team is currently working with SRD recipients to manage and monitor the progress of the data collection effort by each recipient and project. The goal is to provide a data driven approach to these projects and ultimately inform the industry about the practicality and effectiveness of these technologies to improve safety.

- Project Completion Evaluation Questionnaires: CUTR developed a set of questionnaires for both the recipient and FTA project managers. The CUTR evaluation team will conduct interviews with FTA project managers as part of the project close out process. The goal is to capture lessons learned when carrying out demonstration projects with varying degrees of complexity, by recipients and FTA project managers, and document those in the final evaluation report.

Once all the SRD projects are completed, FTA will issue an evaluation report for the SRD Program. The report will provide valuable information regarding the effectiveness of the technologies demonstrated in the research program and the return on investment value of the various solutions. The quantitative and qualitative data generated under this project will allow each agency to make decisions regarding which technology and system they should pursue to prevent collisions and improve worker safety. The evaluation team plans to share information about the projects in different transit stakeholders' venues and keep the industry informed before the final evaluation report is completed and released to the public.

FTA Funding: $750,000

Title: *Safety Standards Research*

Recipient: University of South Florida (USF) Center for Urban Transportation Research (CUTR)

Project Description:

The purpose of this project is to research the area of safety standards. The project goals are to: 1) review current transit safety standards; 2) conduct data analysis; and 3) complete a safety research report that identifies possible gaps in current safety standards. The research conducted under this project aims to provide background information and findings for FTA to identify and assess current safety performance standards. This research provides information in support of standards development activities undertaken through projects authorized under other parts of Federal public transportation law – such as the

standards elements of the FTA's technical assistance and workforce development program funded under Federal public transportation law (49 U.S.C. § 5314).

Results:

FTA used the results of this research to identify and begin additional safety research for transit standards, guidance, or advisories for the transit industry. Results in FY 2019 were as follows:

- Standards Development Research: CUTR began standard development research on five new safety focus areas: 1) Employee Safety Reporting; 2) Right of Way Worker Protections; 3) Trespassers and Suicide Fatalities; 4) Accident/Incident Investigation; and 5) Fatigue Management, Fitness for Duty, and Hours of Service. Final reports will be provided to FTA by the end of FY 2020. Once completed, these documents will provide value to the transit industry and FTA by listing research findings and the need to update or develop new standards in each specific area. These documents will meet the goal of completing a safety research report that identifies possible gaps in safety standards.

- *Safety Standards Research Report*: In May 2019, CUTR submitted a final document internal to FTA titled *Safety Standards Research Report*. The report proposed areas for further research and data collection for new standards for use by the transit industry. The information included in this report identified high-risk areas in transit safety, corresponding gap research analyses, and research findings for further research to close the identified gaps. FTA initiated multiple safety standard research activities in FY 2019 to address the identified safety areas and gaps. The research report met the goals of this project to review current transit safety standards and conduct data analysis.

Documents produced under this project, including two in prior years, provided FTA with a thorough assessment of the efficacy of current safety standards; gaps in safety standards; and areas for future research in safety standards.

FTA Funding: $1,500,000

Figure 7 *Safety Standards Research Report*

FTA finalized the *Safety Standards Research Report* in May 2019. This internal report is based on data analysis, review and compilation of safety standards, and moderated planning sessions with industry stakeholders and the independent working group. It provides detailed information to FTA about safety standards and protocols, National Transportation Safety Board (NTSB) investigation reports and safety advisories and directives issued by FTA and transit safety related research and white papers produced by FTA's Transit Advisory Committee for Safety (TRACS). It also identifies trends and subject areas of greatest safety risk and provides the basis for recommending research areas for new standards/protocols consideration.
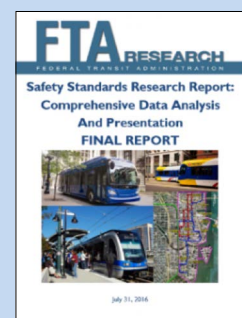
Mobility Innovation

Description:

In alignment with DOT's strategic goal of Innovation, FTA's Mobility Innovation research seeks to strengthen the capacity of transit agencies and communities to navigate the dynamic, evolving landscape of personal mobility. Demonstrations under the Mobility Innovation area explore innovative business models, partnerships, and private-sector solutions that seamlessly expand mobility options for all travelers. These new models are also expected to help reduce costs for public transit agency operations. Demonstrations are designed to complement emerging private-sector technology advancements and investments in autonomous vehicles and mobility, potentially leading to job creation in new businesses and technologies. The definition of mobility is dramatically evolving with the rise of transformative multi-modal concepts, public/private partnerships, traveler expectations, and emerging technological capabilities.

Objectives:

The primary objectives of FTA's Mobility Innovation research are to:

1. Improve transit operations and reduce costs by leveraging public and private assets and technologies.
2. Improve personal mobility by identifying and promoting seamless transportation models that engages all modes—public and private—for enhanced mobility for all travelers.

FTA had 12 active Mobility Innovation programs in FY 2019, shown in Table 5.

Table 5 *Mobility Innovation Programs Receiving Assistance from FTA, FY 2019*

Mobility Innovation Programs		
Type of Project	**Project Title**	**FTA Funding**
Innovation & Development	Mobility on Demand (MOD) Sandbox	$7,931,080
Innovation & Development	Mobility on Demand (MOD) Sandbox Evaluation	$250,000
Innovation & Development	Mobility on Demand (MOD) Metrics and Studies	$750,000
Innovation & Development	Mobility on Demand (MOD) Information and Knowledge Accelerator (IKA)	$600,000
Research	Transit Automation Analysis and Research Plan Development	$950,000
Research	Strategic Transit Automation Research (STAR) Plan Enabling Research and Implementation	$350,000
Research	Transit Bus Automation Strategic Partnerships	$600,000
Research	Accessible Transportation Technologies Research Initiative (ATTRI)	$2,500,000
Research	Mobility Payment Integration (MPI)	$400,000
Research	Transit and Health Access Initiative	$2,355,758
Demonstration & Deployment	Human Services Coordination Research (HSCR) Deployment Program	$2,207,857
Innovation & Development	Mobility Services for All Americans (MSAA)	$333,570
	Total	**$19,228,265**

In FY 2019, FTA funded 38 recipients located in 27 states to advance DOT's Innovation strategic goal.

Figure 8 *Location of Mobility Innovation Program Recipients*
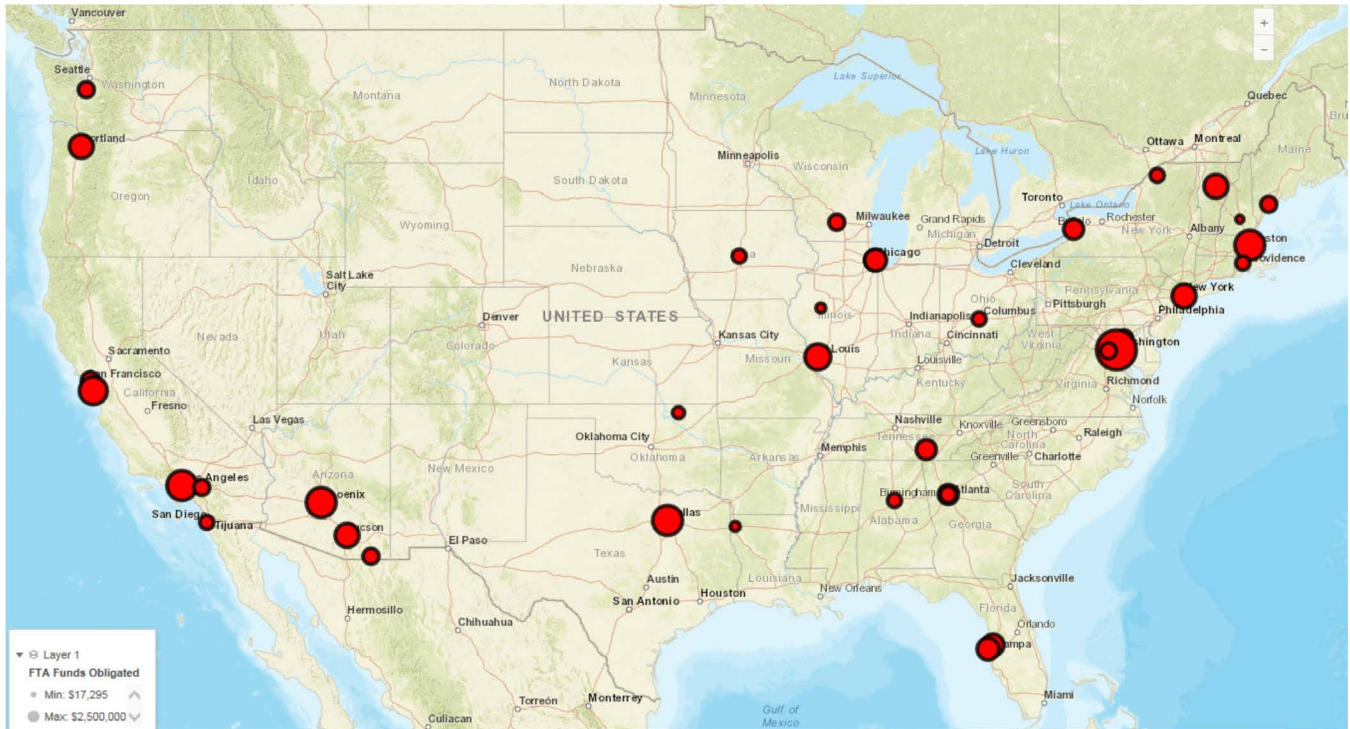
Title: *Mobility on Demand (MOD) Sandbox*

Recipients: Transit agencies, local governments, non-profit organizations, and private entities (see Table 6)

Project Description:

FTA's Mobility on Demand (MOD) Sandbox is a demonstration effort to explore approaches to integrating promising new mobility concepts, technologies, and solutions, with transit to greatly enhance the personal mobility of individuals. New and innovative shared-use mobility concepts and solutions, from bike- and car-sharing systems to ridesharing services summoned though a smartphone app, are providing travelers with new options to plan, pay, and take trips. By weaving together public transit with these new mobility options, the efficiency and effectiveness of existing transit options can flourish while expanding mobility options available to travelers. The MOD Sandbox investigates, through real-world demonstration efforts, how these new mobility solutions can be effectively integrated with existing transit systems to achieve the vision of MOD for an integrated network of safe and reliable transportation options available to all.

The MOD Sandbox is part of FTA's broader MOD research, demonstration, and deployment efforts. The MOD Sandbox consists of 11 pilot projects selected in late 2016 to demonstrate different approaches and technologies. The MOD Sandbox goals are to: 1) explore emerging technology solutions and new business approaches that have the potential to transform mobility services; 2) prepare the transportation industry to deliver these innovative mobility solutions; and 3) enable the widespread deployment of integrated mobility solutions. MOD research projects are also aligned with DOT's strategic goal to lead in the development and deployment of innovative practices and technologies that improve the performance of the nation's transportation system.

Results:

The following are relevant and significant results of the MOD Sandbox projects for FY 2019:

- San Francisco Bay Area Rapid Transit (BART): BART continued the demonstration of the integrated carpool to transit pilot program. The program matched carpool users traveling to BART stations and provided a way to reserve and pay for sought-after parking at the stations, improving access to transit stations. The program is accessible at https://511.org/carpool-vanpool/carpool/bart. By April 2019, more than 16,000 carpoolers were using the system monthly. About 30% of users reported riding BART more because of the carpooling (versus 4% less often). Closer to 40% of users reported driving less often and (versus about 10% more often). In total, 42% reported that they would have driven alone to BART and parked if the program did not exist. BART's Sandbox demonstration has shown the value of such partnerships in supporting the more efficient use transit agency resources, providing a replicable template.

- Valley Metro Rail of Phoenix: Valley Metro launched its Pass2Go app that integrates mobile ticketing and multimodal trip planning. Now, travelers have easier access to a range of mobility providers, including ride-hailing, allowing people at all levels of income, age, and disability to use an integrated, connected multimodal transportation system. Phase 1, a basic trip planner and full-day fare mobile ticketing with visual validation, was launched in March 2018. The program resulted in a significant shift in travel to public transportation and walking. About 40% of users reported using bus transit more often; about 50% reported using rail transit more often; and about a quarter of survey respondents reported walking more often. More than 25% of travelers surveyed reported shorter wait times and 29% reported shorter travel times. Having this data allows transit agencies to understand the potential of this tool, which can be widely applied in other communities, thus meeting the MOD goal of enabling the widespread deployment of such proven solutions.

- Dallas Area Rapid Transit (DART): DART introduced the GoPass regional mobile app, integrating microtransit, dynamic carpooling, and hailing services as a solution to improve first/last mile connections, particularly in non-walkable areas poorly served by transit. Phase 1, which included microtransit (GoLink) and dynamic carpooling (GoPool), was launched in May 2018. All users (including users with disabilities) reported improved access to DART's bus and rail system after GoLink was launched. Over 70% of users reported their approximate wait time as good or excellent. Average monthly GoLink ridership was approximately 4,500. The DART program similarly shows the potential of integrated mobility systems to complement fixed-route services in a way that other communities can replicate to improve the efficiency and effectiveness of transportation options.

- Pierce County Public Transportation Benefit Area Authority (Pierce Transit): The Limited Access Connections project leveraged a partnership with Lyft to connect underserved areas of the community to high-frequency transit hubs. It also provided connections to the local community college so late-night students can return home from classes that end after the bus has stopped running for the night. Between May 2018 and June 2019, the program supported more than 4,500 trips. In the words of one rider whose poor vision has caused her to cease driving, the service is a "game changer." She continues to say the program has "allowed me to remain engaged with friends and businesses in Tacoma. If I did not have access to this program, I would generally be housebound. I hope this program is extended, or simply made permanent. For people like myself, it grants me the ability to stay connected, engaged, and part of life." Given these positive results, Pierce Transit intends to continue the program following the end of the FTA-funded demonstration period, advancing FTA's efforts to foster proven solutions.

- Tri-County Metropolitan Transportation District (TriMet): TriMet updated their existing trip planning app to utilize an open-source geocoder, and provide integrated options for shared mobility services, including bike- and car-sharing, and ride-sourcing. The result is that users now have access to more accurate routing and trips that incorporate new modes to overcome first/last mile challenges, improved pedestrian routing that favors streets with sidewalks, and lower-stress routes due to improved sidewalk data. App users are responding positively in surveys: a majority rate the design as very good to excellent; 30% report that the trip planner greatly improves their ability to get to and from public transit in Portland; and about 70% reported that the trip planner offers some improvement. The development of this open source system that enhances traveler options provides another step forward in the MOD program goal of exploring opportunities to enhance mobility.

To date, the MOD Program has expanded mobility options in communities, supported the capacity of the public transit industry to adopt new solutions in mobility, found new efficiencies in the provision of public transportation services,

and created a more traveler-centric, carefree and effective transportation system. The Sandbox is also linked to MOD program efforts to conduct independent evaluations of the pilots and establish a community of practice around MOD to support industry dialogue.

FTA Funding: $7,931,080

Table 6 *Mobility on Demand (MOD) Projects Receiving Assistance from FTA, FY 2019*

Project Title	Project Recipient	City and State	FTA Award
MOD Sandbox: Adaptive Mobility with Reliability and Efficiency	Regional Transportation Authority of Pima County	Tucson, AZ	$669,158
MOD Sandbox: Mobility Platform	Valley Metro Rail, Inc.	Phoenix, AZ	$1,001,000
MOD Sandbox: Bay Area Fair Value Commuting Demonstration	City of Palo Alto	Palo Alto, CA	$1,085,000
MOD Sandbox: Los Angeles County and Puget Sound MOD Partnership	Los Angeles County Metropolitan Transportation Authority	Los Angeles, CA	$1,350,000
MOD Sandbox: Integrated Carpool to Transit	San Francisco Bay Area Rapid Transit	San Francisco, CA	$358,000
MOD Sandbox: Paratransit Mobility on Demand Demonstration	Pinellas Suncoast Transit Authority	St. Petersburg, FL	$500,000
MOD Sandbox: Integrated Fare Systems – From Transit Fare to Bike Share	Chicago Transit Authority	Chicago, IL	$400,000
MOD Sandbox: Open Trip Planner Share Use Mobility	Tri-County Metropolitan Transportation District	Portland, OR	$678,000
MOD Sandbox: First and Last Mile Solution	Dallas Area Rapid Transit	Dallas, TX	$1,204,000
MOD Sandbox: Flexible Trip Planner Project	Vermont Agency of Transportation	Montpelier, VT	$480,000
MOD Sandbox: Limited Access Connections	Pierce County Public Transportation Benefit Area Authority	Lakewood, WA	$205,922
		Total	$7,931,080

Figure 9 *Mobility on Demand (MOD) Demonstration*

Valley Metro, in Phoenix, AZ, updated their trip planning app to integrate a ridesharing company to provide first/last mile connections to transit stations and allow users to pay for services within the app. As a result, more travelers are using Valley Metro buses and trains, as well as experiencing more seamless travel choice. Also, the Integrated Carpool to Transit managed by San Francisco Bay Area Rapid Transit (BART) was operational in April 2019. More than 16,000 carpoolers were using the system monthly. About 30% of users reported riding BART more frequently because of the carpooling. Closer to 40% of users reported driving less often, and 42% reported that they would have driven alone to BART and parked if the program did not exist. This project presented benefits for Federal policy and regulation review, state and local transportation and transit agency planning and operations, and the general public by producing field evidence and lessons learned of partnerships and business models to advance local goals and outcomes for integrated mobility.

Title: *Mobility on Demand (MOD) Sandbox Evaluation*

Recipients: Booz Allen Hamilton (until 12/31/2018) and ICF International (started 9/25/2018)

Project Description:

The purpose of this project is to support FTA's MOD Program by conducting a comprehensive independent evaluation of the MOD Sandbox demonstrations. The independent evaluation is required by Federal public transportation law (49 U.S.C. § 5312(e)(4)). The goals of this evaluation effort are to: 1) identify and analyze the project impacts from performance measures identified by the independent evaluator and the 11 MOD Sandbox Demonstration sites; and 2) assess the business models used, and how existing FTA policies and regulations may support or impede these new service transportation models. Analysis areas for the 11 sites collectively include system usage (ridership), traveler behavior, user satisfaction, operational impacts (e.g., wait and travel times, service coverage, accessibility, vehicle occupancy), financial impacts to travelers and transportation providers, and environmental impacts.

Results:

FTA worked with Booz Allen Hamilton and ICF International to conduct the required evaluation of each of the 11 MOD Sandbox demonstration projects. In FY 2019, the following results were completed:

- Evaluation Plans: Booz Allen Hamilton completed the evaluation plans for the following six projects:

- Chicago Transit Authority (https://rosap.ntl.bts.gov/view/dot/40262)
- Los Angeles Metro and Puget Sound partners (https://rosap.ntl.bts.gov/view/dot/40261)
- City of Palo Alto (https://rosap.ntl.bts.gov/view/dot/40260)
- Valley Metro (https://rosap.ntl.bts.gov/view/dot/40258)
- Tri-Met (https://rosap.ntl.bts.gov/view/dot/37168)
- Pinellas Suncoast Transit Authority (https://rosap.ntl.bts.gov/view/dot/40259)

With completion of these six evaluation plans, all 11 project evaluation plans have been completed. These plans serve as key reference documents for the evaluation of the demonstration projects from start to finish. Each plan documents an evaluation schedule, major milestones, and the planned evaluation activities for each MOD demonstration project. The plans also show how the independent evaluation team coordinates with the MOD Sandbox project partners. This ensures that the required data are identified and plans are made for its collection and transmission during the demonstrations. The evaluation plans meet both goals under this project.

Results from the evaluation will advance public transportation in the U.S. by identifying impacts and benefits of MOD alternative transportation services. The evaluations will apply lessons learned for other transportation providers interested in adopting these MOD services. The evaluation results will also identify possible changes in current policies and regulations.

FTA Funding: $250,000

Figure 10 *Los Angeles Metro and Puget Sound Partners MOD Sandbox Demonstration Evaluation Plan*
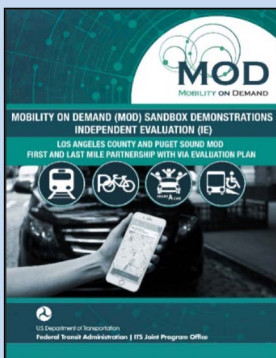
Offering two regions as test beds, Los Angeles (LA) County and the Puget Sound transit operators have entered into a partnership with Via to explore the viability of using transportation network company (TNC) services to provide first/last mile (FMLM) solutions for trips originating and ending at select transit stations. The partnership aims to increase connections with transit by broadening TNC access to a wider audience, including populations without smartphones, those who need wheelchair accessible vehicles, unbanked populations, and populations with limited English proficiency (LEP). The evaluation plan outlines the evaluation approach and methodology with hypotheses, performance metrics, data requirements, roles and responsibilities. Areas of analysis include mobility, geographic access to transit, ridership, reliability of FMLM service, utilization of FMLM vehicles, access for disadvantaged populations through availability of an LEP-enabled call center and affordable service, availability and usability of ADA-compliant accessible vehicle service, cost efficiency to the transit agencies, and greenhouse gas emissions.

Title: *Mobility on Demand (MOD) Metrics and Studies*

Recipient: TransitCenter, Inc.

Project Description:

The purpose of this project is to research current and future performance measurement needs for the integrated mobility environment. The goal of this project is to develop traveler- and system-centric performance metrics as part of FTA's MOD Program. This project synthesized information on how effectively and efficiently the system performs while meeting its travelers' demands; measure the impact of the mobility system both regionally and nationally from multiple perspectives; and measure how well an integrated mobility system meets the needs of its individual travelers.

Results:

This effort produced the following relevant results in FY 2019:

- Volume I, Conceptual Mobility Performance Metrics: Based on the information gathered during the literature reviews, interviews, analyses, and evaluations, a structured and multi-tiered approach was developed to address interfused objectives of public transportation, mobility, travelers, and national interests. This approach is Volume I of the research program, and finalization is expected by the end of Spring 2020. The overarching goal of developing a new set of mode-neutral performance metrics is to measure how well integrated mobility meets the needs of individual travelers, and the overall local and national impact of the mobility system.

- Volume II, Data Assessment: The TransitCenter and its partner Applied Predictive Technologies (APT) prepared a document to assess the relevance of the mobility performance metrics in the analytic evaluation of MOD and similar projects' efficacy, using the MOD Sandbox projects as tangible starting use cases and extrapolating to future potential use cases. This assessment included evaluations of data availability and constraints, opportunities, applicability, and feasibility of the proposed metrics. The research team performed extensive literature scans and had discussions with transit agencies and their mobility partners to understand the needs and develop prioritization-based approaches to performance measurement. They also evaluated all available transit data sources in the public and private domain. The result of this effort was summarized under Volume II in February 2019, internal to FTA. The overarching goal was to uncover the opportunities, challenges, and gaps to functionalize the Mobility Performance Metrics.

The results in FY 2019 created a robust understanding of the needs, applicability, feasibility, and data availability for the Mobility Performance Metrics that are being developed. The results meet the goals of the program by establishing the

parameters for developing traveler- and system-centric performance metrics that will be further refined in the next phases.

FTA Funding: $750,000

Figure 11 *A Systematic Approach to Mobility Performance Metrics (MPM) Development*

Development Phase			Testing Phase	
Development of Metrics	**Data Assessment**	**Policy Assessment**	**Demonstration**	**Implementation**
Literature Review	Applicability Analysis	Program and Policy Review	Target Setting Research	Implementation Plan & Strategy
Evaluation of Current Transit Performance Metrics	Feasibility Analysis	Policy Challenges & Barriers	Development of MOEs	Policy Informing Process
Gap Analysis	Gap & Redundancy Analysis	Gap Analysis	Development of Data & Testing Platforms	Pilot Implementations
Evaluation of Current Mobility Performance Goals	Prioritization Analysis	Short & Long-term Policy Actions	Partnership-based Field-testing	Monitoring & Data Collection
Supplemental Mobility Performance Metrics	Data Integration Strategies	Impact Assessment	Evaluation, Verification, and Validation	Evaluation & Documentation

Research Phases of MPM Development and Testing

The structured approach to the development and testing of Mobility Performance Metrics includes review of the literature and industry practices to understand the current trends in transit and mobility performance measurement; introduction of a new set of supplemental metrics to measure the performance of contemporary mobility systems; evaluation of the feasibility of implementing those metrics from data and policy perspectives; design of relevant measures of effectiveness (MOEs); and development of technology solutions for methodologies and methods to demonstrate the deployment of the supplemental MPM platforms and associated MOEs.

Title: *Mobility on Demand (MOD) Information and Knowledge Accelerator (IKA)*

Recipient: Shared-Use Mobility Center (SUMC)

Project Description:

Through a cooperative agreement with SUMC, the MOD IKA aims to enhance mobility by creating a structured, supported learning and information exchange system. It also supports a community of practice for the MOD Sandbox Program and related efforts not funded by FTA. The IKA allows those investigating MOD solutions from the public and private sectors to share ideas, lessons learned, problems and solutions, and research findings. The goal of the project is to support the successful implementation of MOD Sandbox projects around the country. Key strategies are to convene stakeholders, facilitate discussions, summarize learning, and disseminate knowledge in this rapidly evolving area.

Results:

The IKA project produced the following outputs in FY 2019:

- MOD Community of Practice Workshops: The IKA project hosted semi-annual MOD Community of Practice open workshops with public and private sector stakeholders to promote information exchange and share key lessons learned. The October 2018 workshop was held in conjunction with the Rail~Volution conference in Pittsburgh, and the highlights are accessible at https://sharedusemobilitycenter.org/highlights-from-the-mobility-on-demand-sandbox-workshop-at-railvolution/. Over 80 attendees took part, including 20 MOD Sandbox project participants. Also in attendance were all six MOD On-Ramp agencies, recipients of the Michigan Mobility Challenge grants, several other transit agencies, and private mobility providers. Discussions revolved around the role of payment integration and components of successful MOD business modes. Each workshop also included a site visit. In Pittsburgh, attendees visited a low-income neighborhood that would soon receive subscription-based mobility services through RubyRide, a current MOD project partner in Arizona. Another workshop was held in May 2019 in the Seattle-Tacoma region, home to two of the MOD Sandbox projects. The highlights are accessible at https://sharedusemobilitycenter.org/mod-sandbox-ika-workshop-in-seattle-tacoma-wa-may-14-2019/. The 50 attendees, including 20 from MOD Sandbox agencies, engaged in a session on insurance in the age of MOD, and another on the Mobility Data Specification, a tool several cities are using to share data between mobility providers and local governments. A field trip involving a MOD Sandbox-funded services region allowed participants to understand and contribute to improvements in the user experience, providing insight into signage, the app design, and fare integration. The workshops provided a venue for frank discussions among grantees, transit practitioners, and the private sector that supports the formation of partnerships and the sharing of best practice information.

- MOD Learning Center: The Learning Center was launched successfully in March 2019 with an announcement at the National Shared Mobility Summit in Chicago and is accessible at https://learn.sharedusemobilitycenter.org. The Learning Center is an online resource for those interested in shared mobility and MOD, allowing for a graduated learning experience from novice to expert. The Learning Center contains learning modules, policies, contracts, project details, case studies, multimedia, and other content in a user-friendly and searchable format. The Learning Center has attracted 2,967 visitors, who used the site over 5,017 sessions. The Direct Connect Case Study has been the most popular resource to date, available at https://learn.sharedusemobilitycenter.org/overview/direct-connect-what-the-first-transit-tnc-partnership-can-teach-us-pinellas-county-fl-2019/. The site is also being continually updated with entries, including these featured case studies:

- MetroLink Pilot by CapMetro in Partnership with RideAustin (https://learn.sharedusemobilitycenter.org/casestudy/metrolink-pilot-by-capmetro-in-partnership-with-rideaustin/)
- Seattle Bikeshare Program & Permit Process (https://learn.sharedusemobilitycenter.org/casestudy/seattle-bikeshare-program-permit-process/)
- RTC Paratransit Partnership with Lyft (https://learn.sharedusemobilitycenter.org/casestudy/rtc-paratransit-partnership-with-lyft)

- White Paper: SUMC wrote a white paper titled "Objective-Driven Data Sharing" to synthesize important challenges and recommendations for the transit agencies. It also included a decision tree to assist agencies in their approach to forming data sharing agreements, through lessons from the MOD Sandbox program, other partnerships, and supporting research. The paper was viewed over 1,200 times on SUMC's website, accessible at https://learn.sharedusemobilitycenter.org/overview/white-paper-objective-driven-data-sharing-for-transit-agencies-in-mobility-partnerships/.

- Webinar: SUMC conducted a webinar titled to "Objective-Driven Data Sharing in Mobility Partnerships" to disseminate information and practices on MOD projects. This webinar had 163 live attendees and has since been viewed 87 times. It is accessible at https://learn.sharedusemobilitycenter.org/multimedia/webinar-objective-driven-data-sharing-for-transit-agencies-in-mobility-partnerships/.

FTA Funding: $600,000

Figure 12 *May 2019 Mobility on Demand (MOD) Community of Practice Workshop*

Participants at the Seattle MOD Community of Practice workshop traveled via MOD Sandbox-funded services, including the King County partnership with Via, to test the operations and provide useful feedback to colleagues. Through the field testing experience, the project leads learned about limitations in geocoding and other operational barriers that customers may experience, allowing their demonstrations to be further refined.

Title: *Transit Automation Analysis and Research Plan Development*

Recipient: The Volpe Center

Project Description:

The purpose of this project is to develop the Strategic Transit Automation Research (STAR) Plan for FTA and to implement several projects included in the plan. The plan identifies specific transit bus automation research activities within a five-year horizon. The goals of the STAR Plan are to: 1) conduct enabling research to achieve safe and effective transit automation deployments; 2) identify and resolve barriers to deployment of transit automation; 3) build awareness to socialize automation for transit stakeholder community; 4) demonstrate market-ready technologies in real-world settings; and 5) leverage technologies from other sectors to move the transit automation industry forward. The STAR Plan was published in May 2018, and it can be accessed at https://www.transit.dot.gov/research-innovation/strategic-transit-automation-research-plan-report-0116.

The plan is organized around three complementary work areas: Enabling Research, Integrated Demonstrations, and Strategic Partnerships. Enabling research covers questions that must be addressed for the transit industry to engage more broadly with automation technologies. The research is expected to accelerate entry of manufacturers, suppliers, and transit providers into automation by building a common understanding of and resolving foundational issues – such as human factors, federal policy, costs, and benefits. Integrated demonstrations will spur technology development and growth in the transit industry by applying automation technologies in real-world settings. The evaluation results and lessons learned from the demonstrations will be widely disseminated to transit stakeholders. Strategic partnerships will leverage research projects and investments led by other agencies to improve the quality and usefulness of research by other actors, and disseminate findings to a broad community, expanding participation of providers and suppliers.

The plan includes a set of five technology packages for 14 use cases representing a range of near-term and long-term concepts and automation levels 1–5 (L1–L5) as defined by the Society of Automotive Engineers (SAE) International, accessible at https://www.sae.org/standards/content/j3016_201806/. The technology packages respond to stakeholder needs and include transit bus advanced driver assistance systems (ADAS), automated shuttles, automated maintenance and yard operations, automated MOD service, and automated bus rapid transit (BRT). These technology packages comprise the demonstrations outlined in the Integrated Demonstrations work area of the plan.

Results:

During this period, the following activities were conducted and products produced:

- Test Facility Requirements for Automated Transit Vehicles: Market assessments have shown that the transit industry lags the automobile and commercial vehicle industries in the development and commercialization of automation capabilities. This activity developed a set of voluntary requirements for transit industry consideration, based on industry input, to help transit bus automation manufacturers and other entities select suitable test facilities for automation research and development purposes. This effort aimed to expedite transit industry research and development activities in transit bus automation, leading to domestic commercialization at all levels of automation. It helped to accomplish the goals of conducting enabling research, leveraging technologies from other sectors, and demonstrating market-ready technologies. The requirements were published in February 2019, in the report *Determining Requirements for Automated Transit Bus Test Facilities: Considerations for Practitioners*, accessible at https://www.transit. dot.gov/research-innovation/determining-requirements-automated-transit-bus-test-facilities-considerations. The report contains a set of voluntary requirements, which provide a resource and reference for selecting test facilities with appropriate and necessary characteristics for transit bus automation research and development, and to assure that transit bus automation testing produces meaningful results.

- User Acceptance Study and Human Factors Research: The project included an assessment and study of user acceptance and human factors design considerations for high-priority transit automation, and user cases involving passengers, bus drivers, and other transit users. Human factors considerations were a component of all proposed demonstrations outlined in the STAR Plan. This activity helped inform the human factors research requirements for Demonstrations 1 and 2 outlined in the STAR Plan. During this period, a literature review was performed. Activities will continue once projects are selected for Demonstrations 1 and 2 as a part of the Integrated Mobility Innovation (IMI) solicitation. The activity addresses the STAR Plan goal of conducting enabling research to achieve safe and effective transit automation deployments and to understand human factors issues and needs as it pertains to transit bus automation.

- Knowledge Transfer: Sharing research results with the transit industry is important to advance the state of knowledge and progress in transit bus automation. Topics of the activity addressed all five of the STAR Plan goals. As a part of this effort, the following fact sheets were produced and published during this period:

- "Challenges of Transferring Automation Technologies from Light-Duty Vehicles and Commercial Trucks to Transit Buses" was published in Fall 2018, accessible at https://www.transit.dot.gov/research-innovation/fact-sheet-challenges-transferring-automation-technologies-light-duty-vehicles. This fact sheet summarized the findings of the Transferability of Automation Technologies report, published in FY 2018. The report examined the feasibility of transferring automated systems technologies from light-duty vehicles and commercial trucks to diesel transit buses.

- "Transit Bus Automation Risks, Barriers, and Mitigations" was published in February 2019, accessible at https://www.transit.dot.gov/research-innovation/transit-bus-automation-risks-barriers-and-mitigations-fact-sheet. This fact sheet summarized the potential risks, barriers, and mitigation strategies associated with the implementation of automation technologies in transit buses. The full report is found in Appendix B of the STAR Plan.

- Policy Review: This activity identified and analyzed Federal, state, and local policies relevant to transit automation, identified potential barriers to automation, and provided recommendations for revisions and/or development of new policies. This effort helped to identify statutes, regulations, and rules that affect transit bus automation implementation, provided clarity on the impacts, and made recommendations for potential changes to or modernization of relevant policies. An internal "Interim Policy Review Memorandum" was completed in 2018. It included key Federal policies, regulations, and guidance that may pose challenges to, or require revision in light of, the adoption and deployment of automated technologies by transit agencies in the U.S. This activity addressed the STAR Plan goal of identifying and resolving barriers to deployment of transit automation. The following additional policy review deliverables were produced during this period:

  - "State and Local Transit Bus Automation Policy Scan" was completed in Fall 2019. This internal document provided follow-on research to the Federal policy review to identify state and local policies that may pose challenges to the implementation of transit bus automation.

The results provided information to the public on the STAR Plan as a useful communication for planning and executing DOT-sponsored transit automation projects, and FTA research programs that include elements of automation.

FTA Funding: $950,000

Figure 13 *Strategic Transit Automation Research (STAR) Plan Related Reports*

The report *Determining Requirements for Automated Transit Bus Test Facilities: Considerations for Practitioners*, accessible at https://www.transit.dot.gov/research-innovation/determining-requirements-automated-transit-bus-test-facilities-considerations, describes the FTA-conducted research on guidelines for test facility requirements. It supports automated transit vehicle testing and demonstration projects. Stakeholders were consulted, including federal agencies, universities, transit agencies and operators, test facilities, and industry representatives. Based on those conversations, a list of requirements was compiled in the areas of test facility features, functionality and performance, safety, environmental resilience, human factors, and data collection and management. Multiple audiences may benefit, including transit agencies, state and local transportation departments, academic and research institutions, industry representatives, and other organizations interested in testing automated transit vehicles. Uses could include informing product development, test facility designs, pilot demonstrations, and other planning activities.

Title: *Strategic Transit Automation Research (STAR) Plan Enabling Research and Implementation*

Recipient: The Volpe Center

Project Description:

Continued implementation of FTA's Strategic Transit Automation Research (STAR) Plan includes additional research, development, and demonstration of automation in transit bus vehicles. This project implements 3 activities outlined in the STAR Plan: 1) Market Analysis for Automated Transit Buses and Supporting Systems; 2) Business Case for Transit Automation; and 3) Evaluation Guidance for Integrated Demonstrations. The STAR Plan was published in May 2018, available at https://www.transit.dot.gov/research-innovation/strategic-transit-automation-research-plan-report-0116. The goals of these additional activities are to gain an understanding of the concerns about the viability of transit automation as an investment, assess the market for automation of transit buses, develop a business case for deploying automated transit buses, and assist transit agencies in developing a robust, rigorous evaluation component for the pilot and demonstration projects.

Results:

Significant outputs from FY 2019 include:

- Market Analysis for Automated Transit Buses and Supporting Systems: This activity provided an assessment of the U.S. product market for partial and full automation technologies for transit buses. Information and results from this activity were obtained from a literature review and technology provider

interviews. The findings were documented in the following report titled *Transit Bus Automation Market Assessment*, published in Summer 2019 (https://www.transit.dot.gov/research-innovation/fta-reports-and-publications). The assessment helped FTA understand the readiness and scope of planned activities outlined in the STAR Plan, such as the integrated demonstrations, and was necessary for transit agencies to understand the viability of transit automation as an investment. The assessment revealed that partial automation of transit buses, such as automated steering or braking, is not commercially available currently in the U.S. However, smaller fully automated shuttles are becoming more available for early pilot testing. While many automated shuttle demonstration and pilot projects are being conducted, this vehicle mode is not currently produced at scale, and many models do not comply with Federal regulations. Therefore, currently available automated vehicles may need to be adapted or modified for transit use, and STAR Plan Demonstrations 1 and 2 will need to include a development phase for these vehicles prior to their testing in the field.

• Business Case for Transit Automation: The scope of this activity was to develop a business case framework for automated transit bus operations; gather data; build, test, and refine the model; and produce a report documenting the results. It was based on the abovementioned *Transit Bus Automation Market Assessment*. This activity produced a model to help transit agencies determine and make a business case for transit bus automation investments. The model included overall processes and metrics for investment prioritization, project selection, and business case development. The business case described the commercial benefits of adopting transit bus automation practices, thus justifying such an investment to the transit industry and encouraging the adoption of automation. Work will continue into FY 2020 when the final report will be published.

• Evaluation Guidance for Integrated Demonstrations: A number of transit agencies are, or are planning to, conduct pilot demonstrations of partial or full automation of bus service and operations. These pilots typically showcase the capability of automation, but also provide an opportunity to assess the impacts (e.g., benefits). Since automation is a new field, and many transit agencies lack the expertise and experience of conducting impacts analyses of these complex technologies and systems, FTA developed a guidance document titled *Considerations for Evaluating Automated Transit Bus Pilots and Demonstrations*, published in Summer 2019 (https://www.transit.dot.gov/research-innovation/fta-reports-and-publications) to assist transit agencies with planning and conducting self-evaluations. The guide helps facilitate data and information collection from these pilot projects and increases the body of knowledge in the industry to advance transit bus automation development and implementation.

The information and results from these activities will assist and encourage the transit industry in adopting automation in an informed and coordinated manner by providing an understanding of the automation market and articulating the benefits, ultimately increasing the use of automated technologies nationwide.

FTA Funding: $350,000

Figure 14   *Transit Bus Automation Market Assessment*

The emerging automated transit bus market has received enthusiastic media coverage, but stakeholders may not clearly understand the difference between conceptual ideas, prototype systems, and available products. To help align expectations with reality and assist in planning, this market assessment report conveys the state of automated transit bus technology in terms of its availability, capabilities, and limitations. It aims to inform FTA, transit agencies, and other transit industry stakeholders in understanding the market, educate transit agencies on the availability and level of automation commercially available, and clarify the level of transit industry research and development needed to address transit agencies' interests and needs. The *Transit Bus Automation Market Assessment* report is available to the public at https://www.transit.dot.gov/research-innovation/fta-reports-and-publications.

Title: *Transit Bus Automation Strategic Partnerships*

Recipient: University of South Florida (USF) Center for Urban Transportation Research (CUTR)

Project Description:

The purpose of this project is to supplement the work organizations are conducting on transit bus automation research and help disseminate their research findings to the broader transit community. The goals of this project are to: 1) leverage investment by others, in both the private and public sectors; and 2) gain access to datasets and results which would otherwise be unavailable. This project assists FTA in creating strategic partnerships with organizations conducting automated vehicle research, an activity prioritized in the Strategic Transit Automation Research (STAR) Plan. Partnering with transit agencies on their own pilots increases the opportunity for FTA to expand and accelerate learning about automation implementations and share that information with the industry. In turn, this can enhance industry knowledge regarding automation, highlight successful strategies for automation adoption, and facilitate the industry's adoption of automated technologies, which have numerous safety and economic benefits.

Results:

The Transit Bus Automation Strategic Partnerships project was active in FY 2019. The recipient produced the following relevant outputs:

- Strategic Partnerships Solicitation: In January 2019, CUTR announced the Transit Bus Automation Strategic Partnerships solicitation, which called for organizations to apply to become an FTA strategic partner. The announcement is available at https://www.transit.dot.gov/research-innovation/ transit-automation-research-funding-opportunities. CUTR promoted this notice through various media, such as APTA's *Passenger Transport* and *Mass Transit Magazine*, as well as the website for the Community Transportation Association of America (CTAA). CUTR received, reviewed, and summarized 11 applications and assisted FTA in making its final recommendations.

Following the announcement of strategic partners in Summer 2019, FTA and the selected strategic partners will share data on the partners' project and will respond to requests for assistance, such as inquiries from agencies who are considering similar automation projects. This activity meets the project goals of leveraging investment by others and accessing datasets and results.

FTA Funding: $600,000

Title: *Accessible Transportation Technologies Research Initiative (ATTRI)*

Recipients: State DOTs, transit authorities, and non-transit providers

Project Description:

ATTRI identifies, collaborates, coordinates, develops, and implements transformative solutions to advance accessible transportation and independent mobility. It is a multi-year, multimodal, multi-agency research and development effort co-led by FTA, the Federal Highway Administration (FHWA), and the Intelligent Transportation Systems (ITS) Joint Program Office (JPO). ATTRI's goals are to: 1) leverage recent advances in vehicle, infrastructure, and pedestrian-based technologies; and 2) identify accessible data, mobile computing, robotics, artificial intelligence, object detection, and navigation tools to identify, develop, and deploy transformative solutions in advancing accessible transportation and independent mobility solutions. Many of America's 57 million people with disabilities face barriers to transportation and the opportunities afforded by mobility. Whether to ensure access to jobs, healthcare, or basic life activities, mobility is a key enabler of quality of life and success. FTA is working with ATTRI and seizing on technological advances to enable people to travel independently, regardless of their individual abilities, thus removing barriers to transportation.

Results:

In FY 2019, the applications in the target technology areas progressed to Phase II of the research plan:

- Wayfinding and Navigation Technologies: ATTRI had the following results in FY 2019 with significant impacts to the areas served:

  – *Smart Cane for Assistive Navigation (SCAN)*: A robotic white cane for blind persons and based on previous Intelligent Situation Awareness and Navigation Aid (ISANA) and Co-Robotic-Cane applications developed by City College of New York (CCNY).

  – *Specialized Media for Assisting Route Travel (SMART) Wayfinding Specification*: An open wayfinding media specification and application developed by AbleLink Technologies, Inc. This project is developing a common route format for presenting travel instructions to individuals with cognitive disabilities to allow users of these wayfinding technologies to access and share routes that enable them to use public transit more independently. AbleLink developed a final SMART specification in February 2019, updated the WayFinder application to be compliant with the specification, and begun an eight-week field demonstration in June 2019 with over 20 participants with cognitive disabilities. The field demonstration and final report were completed in Summer 2019. The report is accessible at https://rosap.ntl.bts.gov/view/dot/43629/.

  – *AccessPath*: A wayfinding tool for wheelchair users and people with visual disabilities developed by Pathway Accessibility Solutions, Inc. This project includes wayfinding algorithms using a connected network of sidewalks, pathways, and crosswalks that integrate pathway quality, and a user interface tailored towards wheelchair users and people with visual disabilities, customized based on a user's preferences. Progress to Phase II was approved in June 2019 to update the wayfinding application and provide additional sidewalk condition data. The Phase I prototype application was released in March 2019, and Phase II updates are expected to be released in Fall 2020.

  – *NEON® Smart Wayfinding and Navigation Service (SWaN)*: Sensor-based indoor navigation using high accuracy 3-D location technology and NEON sensor fusion and mapping technology developed by TRX Systems, Inc. TRX conducted a hackathon and developed updated developer tools in May 2019. Testing of the application in a complex transit hub will be completed by the end of Summer 2019.

  The benefits of the wayfinding and navigation technologies are increased access to transit, especially access of target populations such as people with disabilities and older adults. The benefits meet the goal of ATTRI by improving access to transportation, thus increasing access to opportunities.

- <u>Pre-Trip Concierge and Virtualization Technologies</u>: Smart Travel Concierge System (STCS): A suite of technologies for assessment of transportation readiness, pre-trip planning and execution, and trip virtualization activities specifically for individuals with cognitive disabilities developed by AbleLink Technologies, Inc. AbleLink added additional learning curriculum content in February 2019 and demonstrated the updated software in June 2019. The final demonstration, testing and reporting was completed in Fall 2019. The benefit of the pre-trip concierge and virtualization is that it sets the standards for access of people with cognitive disabilities into the transit after their readiness levels are assessed by the system. This meets the goals of ATTRI by providing access for people with cognitive disabilities to opportunities that did not exist for them without the use of this system.

- <u>Safe Intersection Crossing Technology: Adaptive Safe Intersection Crossing</u>: An application developed by Carnegie Mellon University to connect smart phone devices of pedestrians with disabilities to traffic signal controllers allowing pedestrians to determine the current walk phase of the intersection and request additional time to cross. The Concept of Operations, Requirements and System Design document were updated with additional localization and tracking functionality in Winter and Spring 2019. A final field test was conducted in Summer 2019. The benefit of safe intersection crossing is that it closes the gap in the complete trip cycle by providing safe travel options to people with disabilities in completing their trip. Safe intersection crossing application meets the ATTRI goals by providing scalable solutions for people walk to transit stations and other destinations, which they would have avoided in the past due to unsafe crossing conditions.

Robotics applications using assistive technologies are also being developed under a different technology area, Automation and Robotics, separately sponsored by a partner organization, the National Institute on Disability, Independent Living, and Rehabilitation Research. Documents, detailed project descriptions, updates, and webinar recordings, and upcoming events regarding the applications and prototypes developed under the ATTRI Program can be accessed at the ATTRI Program website located at https://www.its.dot.gov/research_areas/attri/index. htm.

FTA Funding: $2,500,000

Figure 15 *Pre-Trip Concierge & Virtualization: Specialized Media for Assisting Route Travel (SMART) WayFinder*

As part of its Accessible Transportation Technologies Research Initiative (ATTRI)-funded research, AbleLink Technologies is developing independent travel support technologies for individuals with cognitive disabilities. Its suite of tools consists of Travel Manager, SMART Travel Library, and WayFinder Mobile App, which utilizes SMART-compliant routes for desired destinations to provide geo-location-based multimedia instructions. WayFinder helps people with intellectual disabilities travel safely, whether by bus or on foot, by simply tapping on the picture of their desired destination and the software takes over from there. With Way-Finder, specific travel routes can be created, then activated from the GPS location. A support professional, caregiver, or family member can create completely customized and personally meaningful content, all delivered in the AbleLink trademark simplified interface. The GPS-based tracking triggers WayFinder to safely guide the user with step-by-step visual and audio instructions. WayFinder can help assure the traveler that they are on the correct route by pointing out important landmarks along the way, even telling them "this is not your stop" when they see others departing. This new "de facto" industry standard will encourage new wayfinding technologies to be developed for individuals with cognitive disabilities and others with special needs. Details and demonstration videos of this technology can be found at https://www.ablelinktech.com/index.php?id=33.
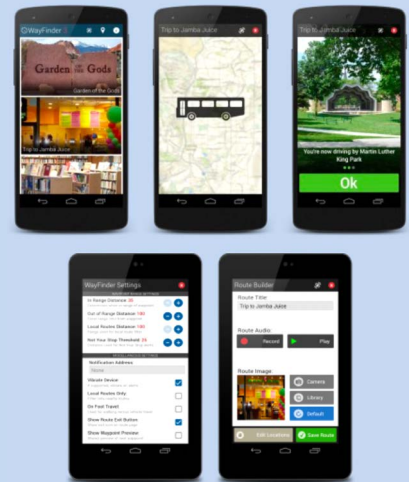
Route building is easy for the travel trainer or other support professional. A simple wizard guides the user to record audio prompts, select images, and create steps the user will experience along the way.

Title: *Mobility Payment Integration (MPI) Program*

Recipient: The Volpe Center

Project Description:

The purpose of this program is to position FTA to understand the advanced and evolving technologies for payment systems within the public transportation and overall mobility domains. Evolving personal mobility options include publicly owned docked bikeshare systems and privately-owned options such as dockless bikeshare, ridesourcing applications to hail rides via smartphones, and microtransit services. The goals of this program are to: 1) explore evolving solutions and operational approaches for integrated payment solutions; 2) demonstrate and evaluate integrated payment solutions through investment and strategic partnerships; 3) prepare the transportation industry to utilize multimodal integrated payment services that will enhance efficiency, improve customer convenience, and increase access to mobility services; and 4) support DOT's strategic goal of innovation by enabling the widespread deployment of multimodal integrated mobility solutions that are connected, equitable, and effective. The program aims to explore relationships between public transit agencies, payment integrators, payment suppliers, private mobility service providers (MSPs), technology companies and their impacts.

The MPI program is an opportunity to establish and influence data harmonization, data sharing and integration, data standardization, and data requirements for regional integration of mobility payment systems. The MPI program will provide the additional research that is needed to establish guidance on policy, system integration, data sharing and management, standards, and sustainable collaboration models to make informed policy and deployment decisions.

Results:

In FY 2019, the program produced the following results:

- Internal and External Stakeholder Engagement: The Volpe Center and FTA conducted a series of outreach efforts with stakeholders, including representatives of FTA and other DOT modal administrations. It also included urban and rural transit agencies, MSPs, paratransit and specialized transportation providers, along with payment industry experts. These activities included periodic web forums, interviews, and roundtables. The discussion covered technical challenges and opportunities, emerging trends, equity concerns and solutions, data management and standards, procurement options, customer experience and satisfaction, and other related topics. The engagement activities assisted FTA to develop prioritizations and inform the overall direction for the research program.

- State of the Practice Scan Report: In May 2019, FTA completed the *Mobility Payment Integration: State-of-the-Practice Scan* report. The document presents findings collected through a review of published literature, an ongoing dialogue with stakeholders in the private and non-profit sectors, and government agencies currently engaged in payment integration efforts. The report can be accessed at https://www.transit.dot.gov/research-innovation/fta-reports-and-publications. The report allows for the understanding of the current state of the industry, potential benefits, challenges and risks related to MPI.

- Framework: The MPI stakeholder engagement efforts led to the development of a framework orienting the primary focus areas of the research towards governance, system architecture/security, and customer service. The framework reflected the input from the internal and external stakeholders, informing FTA about the practical needs and challenges. The framework focused primarily on: 1) policy and governance; 2) multimodal payment products and architecture; 3) payment settlement and revenue reconciliation; and 4) testing, implementation and customer service. The framework document was completed in Fall 2018 and appended to the *Mobility Payment Integration: State-of-the-Practice Scan* report. In order to stay relevant and capture the evolvements in the industry, the framework will be periodically updated with continuous input from the stakeholders.

FTA Funding: $400,000

Figure 16 *Mobility Payment Integration: State-of-the-Practice Scan*

Mobility Payment Integration: State-of-the-Practice Scan is a scan of state-of-the-industry efforts toward MPI, which can deliver many potential benefits. This scan presents findings collected through an extensive literature search, an Internet inventory of deployments, and more than 20 group and individual discussions with professionals from the public, private, and non-profit sectors that are currently engaged in MPI. The FTA MPI project team is iteratively developing an MPI demonstration and deployment planning framework based on ongoing input from MPI Program stakeholders. The report can be accessed at https://www.transit.dot. gov/research-innovation/fta-reports-and-publications.

Title: *Transit and Health Access Initiative*

Recipients: Competitively selected Transit and Health Access demonstration grant recipients

Project Description:

The Transit and Health Access Initiative (formerly known as "Rides to Wellness") builds partnerships, stimulates investment, and drives change across the health and transportation sectors to ensure that everyone can reach the health services they need. It is associated with the Coordinated Council on Access and Mobility (CCAM), a federal interagency council established by Executive Order 13330 in 2004.

The primary purpose of the initiative is to test promising, replicable public transportation healthcare access solutions that support the goals of increased access to care, improved health outcomes, and reduced healthcare costs. The selected projects are diverse, piloting innovative concepts from assessing new technology innovations to determining more efficient ways to schedule a ride. The projects leverage creative community partnerships and test systems for coordinating trips. While demonstrating and deploying these real-world solutions, recipients are collecting data to prove the value of linking transportation options with healthcare appointments.

Results:

Seven of the eight demonstration grant projects were active in FY 2019. The Detroit Department of Transportation was unable to provide the 20% local match, despite trying to obtain a new partner, and the funding lapsed. The following are relevant and significant results of the Transit and Health Access projects for FY 2019:

- Riverside County Transportation Commission (RCTC): Created the Blythe Wellness Express (BWE), a program that provides the underserved and geographically isolated community of Blythe with access to preventive healthcare. At program registration, 42% of BWE riders reported being unable to go to the doctor in the last six months because of a lack of transportation. Throughout the program, numerous survey comments from riders noted that BWE is their only way to access healthcare. Of the riders who provided health information that could be tracked over time, 88% reported being able to improve or maintain their health during the period from registration to their most recent trip. BWE consistently delivered more than 100 one-way trips per month since February 2018. Blythe's smaller population and rural isolation limits the pool of potential riders, meaning that continuing promotion and outreach will be crucial to the program's sustainability. After the pilot period, BWE service will expand to allow trips beyond medical purposes, a change that is expected to increase new registrations and help to grow ridership. The BWE supported the goal of the Transit and Health Access Initiative by providing valuable best practices and lessons learned for connecting isolated communities with lifeline access to healthcare.

- Atlanta Regional Commission (ARC): Launched Rides for Wellness, a mobility management program that empowers patients to take public transportation to healthcare and other essential services with confidence. The program achieves this through travel training, free transit passes, and assistance with enrollment into paratransit and reduced fare programs. Of the patients served during the pilot, 68% improved their appointment adherence as follows: approximately 39% increased their appointment attendance rate, nearly 48% decreased their appointment cancellation rate, and 40% decreased their no-show rate. At the end of the program, participants reported that their health was "good" as opposed to "fair" before entering the program, and participants' self-reported average number of healthy days increased by 26%. Among participants who improved their appointment adherence, the average number of self-reported healthy days increased by 33%. Moreover, an analysis comparing Rides for Wellness to a no-intervention control group showed the program to be a cost-effective method to improve patients' health-related quality of life. The Rides for Wellness demonstration provides a replicable model for using mobility management to successfully increase access to care, improve health outcomes, and reduce healthcare costs.

- Iowa Department of Transportation: Introduced Delaware County Connections, a volunteer-based transit service that provides low-income riders in rural areas of Delaware County with a transportation alternative for accessing healthcare and wellness activities. The grant enabled the purchase of an ADA accessible van that offers 40 hours of weekly service, including service on evenings and Saturdays, when RTA buses have stopped running.

During the pilot period, the service provided 364 rides traveled over 3,649 miles, and secured 4 volunteer drivers and 2 volunteer dispatchers. Results from Community Health Needs Assessments conducted in 2015 and 2019 show that the number of people reporting transportation as a major barrier to accessing healthcare had decreased 90% by the end of the pilot period. Given these positive results, RTA intends to continue the program beyond the FTA-funded demonstration period. The next priority is to develop the capacity to accommodate every ride request, a goal that will require expanding the pool of volunteer drivers by actively recruiting on a continual basis.

- Ohio Department of Transportation: Created the Mommy and Me Ride Free (MMRF) program to provide transportation options to pregnant and parenting women living in areas of Toledo. Using the local fixed-route bus and paratransit service, the MMRF program provides clients with transportation for purposes not covered by Medicaid Managed Care plans such as same-day medical appointments, employment, the grocery store, the diaper bank, and parenting classes. Since the pilot's inception, 619 clients were enrolled into MMRF, 105 clients were renewed, and 474 one-way rides were provided. Usage varies by month but has been steadily increasing. Of the clients that renewed their enrollment in MMRF, 92% reported that the program helped them get where they need to go; other comments indicated that the program gave clients more independence and personal control over their lives and helped them to reach their goals. Many clients reported that for healthcare appointments, where timeliness is essential, they chose to ride the bus because it was often more reliable than the Medicaid cab rides. The feedback received about MMRF was overwhelmingly positive, and numerous clients and care coordinators expressed concern about the program's end.

Project/Program Evaluation:

The currently active Transit and Health Access demonstration projects provide access to healthcare and other quality of life destinations to some of the most vulnerable populations: older adults, people with disabilities, and people with low incomes. Particularly in rural, geographically isolated communities, these services are a lifeline and have an immense impact for people who would otherwise have no access to medical care.

Through creative partnerships between health, transportation, and other service providers, the demonstration projects have introduced creative new services or capitalized on existing transit services. The projects are diverse and multi-faceted, making use of a number strategies including innovative mobility management and coordination, specialized rural transit services, volunteer drivers, travel training, and assistance with enrollment into reduced fare and paratransit programs.

By removing transportation as a barrier to healthcare access, the demonstration grants have enabled clients to improve their appointment adherence, increase their number of healthy days, and improve or maintain their overall health status, ultimately leading to greater independence and enhanced quality of life. Due to the successes enable by the grants, many programs are continuing beyond the pilot period and focusing on new priorities to refine and expand their services.

Furthermore, the demonstration projects are informing the industry on how to approach transit and health-related partnerships and show the value of such partnerships in terms of increased access to care, improved health outcomes, and reduced healthcare costs. The Independent Evaluation of the demonstration grants also includes knowledge transfer activities to drive positive, transformational change at the intersection of healthcare and transportation.

FTA Funding: $2,355,758

Table 7 *Transit and Health Access Projects Receiving Assistance from FTA, FY 2019*

Project Title	Project Recipient	City and State	FTA Award
Blythe Wellness Express	Riverside County Transportation Commission	Riverside, CA	$185,753
Rides to Wellness: Coordinating Inpatient Medical Transportation for San Diego County	San Diego Association of Governments	San Diego, CA	$160,000
Rides for Wellness	Atlanta Regional Commission	Atlanta, GA	$337,628
Delaware County Connections Program	Iowa Department of Transportation	Ames, IA	$130,560
Rides2Wellness Detroit	Detroit Department of Transportation	Detroit, MI	<$509,475>*
Gateway Program	Bi-State Development Agency	Saint Louis, MO	$940,251
GO Buffalo Mom	Niagara Frontier Transportation Authority	Buffalo, NY	$468,566
Mommy and Me Ride for Free Program	Ohio Department of Transportation	Columbus, OH	$133,000
		Total	$2,355,758

Project lapsed; the Detroit Department of Transportation was unable to provide the 20% local match, despite trying to obtain a new partner.

Figure 17 *Transit and Health Access Initiative Impact*

Riverside County Transportation Commission and its partner organizations received $185,753 for the Blythe Wellness Express (BWE), a program that provides access to preventative healthcare for South California residents. The travel navigator/mobility management coordination project addresses access to services in an underserved area and involves staff from the public transit agency, healthcare providers, and community volunteers. Blythe local and Navy veteran Charles Griffin used the Veterans Administration bus to his medical appointments. Griffin considered the Blythe Wellness Express bus a "literal life saver." The project increased access to care by allowing users to make and keep appointments.

Title: *Human Service Coordination Research (HSCR) Deployment Program*

Recipients: Transit agencies, local governments, non-profit organizations, and state DOTs (see Table 8)

Project Description:

The purpose of this program is to support the implementation of innovative strategies to better coordinate human services transportation with the intention of providing more effective and efficient transit services to seniors, individuals with disabilities, and individuals with low-incomes. The goals of the program are to: 1) integrate new mobility tools such as demand-responsive bus services; 2) improve multi-modal connectivity; 3) address accessibility issues through innovative technologies and practices; 4) improve the quality of the traveler experience and the transit product; and 5) identify new, mobility-enhancing practices and technologies. The projects funded through this program address gaps in transportation services pre-identified in locally developed Coordinated Public Transit-Human Services Transportation Plans. Nationally, these projects can serve as implementation guides to communities seeking to improve access to public transportation by building partnerships among health, transportation, and other service providers.

Results:

On May 22, 2019, FTA announced the selection of 14 projects funded under Federal public transportation law (49 U.S.C. § 5312(b)). The selected projects are shown in Table 8. FTA is working with the selected recipients to define the statement of work for each project and how they will meet the goals of HSCR. FTA expects to have the 14 projects active by the end of March 2020.

Project/Program Evaluation:

Under Federal public transportation law (49 U.S.C. § 5312(e)(4)), demonstration programs, including the HSCR Deployment, require an independent evaluation to be conducted no later than two years after the date on which it received assistance. FTA will plan how to conduct the independent evaluation once the 14 projects are active.

FTA Funding: $2,207,857

Table 8 *Human Service Coordination Research (HSCR) Projects Receiving Assistance from FTA, FY 2019*

Project Title	Project Recipient	City and State	FTA Award
Central Alabama Transportation Resource Center	United Way of Central Alabama, Inc.	Birmingham, AL	$148,000
Bridging Medical and Healthy Food Access with Transportation in Cochise County, Arizona	Southeastern Arizona Governments Organization	Bisbee, AZ	$235,852
Alternative Senior Transportation Service using TNC's	County of Fulton	Atlanta, GA	$243,778
Partners for Enhanced Access to Treatment (PEAT)	Community Action Partnership of Central Illinois	Lincoln, IL	$40,000
City of Shreveport Paratransit Passenger Portal Project	City of Shreveport	Shreveport, LA	$54,472
Enhancing Technology Resources for Increased Mobility Options	Maryland Transit Administration	Baltimore, MD	$240,000
Mobility Solutions for Maine: Building a Multi-Sector Network to Drive Improved Coordination and Access	Greater Portland Council of Governments	Portland, ME	$240,000
2-1-1 NH as NH's Simplified Ride Guide	New Hampshire Department of Transportation	Concord, NH	$17,295
NJ Transit: Transportation for Everyone Videos	NJ Transit	Newark, NJ	$60,600
Coordinated Volunteer Transportation in Western New York State	Volunteer Transportation Center, Inc.	Watertown, NY	$145,968
Osage Nation HSCR Project – Increasing access to transportation for targeted populations	Osage Nation	Pawhuska, OK	$73,892
Rides Toward Work	Rhode Island Public Transit Authority	Providence, RI	$150,000
Human Services Transportation Assistance – Bus purchase and Operating Assistance	Southeast Tennessee Human Resource Agency	Dunlap, TN	$388,000
Recovery Rides – Access to Substance Abuse Treatment and Employment	Vermont Agency of Transportation	Montpelier, VT	$170,000
		Total	**$2,207,857**

Title: *Mobility Services for All Americans (MSAA)*

Recipients: State DOTs and transit authorities (see Table 9)

Project Description:

The purpose of MSAA is to increase mobility and transportation accessibility through deployment planning and preparation of coordinated Human Service Transportation (HST) systems that use Intelligent Transportation Systems (ITS) capabilities. Persons with disabilities comprise nearly 20% of the US population. In addition, 45% of eligible veterans file claims for disability, and 72.1 million people will be over age 65 by 2030. A lack of accessible transportation options hinders the mobility of many of the travelers in those groups. MSAA assists communities and service providers to bridge that gap by developing a scalable and interoperable Travel Management Coordination Center (TMCC). It allows agencies to use a coordinated system for the customers to easily book rides and transfers across service area and providers. MSAA builds upon a centralized data exchange capability that allows

multiple providers to share information about availability, capacity, rider needs, rider credentials, and useful data such as real-time vehicle locations and schedules.

The goals of MSAA are to: 1) apply ITS solutions to advance HST delivery; 2) overcome technical and institutional barriers to promote system interoperability; and 3) showcase promising technologies and practices that improve travel planning and coordination for people who need specialized transportation and who are transit-dependent. The initiative helps the transit community by providing vital services for veterans, older adults, people with disabilities, and others who rely on community transportation to access everyday needs such as employment, medical care, education, social, recreation, and entertainment.

Results:

Two MSAA projects were active in FY 2019, and two projects were completed in prior fiscal years. In FY 2019, MSAA produced the following relevant results:

- Project Final Reports: The following four final reports were published in FY 2019:
  - Atlanta Regional Commission (ARC) – *Atlanta Region TMCC Platform for One Click*: This report summarizes the concept of operations, system development, and design work conducted to extend the functionality of the current Simply Get There multimodal trip planner. The full report can be accessed at https://www.its.dot.gov/research_archives/msaa/pdf/ARC_MSAA_SimplyGetThere_FINAL.pdf.
  - United Cerebral Palsy San Luis Obispo/ Ride-on Transportation – *Travel Management Coordination Center (TMCC) Project*: This report provides a comprehensive review of the administrative, operational, and technical design and development of the SLO County Travel Management Coordination Center (TMCC). The full report can be accessed at https://www.its.dot.gov/research_archives/msaa/pdf/Ride-On_FinalReport.pdf.
  - VIA Mobility Services - *Trip Exchange Software Platform*: This report summarizes the system development and integration efforts for the platform that enhances the current coordination model used in Longmont, CO, and scales the concept up to more locations and more providers, with a goal of having a product that can be replicated by other systems. The full report can be accessed at https://www.its.dot.gov/research_archives/msaa/pdf/Denver_Final_Report.pdf.
  - Wisconsin Agency on Aging Resources - *GWAAR TMCC of Southern Wisconsin*: This report summarizes the concept of operations, system requirements and design, and implementation plans, as well as outlines the processes undertaken to develop them, including stakeholder involvement, needs identification, and collaborative design sprints. The full report can be accessed at https://www.its.dot.gov/research_archives/msaa/pdf/Madison_FinalReport.pdf.

These reports provided benefit by documenting project successes and serving as a medium for sharing the technical and process knowledge with other agencies/entities that wish to develop and deploy similar systems.

- Knowledge and Technology Transfer (KTT): Activities to update the MSAA Program website with, a library of technical documents and publications, including project documents, external resource links, and program contact information. The website can be accessed at https://www.its.dot.gov/ research_archives/msaa/index.htm.

- Publications: The following three articles were posted on the MSAA website to provide information and technical assistance to researchers and potential MSAA deployers:
  - "Mobility Services for All Americans (MSAA): Integrating Human Service Transportation in the Mobility on Demand (MOD) Future": This article discusses the MSAA concepts that are key tools of mobility management, presenting an opportunity to better leverage Human Service Transportation (HST) resources and serve HST populations. It is accessible at https://www. its.dot.gov/research_archives/msaa/pdf/Integrating_HST_MOD.pdf.
  - "Supporting the Mobility on Demand (MOD) Vision through Mobility Services for All Americans (MSAA)": This article discusses the feasibility of expanding mobility options to serve the broader population, and is accessible at https:// www.its.dot.gov/research_archives/msaa/pdf/Supporting_MOD_Vision.pdf.
  - "Deploying Technology to Facilitate Service Coordination: Making it Work": This article summarizes the service-related challenges agencies face. It also summarizes the technologies and characteristics of the nine service stages of the agencies that responded to a survey, distributed at the National Conference on Rural Public and Intercity Bus Transportation. The survey is accessible at https://www.its.dot.gov/research_archives/msaa/pdf/ MSAA_Survey_MakingItWork.pdf.

The MSAA assisted with meeting stakeholder needs, requirements, and architecture models shared and used as baselines for TMCC systems nationwide. It provided documentation of TMCC evaluations and lessons learned. It provided service and expanding travel opportunities for all Americans, including those with mobility challenges to provide a better quality of life. The MSAA program worked to improve the travel experience for all Americans, with an emphasis on those who are transportation disadvantaged. The impact of the MSAA program is the improvement to the quality of life of people who are transportation disadvantaged by integrating paratransit, HST, and other specialized transportation services, thus providing travelers more options for destinations, schedules, fees, service frequency, and, as a result, more opportunities. The MSAA funding recipients have already improved their systems or in the process of deploying a system based on the concepts proposed by MSAA.

FTA Funding: $333,570

Table 9 *MSAA Projects Receiving Assistance from FTA, FY 2018*

Project Title	Project Recipient	City and State	FTA Award
San Luis Obispo County Travel Management Coordination Center	United Cerebral Palsy of San Luis Obispo County/Ride-On Transportation	San Luis Obispo, CA	<$186,850>*
Atlanta Region Platform for One Click, Phase II	Atlanta Regional Commission	Atlanta, GA	$140,250
Northwest Metro Denver Coordination System	Via Mobility Services	Denver, CO	<$275,125>*
Travel Management Coordination Center (TMCC) of Southern Wisconsin	Greater Wisconsin Agency on Aging Resources	Madison, WI	$193,320
		Total	$333,570

* Project closed prior to FY 2019.

Figure 18 *Atlanta Region Simply Get There Phase II (Trip Triage Design)*

The Atlanta region's Simply Get There web application serves as a one-stop shop for information and referral related to multi-modal transportation options. Upon completion of their MSAA project, the Atlanta Regional Commission (ARC) demonstrated that the fully functional Simply Get There system met each of the MSAA goals presented during the project kickoff. The Atlanta region MSAA project demonstrated that public transportation needs can be met in a manner that is both more efficient and more beneficial to the general public. This MSAA project enhanced mobility and accessibility for the transportation disadvantaged and general public; used Federal transportation funding resources efficiently; was driven by the needs and efforts of the local community; provided a simplified point of access for traveler support; supported coordinated and comprehensive service operations and management; and streamlined program management requirements and procedures. The fully functional Simply Get There web application can be accessed at https://www.simplygetthere.org/en/content/project_background.

Infrastructure

Description:

FTA has a successful history of supporting transformative public transportation infrastructure research and demonstration projects to include those assets that are used to directly support and provide public transportation service. FTA's research focus is to ensure that transformative innovations meet the public demand for safe and speedy adoption and create private sector economic benefits. FTA applied this thinking to all research activities within the infrastructure research program to include zero emissions vehicles, and related facilities. Through infrastructure research activities, FTA assessed the development and deployment of zero emission transit buses, facilities, and related charging and maintenance technologies as well as ways to ensure effective management of all capital assets.

Objectives:

- Improve lifecycle maintenance by evaluating methods, products, approaches, and practices to develop products or service more efficiently.
- Enhance the environment by providing mechanisms for mainstreaming and determining performance specifications for low and no emission transit bus components through university-based laboratory testing.
- Improve the build and project approval process.
- Stimulate economic growth.

FTA had seven active Infrastructure projects in FY 2019, as shown in Table 10.

Table 10 *Infrastructure Programs Receiving Assistance from FTA, FY 2019*

Infrastructure Programs		
Type of Project	**Project Title**	**FTA Funding**
Research	Low or No (LoNo) Emission Component Assessment Program	$12,000,000
Innovation & Development	Low or No (LoNo) Emission Bus Testing Centers	$2,000,000
Demonstration & Deployment	Track Asset Management Demonstration	$4,225,000
Research	Best Practices and Research for Lifecycle-Based Management	$200,000
Research	Bus Propulsion Evaluation and Support	$1,400,000
Demonstration & Deployment	Bus Efficiency Enhancements Research and Demonstrations (BEERD) Program	$3,000,000
	Total	**$22,825,000**

In FY 2019, FTA funded eight recipients located in seven states to advance DOT's infrastructure priority as demonstrated in Figure 20.

Figure 19 *Locations of Infrastructure Program Recipients*
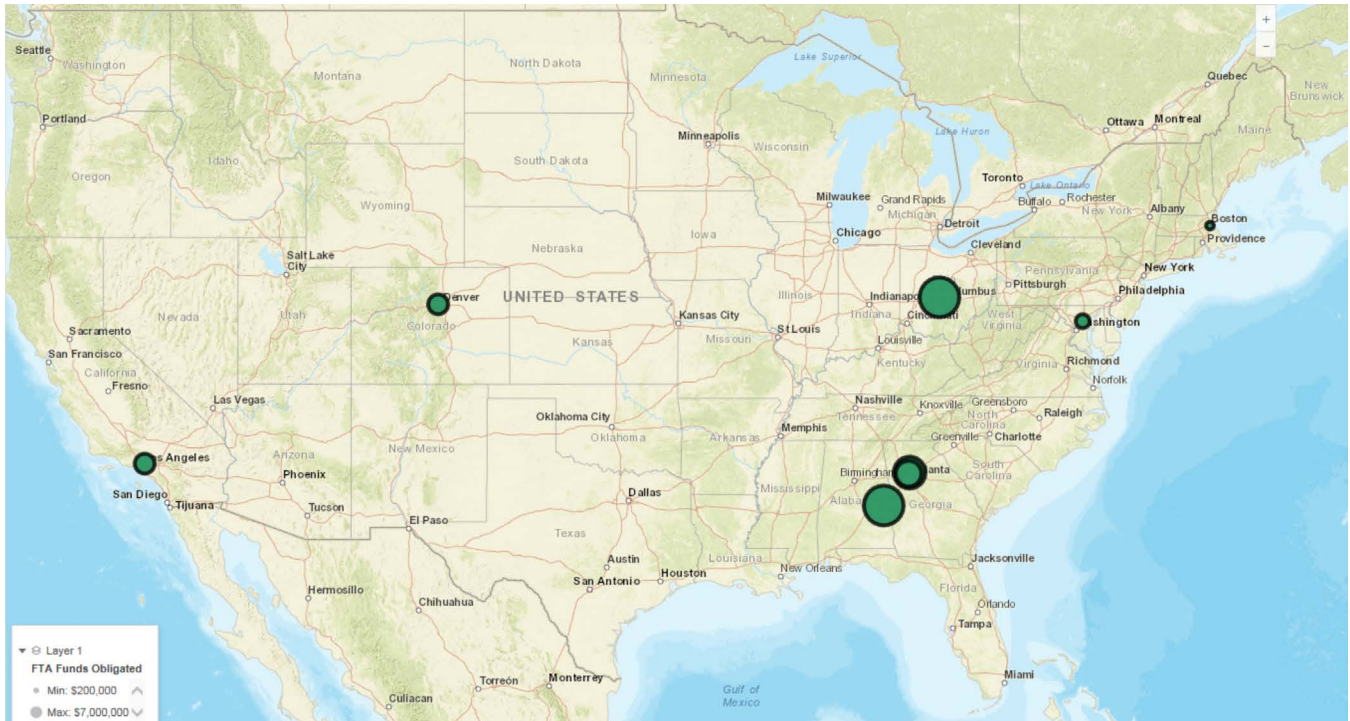
Title: *Low or No (LoNo) Emission Component Assessment Program (LoNo-CAP)*

Grantees: The Ohio State University (OSU) and Auburn University (AU)

Project Description:

The purpose of LoNo-CAP is to conduct testing, evaluation, and analysis of low or no (LoNo) emission vehicle components intended for use in low or no emission vehicles, as required by Federal public transportation law (49 U.S.C. § 5312(h)). FTA competitively selected two recipients – OSU and AU – to implement and manage low or no emission vehicle component testing centers. The goals of the program are to: 1) perform low or no emission component tests; 2) establish performance benchmarks for low or no emission component for vehicle manufacturers; and 3) support emerging low and no emission bus technologies and innovations. Assessing low or no emission components directly supports FTA's statutory low and no emission transit bus capital programs by providing objective assessments of components used for low or no emission transit buses that ultimately are used in transit passenger service.

Results:

To date, the outputs of the LoNo-CAP program include:

- The Ohio State University: OSU promoted LoNo-CAP by marketing its services to the industry. OSU is working with specific manufacturers of LoNo components on the details of procedures and testing requirements. To date, no Federal funds have been expended by OSU because OSU has not completed any testing. OSU intends to start testing electric-range benchmarking, in-use energy storage verification, batteries, and air conditioning systems on a limited scale in 2020.

- Auburn University: AU informed FTA that it was ready to test LoNo components, but was unable to sign any contracts to test LoNo transit bus components in FY 2019. AU believes that some of the component tests that it can currently conduct with existing facilities will be quick-turnaround tests, such as brake testing. once the component manufacturers are ready for testing.

Successful completion of annual LoNo-CAP will advance low and no emission technology and increase use of such components in the transit bus fleet. As more transit manufacturers participate in the voluntary program, it is expected that the industry will start using benchmarks for certification and increase development of the low and no emission components. This is also expected to increase competitiveness in transit component manufacturing and help the industry to be a leader in the low and no emission area.

FTA Funding: $12,000,000

Title: *Low or No (LoNo) Emission Bus Testing Centers*

Grantees: The Ohio State University (OSU) and Auburn University (AU)

Project Description:

The purpose of this effort is to establish, operate, and maintain facilities to conduct testing of new Low or No (LoNo) Emission bus models, as authorized by Federal public transportation law (49 U.S.C § 5312(h)). The goals of this effort are to: 1) document and support activities related to creating new testing centers; 2) conduct activities related to a facility and capability review, develop a capital project plan and a detailed budget plan; 3) develop a final report; and 4) conduct dissemination and outreach activities regarding the findings of the Centers.

Results:

OSU and AU were awarded $1,000,000 each in FY 2019. The OSU Center for Automotive Research (CAR) developed a comprehensive plan to conduct testing, evaluation, and analysis of LoNo emissions buses. OSU is partnering with the Transportation Research Center, Inc. (TRC) to complete bus testing in support of the OSU LoNo Bus Testing program. AU intends to use the existing National

Center for Asphalt Testing (NCAT) test track location in Opelika, AL, as a test facility for the AU center. FTA is working with both institutions to conduct a feasibility study to develop capital project plans and detailed budget plans for the construction of the test centers.

Project/Program Evaluation:

The recipients will develop a LoNo Emissions Management Plan detailing their approaches to FTA and customer communications.

FTA Funding: $2,000,000

Title: *Track Asset Management Demonstration*

Recipients: Metropolitan Area Rapid Transit Authority (MARTA)

Project Description:

The purpose of this project is to demonstrate an autonomous track inspection system (ATIS) in order to help FTA disseminate innovative track asset management practices to the transit industry. An autonomous and non-contact track inspection system with technologies for vehicle and track interaction, track geometry monitoring, and video inspection mounted under rail vehicles has been used on passenger and freight rail for several years but not on transit rail. The goals of this project are to: 1) demonstrate the transferability of an ATIS system to transit; 2) demonstrate its effectiveness compared to existing transit track management practices (track inspection, data analysis, data management and maintenance); and 3) evaluate the return on investment of the system at MARTA. The full objective of this effort is to demonstrate a more autonomous safety and asset management ATIS system with thermal imaging of the third rail and overall track imaging while providing office-based review.

Results:

Phase I of the project tested and evaluated existing track inspection technologies and associated data analytics to demonstrate autonomous capability. The program finalized the design and produced the following results:

- Design and Test: Project completed four major tasks to achieve the following design and test objectives:
  - Electrical and final design reviews completed in May 2019
  - Final hardware and software integration completed in June 2019
  - Installation configuration and integration completed in July 2019
  - Factory acceptance test effort started in December 2018 and completed in July 2019

These completed tasks proved the concept of the ATIS technology and prepared for next steps in demonstration and data collection efforts of the project.

- Industry Presentation: MARTA presented the project abstract at the APTA Rail Conference held in Toronto, Canada, in June 2019. The audience included major rail professionals and APTA members. The goal was to share the new technology with track experts and transit agencies in general who considered implementing the autonomous technology for improving safety and managing rolling stock infrastructure.

Future Phase II involves expanding on autonomous inspection capabilities by adding unmanned inspection systems to those established in Phase I. This project will be the first deployment of this technology on a transit system in the U.S. It will assist track workers to find track anomalies in a real-time environment. This will increase the safety and resiliency of the overall system. FTA will work with MARTA to disseminate this information through various venues.

Project/Program Evaluation:

The program is conducting an independent and continuous evaluation during the project performance period. An independent evaluator, Transportation Technology Center (TTCI), led the conceptual, test, and design reviews that began in FY 2018 and finished the final design review. The evaluator will include detailed information about design, issues, and resolutions in its final evaluation report. The final project report will include a separate section for the evaluation report, due to FTA in December 2021.

FTA Funding: $4,225,000

Figure 20 *Autonomous Track Imaging System (ATIS)*

Metropolitan Atlanta Rapid Transit Authority (MARTA), with FTA funding, is working on an Autonomous Track Imaging System (ATIS). It identifies component defects in the rail, ties, and fasteners by using cameras, thermal images, and other sensors. This system is very important in the demonstration of the technology, as it takes away the manual and operator inspection and replaces with automatic measurement system, and therefore increases operator safety. This demonstration will also meet the goal of improved rail transit safety and maintenance.

Title: *Best Practices and Research for Lifecycle-Based Management*

Recipient: The Volpe Center

Project Description:

The purpose of this project is to identify best practices for lifecycle-based asset management. The goals of the project are to: 1) produce a literature review on practices from related industries on lifecycle cost management and develop protocol for a pilot project; and 2) identify best practices in lifecycle management that could be applied in the project development stage to transportation projects. This project is being completed over two phases. Phase 1 of this research is to identify and incorporate best practices in life-cycle management applicable to public transportation projects. Phase 2 is to analyze findings from a pilot program to determine effective methodologies that will aid Transit Asset Management (TAM) practices. This project reports the continued increases in actual capital cost versus budgeted costs are not consistent, which creates sizeable funding gaps. This project provides better use of current transit assets by improving reliability and maximizing lifecycles, which positively impacts the industry. Most transit lifecycle costs occur during the operations and maintenance (O&M) phase, yet many of these costs are a product of short-term cost decisions made during capital development and equipment acquisition. Currently, deferred maintenance costs exceed $120 billion and grow by $3 billion per year. A return on invest would be strong if there is a 1% cost reduction.

Results:

Activities under this project for FY 2019 include:
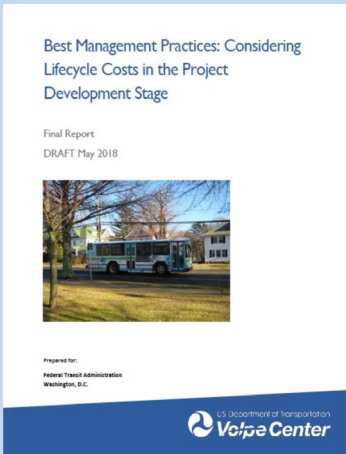
- Literature Review: The Volpe Center completed the Phase 1 literature review. The review addressed and resolved reliability, supportability, maintainability, and sustainability challenges throughout capital project development. It also included benchmarking in the U.S. and internationally. This research provided industry current best practice processes and procedures regarding lifecycle management throughout all phases of a project. This effort met the goal of production of literature review. Results of the expanded literature review will be reported upon completion of Phase 2. Phase 2 will expand on this literature review and report on upon completion. This will include methods used by public capital institution managers in other industries, especially the airline and railroad industries.

- Reports: The Volpe Center completed Phase 1 and delivered findings in an internal report to FTA in May 2018. The report identified best practices for managing lifecycle costs and incorporating such practices into the project development phase. It also assembled a base of knowledge that could be used to assess potential lifecycle cost strategies. This report provided FTA with information on transit agencies' practices in the U.S. and other highly

developed nations, as well as practices in related transportation industries such as inter-city passenger and commuter rail, freight rail, air transport, highways, and pipelines. This effort met the goal of identifying best practices.

Final deliverables are planned for Spring 2020, including a summary of the case studies for FTA and outreach materials for transit agencies on lifecycle and vehicle useful life benchmarks. The Volpe Center is applying insights from Phase 1 to the TAM process for Phase 2, with a focus on useful life benchmarks for vehicles, and more broadly the repair-versus-replace decision in a lifecycle cost framework. The outcomes of this project will assist FTA in determining what analytical tools and processes can significantly aid in extending the life of transit assets. The impact of this project is gradual reduction of transit lifecycle costs for the operations and maintenance of transit systems, which will result in additional savings in the long term.

FTA Funding: $200,000

Figure 21 *Lifecycle-Based Management Internal Report*

In May 2019, FTA received the *Best Management Practices: Considering Lifecycle Costs in the Project Development Stage* internal report. It provides information on the literature review conducted by the Volpe Center on best practices for managing lifecycle costs and incorporating such practices into the project development phase. The emphasis was on transit agencies' practices in the U.S. and other highly developed nations as well as practices in related transportation industries, such as inter-city passenger and commuter rail, freight rail, air transport, highways, and pipelines. Through this report, FTA obtained knowledge on how to assess potential lifecycle cost strategies that could be implemented by transit agencies. The information from this report was used to determine a preliminary pilot program framework. Through this pilot program, FTA will learn and study what agencies need most in order to utilize life cycle cost analysis tools and processes.

Title: *Bus Propulsion Evaluation and Support*

Recipients: National Renewable Energy Laboratory (NREL), U.S. Department of Energy

Project Description:

The goal of this interagency agreement with NREL is to evaluate the performance of new bus technology in real-world applications. The goals of this effort are to: 1) provide detailed assessments of new bus technology in revenue service to inform decision makers about the suitability of the technology for transit service;

and 2) measure bus and bus technology performance on regularly scheduled bus routes over the course of at least a year. Fuel economy, fuel costs, bus availability, maintenance costs, and frequency of breakdowns are all assessed in this effort. Maintenance issues are further identified by component type, enabling detailed analysis of bus technology performance. New technology is compared against a baseline of established technology, such as diesel or compressed natural gas buses, that run similar routes and service. This comparison ensures new technology is assessed against known technology as well as against all local climate and seasonal variables. NREL is an independent third-party with no institutional or financial interest in the outcome of this project, ensuring unbiased results accepted across the industry. The project guarantees consistent and identical metrics and measures are applied in all FTA technology evaluations, meaning all the results from all evaluations can be compared across all projects over time.

Results:

In FY 2019, the project documented critical advancements in the understanding of bus technology in real-world applications. Examples include the following:

- *Zero-Emission Bus Evaluation Results Report*: Published in May 2019. This report evaluates the demonstration of a fuel cell electric bus by the Orange County Transportation Authority (OCTA) and is based on data collected over a one-year period. It provides information about the actual cost and reliability of fuel cell electric bus technology in comparison to other types of bus propulsion technology as well as technical data on the conditions that made this a successful project. This demonstration benefits the industry providing information that will assist transit agencies in understanding how fuel cell electric buses might be expected to perform The report can be accessed at https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/132691/zero-emission-bus-evaluation-results-orange-county-transportation-authority-fuel-cell-electric-bus.pdf. The report met the goal of demonstrating the usefulness of fuel cell electric buses in a hot climate under a heavy-duty cycle.
- *Final Report*: NREL submitted an internal report to FTA in May 2019 describing the evaluation of fuel cell electric buses in Massachusetts Bay Transportation Authority (MBTA). The report provided information about the actual cost and reliability of fuel cell electric bus technology in comparison to other types of bus propulsion technology. This information will help FTA understand how fuel cell electric buses might be expected to perform. The benefit to the transit industry was derived from understanding how preventative maintenance cycles and daily repairs impact data collection.

FTA Funding: $1,400,000

Figure 22 *2019 Bus Technology Evaluation Report*

NREL recently completed a year-long evaluation of a fuel cell bus of the Massachusetts Bay Transportation Authority (MBTA). The bus is part of FTA's National Fuel Cell Bus Program. The primary interest in this evaluation was to gather cold weather data on the Fuel Cell Electric Bus and to document the experience of a large agency with hydrogen fueled buses. The success of the demonstration may lead to MBTA acquiring a hydrogen station and a limited fleet of fuel cell electric buses.

Title: *Bus Efficiency Enhancements Research and Demonstrations (BEERD) Program*

Recipients: Center for Transportation and the Environment (CTE) and Maryland Transit Administration (MTA)

Project Description:

The purpose of the BEERD Program is to promote the development and demonstration of energy efficiency-enhancing technologies for buses used in public transportation specifically, enhanced electrification of accessories and improvements in thermal management of bus bodies. The program will reduce energy use by transit buses and will have favorable impacts on meeting the needs of the riding public, public transportation operators, and the American bus industry and its supplier base. The program advances DOT's strategic goals, which include improving safety, enhancing the state of good repair of transit systems, promoting economic competitiveness, fostering quality of life in communities, and environmental sustainability.

Results:

All the demonstration projects shown in Table 11 were active in FY 2019. Significant outputs for BEERD included:

- Thermoelectric Generator (TEG): This project was based on the cost analysis conducted by the independent evaluator, Florida Solar Energy Center (FSEC). Under the conditions of this demonstration, a transit agency could save approximately $600 per year for a single bus through the use of this generator. The payback period for a TEG would be over 8 years, significantly shorter than the 12-year lifespan of transit buses. The TEG also reduced the load on the alternator and therefore extended the alternators lifespan that helped to reduce vehicle downtime and maintenance costs for Central Florida Regional Transportation Authority (LYNX).

- Hybrid Beltless Alternator Retrofit Project: The Mean Distance Between Failure (MDBF) for belt-related failure was calculated pre- and post-retrofit. Subsequently, an analysis was conducted to determine the number of belt-related failures that would have occurred had the retrofitting not been done. The analysis also showed that the fuel consumption rate was reduced by 6% after retrofit. In addition, CO_2 emissions were reduced by 461,000 pounds, and the MDBF of belt-related failures increased from 19,258 miles to 26,200 miles (frequency and number of failures per time period dropped). The results of the analysis conducted for the post retrofit also showed that the project resulted in cost savings. Combined annual maintenance cost savings were estimated to be around $659.95 for each bus—$98.78 due to reduced belt maintenance and $561.17 due to reduced alternator replacement costs.

The BEERD Program supported the demonstrations of different technologies that expected to help American transit bus manufacturers and component suppliers to achieve greater competitiveness by offering highly desirable advanced technologies for the transit industries. The demonstration of two projects was completed at the end of May 2019. The report is accessible at https://www.transit.dot.gov/research-innovation/fta-reports-and-publications. The remaining projects are in demonstration phase and will be completed by the end of 2020.

Project/Program Evaluation:

Each project selected under the BEERD Program includes a built-in, fully funded, independent evaluation carried out by a contractor or university. Individual project evaluations are in progress, and the results will be presented to FTA in a final projects report.

FTA Funding: $3,000,000

Table 11 *Bus Efficiency Enhancements Research and Demonstrations (BEERD) Projects Receiving Assistance from FTA, FY 2019*

Project Title	Project Recipient	City and State	FTA Award
Thermoelectric Generation Demo	Center for Transportation and the Environment	Atlanta, GA	$532,258
Reduced Engine Idle Load System	Center for Transportation and the Environment	Atlanta, GA	$1,274,936
UTA Paratransit Accessory Electrification	Center for Transportation and the Environment	Atlanta, GA	$697,185
Hybrid Beltless Alternator Retrofit	Maryland Transit Administration	Baltimore, MD	$495,621
		Total	$3,000,000

Figure 23 *Thermoelectric Generator (TEG) Designed and Built for Transit Diesel Buses*

The Center for Transportation and the Environment (CTE) and its partners, along with FTA built, tested, installed, and demonstrated Thermoelectric Generator (TEG) that was designed by Hi-Z Technologies, Inc. The Central Florida Regional Transit Authority doing business as LYNX in Orlando, FL provided a 2007 diesel bus for the demonstration. The University of Central Florida's Florida Solar Energy Center (FSEC) developed the data collection system for this effort and conducted a thorough analysis of the data. International Trade Bridge (ITB) supported the installation and testing of the TEG, and they worked with the Kennedy Space Center (KSC) to provide the team with access to private roads for testing. The team drove the bus on private roads at KSC, testing performance at highway speeds, simulating transit service, and evaluating the impact of the HVAC system on TEG performance. During this testing, the dump valve worked as expected, and the TEG generated over 1100 watts of power. FSEC performed an analysis of the data from the demonstration, predicting what the fuel economy improvements and fuel cost savings from installing a TEG on a transit bus might be. Energy Florida used the results of this effort to develop a commercialization plan for the TEG. The project met the intended goal of using the bus exhaust heat to warm the "hot side" and a coolant to keep the "cold side" colder. The resulting electric current could then be used to take load off the vehicle alternator, improving vehicle fuel economy. For this thermoelectric system and the operating conditions of the demonstration, LYNX saved about 180 gallons of diesel per year per bus, which, at $3.20 per gallon of diesel, that is approximately $600 per year.

Title: *Low or No (LoNo) Emission Vehicle Deployment Program*

Recipients: Transit agencies; and project teams comprising transit agencies, systems experts, and bus manufacturers

Project Description:

FTA's LoNo program began in 2013 as a program funded under Federal public transportation law (49 U.S.C. § 5312), bridging FTA's research and capital programs. Project recommendations were made by the research program to deploy a portfolio of projects that met the goal of deploying new bus technologies that had been largely proven in research programs but were not yet widely deployed in transit fleets. The program supports transit agencies willing to demonstrate small fleets (at least five buses) of new bus models. After project selection, the FTA Regional Offices assumed responsibility of the projects as if they were capital projects to determine the readiness of the technology for the stricter rules governing capital purchases. The program shares the risk of early deployments of new bus technology and helps inform the industry of the capabilities and challenges of new technology. Electric bus technology has significant differences from diesel technology, and the program is helping the U.S. transit industry identify, understand, and accommodate those differences. Further,

LoNo Program projects are helping FTA determine where additional research is needed before larger fleet purchases are considered. Economically, the program increases private investment in cutting-edge U.S. transit bus development and increases the number of American job opportunities in bus design, manufacturing, and operations. This program is resulting in lower cost and increased availability of more energy efficient buses; more private investment in transit bus development; new jobs in U.S. transit bus design and manufacturing; and greater knowledge about strengths and weaknesses and how best to deploy the buses. The LoNo Program enables transit agencies to incorporate lessons learned from the initial deployment of low or no emission buses into their plans for bus procurements. This program is now a yearly capital program and not a research program.

The LoNo Program was funded for three years as a research program under Federal public transportation law (49 U.S.C. § 5312) where it gained increasing popularity and success. In FY 2016, the FAST Act authorized the LoNo Program at $55 million annually as a competitive grant program under Federal public transportation law (49 U.S.C. § 5339), and funding increased to $55M annually. The program is managed by the FTA's Office of Program Management and was renamed "Low-No."

Results:

In total, 15 projects were active in FY 2019, and two projects closed prior to FY 2019. The following are examples of outputs with significant results:

- Duluth Transit Authority: The cold-weather use of battery electric buses is underway in Duluth, MN. Significant challenges to electric bus operations in cold weather are being experienced and documented. Even though passenger compartments of the buses are equipped with diesel-fired heaters, the buses are losing significant amounts of energy in winter operations, resulting in buses operating for only a few hours under a single charge. The transit agency has documented an underperformance of the technology in cold weather and is concerned about the long-term viability of the present generation of battery electric technology in a northern climate.

- Southeast Pennsylvania Transit Authority (SEPTA): In all, 25 battery electric buses were delivered and introduced in October 2018. The project is the largest fleet purchase under the LoNo Program and results in one of the largest battery electric fleets in the U.S. The operation at SEPTA is being evaluated under a separate FTA project conducted through the Department of Energy (DoE). Information about the buses' performance will be collected and analyzed, covering issues such as fuel economy, fuel costs, bus availability, maintenance costs, and frequency of breakdowns. Maintenance issues will be identified by component type, enabling detailed analysis of bus technology performance.

- Utah Transit Authority (UTA): Three of the five new buses were deployed on UTA routes servicing the university (primarily Route #2). UTA will retain

title to the other two buses to be used on University of Utah's new public transit shuttle service and maintain continuing control of the maintenance of the vehicles. The shuttle service connects with UTA's Route #2. CALSTART is collecting data for analysis and a report on performance of electric buses through a year of operations. Project benefits will be significant emission reductions and promotion of alternative fuel vehicles. This project is beneficial to the region, as Salt Lake City is an Air Quality Maintenance Area for Carbon Monoxide (CO), a Non-Attainment Area for Particulate Matter (PM), and a Maintenance Area for Ozone. With natural constraints along the Wasatch Front, residents are exposed to air pollution episodes during summer and winter months.

- <u>San Joaquin Regional Transit District (RTD)</u>: This project supports the purchase of five zero-emission buses along with one overhead charger. RTD will operate these project vehicles to provide transit service and reduce emissions of harmful greenhouse gases. The project objective is to provide a reliable transit service that eliminates the emission of harmful greenhouse gases. These project vehicles are all Americans with Disabilities Act (ADA) compliant. A major benefit of this project is the elimination of harmful greenhouse gas (GHG) emissions. RTD is replacing automobile miles with zero-emission bus miles. Finally, this project will provide benefits to an area that is considered a disadvantaged community and an environmental justice area. Performance data will be collected and analyzed, covering issues such as fuel economy, fuel costs, bus availability, maintenance costs, and frequency of breakdowns. Maintenance issues will be identified by component type, enabling detailed analysis of bus technology performance.

- <u>Stark Area Regional Transit Authority (SARTA)</u>: This project involves the acquisition of hydrogen-fueled replacement buses for use in and around Stark County, OH. This area is a designated ozone non-attainment area – with a variety of operating conditions, including congested downtown streets, major urban thoroughfares and rural highways. SARTA has made notable strides toward full-scale commercialization in the wake of the initial LoNo award. The proposed bus implements the commercialization of the fuel cell bus model, by deploying a lower cost, commercialized fuel cell along with manufacturing efficiencies and lessons learned from previous fuel cell bus deployments. Project deployments are supporting an increased focus on optimizing design, increasing and improving performance, further optimizing the manufacturing process and ultimately, achieving significant additional cost reductions. The project assists in developing and implementing training plans and deploying a warranty and maintenance structure for bus operation and will support further outreach and public education.

As buses purchased under LoNo are delivered and made operational, the evaluation of the program continues to assist the U.S. transit industry in understanding how to adopt new technology buses in transit service. The impact

of the program is an improved understanding of the strengths and weaknesses of electric buses and of how best to deploy them. The program continues to result in the improved availability of lower cost, cleaner buses, and the increase in American jobs in this cutting-edge technology sector.

Project/Program Evaluation:

Through an interagency agreement with the National Renewable Energy Laboratory (NREL), part of the Department of Energy (DoE), FTA is supporting the technology evaluations of a cross-section of LoNo project sites. The evaluation work by NREL began under the National Fuel Cell Bus Program and continues under an agreement between DoE and FTA created in 2015. NREL's evaluation measured bus and bus technology performance on regularly scheduled bus routes over the course of a year. Fuel economy, fuel costs, bus availability, maintenance costs, and frequency of breakdowns were all addressed. Current evaluations of LoNo sites include projects in Canton, OH; Duluth, MN; and Philadelphia, PA. Additional technology evaluations will be performed if funding is available. For more detail about the NREL work, see the Bus Propulsion Evaluation and Support description of this report.

FTA Funding: $73,328,249

Table 12 *Low or No (LoNo) Emission Vehicle Deployment Projects Receiving Assistance from FTA, FY 2019*

Project Title	Project Recipient	City and State	FTA Award
5 fuel cell electric buses	SunLine Transit Agency	Thousand Palms, CA	$9,803,860
5 fuel cell electric buses	Stark Area Regional Transit Authority	Canton, OH	$8,877,405
5 60-foot articulated battery electric buses	Massachusetts Bay Transportation Authority	Boston, MA	$4,139,188
5 battery electric buses	Transit Authority of River City	Louisville, KY	$3,321,250
5 battery electric buses	San Joaquin Regional Transit District	Stockton, CA	$4,702,011
5 battery electric buses	Duluth Transit Authority	Duluth, MN	$6,343,890
7 battery-electric buses	Dallas Area Rapid Transit Authority	Dallas, TX	$7,637,111
5 battery-electric buses	Transit Authority of Lexington Fayette Urban County	Lexington, KY	$6,003,534
5 battery-electric buses	Los Angeles County Metropolitan Transportation Authority	Los Angeles, CA	$5,585,000
5 battery-electric buses	Alameda-Contra Costa Transit District Commission	Oakland, CA	$1,551,611
Deploy 3 additional fuel cell electric buses to SARTA's fuel cell electric fleet	Stark Area Regional Transit Authority	Canton, OH	$4,015,174
25 battery-electric buses	Southeastern Pennsylvania Transportation Authority	Philadelphia, PA	$2,585,075
5 battery-electric buses	Utah Transit Authority	Salt Lake City, UT	$5,427,100
Deploy 8 additional battery-electric buses to King County's electric fleet	King County Metro	Seattle, WA	$3,336,040
		Total	**$73,328,249**

Figure 24 *Example of Impact of Low or No (LoNo) Emission Vehicle Deployment Program*

The Stark Area Regional Transit Authority (SARTA) provides public transit service to Stark County, Ohio. SARTA began investigating hydrogen-fueled buses in 2014 and successfully competed for funding from two FTA programs, adding a total of ten 40-foot Fuel Cell Electric Buses (FCEBs) to its fleet. The agency was awarded over $8 million in the first round of the LoNo Program for 5 FCEBs. The FCEBs are 40-foot El Dorado National-California (ENC) buses with BAE Systems hybrid electric propulsion systems powered by Ballard's FCvelocity-HD6 150-kW fuel cells. With the new buses, SARTA now operates the largest fleet of American fuel cell electric buses outside of California. Ohio is a major source of component manufacturing for fuel cell technology. Supported by FTA, the National Renewable Energy Lab is in the process of conducting a technology evaluation of the fuel cell buses at SARTA. Information about the performance of the buses is available at https://www.transit.dot.gov/research-innovation/fta-reports-and-publications.

Supporting Programs and Other Initiatives

Description:

FTA has programs and projects that address cross-cutting issues associated with the three research priorities—Safety, Infrastructure, and Mobility Innovation—and to support research to practice implementation. In addition to those programs, FTA manages the statutorily required Transit Cooperative Research Program (TCRP) through the National Academies of Sciences, and the Small Business Innovation Research Program (SBIR) to support the growth of U.S. small businesses.

Objective:

Programs under this section support FTA with dissemination, evaluation, and additional industry-driven and selected research.

Outputs:

- Develop evaluation frameworks and models to evaluate the effectiveness of research projects, priorities, and programs within a three-tiered concept.
- Support industry-driven research projects.
- Disseminate research findings.
- Ensure accessibility and 508 compliance of all FTA documents posted on the FTA website.

FTA had seven supporting programs and initiatives active in FY 2019, as shown in Table 13.

Table 13 *Supporting Programs and Initiatives Receiving Assistance from FTA, FY 2019*

Supporting Programs and Initiatives		
Type of Project	**Project Title**	**FTA Funding**
Evaluation & Implementation	Information Dissemination and Evaluation Program	$1,439,692
Evaluation & Implementation	Information Dissemination and Outreach Program	$1,100,000
Evaluation & Implementation	Research Evaluation Implementation Plan	$480,000
Evaluation & Implementation	Transit Data Research Project Secure Data Commons System	$100,000
Evaluation & Implementation	Workforce Development Program Evaluation and Dissemination	$250,000
Research	Transit Cooperative Research Program (TCRP)	$5,000,000
Innovative Development	Small Business Innovation (SBIR)	$3,494,756
	Total	**$11,864,448**

Title: *Information Dissemination and Evaluation Program*

Recipients: University of South Florida (USF) Center for Urban Transportation Research (CUTR)

Project Description:

The purpose of this effort is to complete the evaluation component of the program as required under Federal public transportation law (49 U.S.C. § 5312(e)(4)). The information dissemination component of the program was completed, leading to the creation of the new and improved Information Dissemination and Outreach Program and the Research Evaluation Implementation Plan. The remaining work on this program is to conduct a comprehensive evaluation of the DOT–FTA-funded Transit and Health Access Initiative Demonstration Grants Program funded under Federal public transportation law (49 U.S.C § 5312). Demonstration program evaluations use data from demonstration project recipients to report on high-level, crosscutting results of demonstration programs at the national level.

Results:

CUTR continues to monitor recipients progress and collect data and information for the comprehensive independent evaluation of the six active projects. Outputs from the project in FY 2019 include:

- Conduct Evaluation of Transit and Health Access Initiative Grants and Report Results: Evaluation activities included planning for and conducting an analysis of the institutional, business, customer service, and operational impacts for multiple individual projects, obtaining feedback from grants project stakeholders, and determining replication feasibility. The five-step Demonstration Program Evaluation Process developed by CUTR is presented graphically in Figure 26. The results of the evaluation assisted FTA in learning about the status of each project, the level of communication needed with each recipient, and how to move forward with similar programs in the future.

CUTR will continue to monitor the performance of each project and will continue to conduct a comprehensive independent evaluation of the Transit and Health Access Initiative program through the duration of the project, until September 30, 2020.

FTA Funding: $1,439,692

Figure 25 *Demonstration Program Evaluation Process*

Demonstration Program Evaluation Planning	Project Mobilization	Data Collection	Analyze Program Results	Knowledge Dissemination
Background review, program goals, project planning, and kickoff	Project schedules, communications plan, and evaluation plan	Baseline information, performance measures, quantitative and qualitative data	Data synthesis, assessment of program benefits and outcomes, feedback	Knowledge transfer activities, most successful innovations, replicability
- Review background material, including demonstration program goals and stakeholder input - Conduct kickoff meeting with FTA - Develop communications plan - Identify key issues	- Establish integrated schedule - Implement communications plan - Conduct initial project interviews - Determine availability of baseline and other Tier 4 data - Develop and implement evaluation plan - Identify key issues	- Catalog project performance measures - Compile Tier 4 quantitative data from grantees - Compile Tier 4 qualitative data from grantees (lessons learned) - Identify key issues	- Synthesize Tier 4 data to the program level - Assess program costs, benefits, and outcomes - Analyze actual vs. expected outcomes - Obtain feedback from project stakeholders - Develop key findings	- Assess the Innovations most likely to succeed - Assess replicability of demonstration program to other sites - Generate a report of program evaluation findings - Produce resource materials - Conduct webinars - Policy analysis
- Kickoff Meeting - Communications Plan	- Demonstration Project Schedules - Evaluation Plan	- Performance Measures Catalog - Summary of Demonstration Project Activities	Analysis of Program Results	- Report of Findings - Resources, Webinars - Policy Recommendations

CUTR developed the Demonstration Program Evaluation Process to help FTA meet the requirements under Federal public transportation law for the evaluation of demonstration programs. Demonstration program evaluations use data from demonstration project grantees to report on high-level, crosscuttin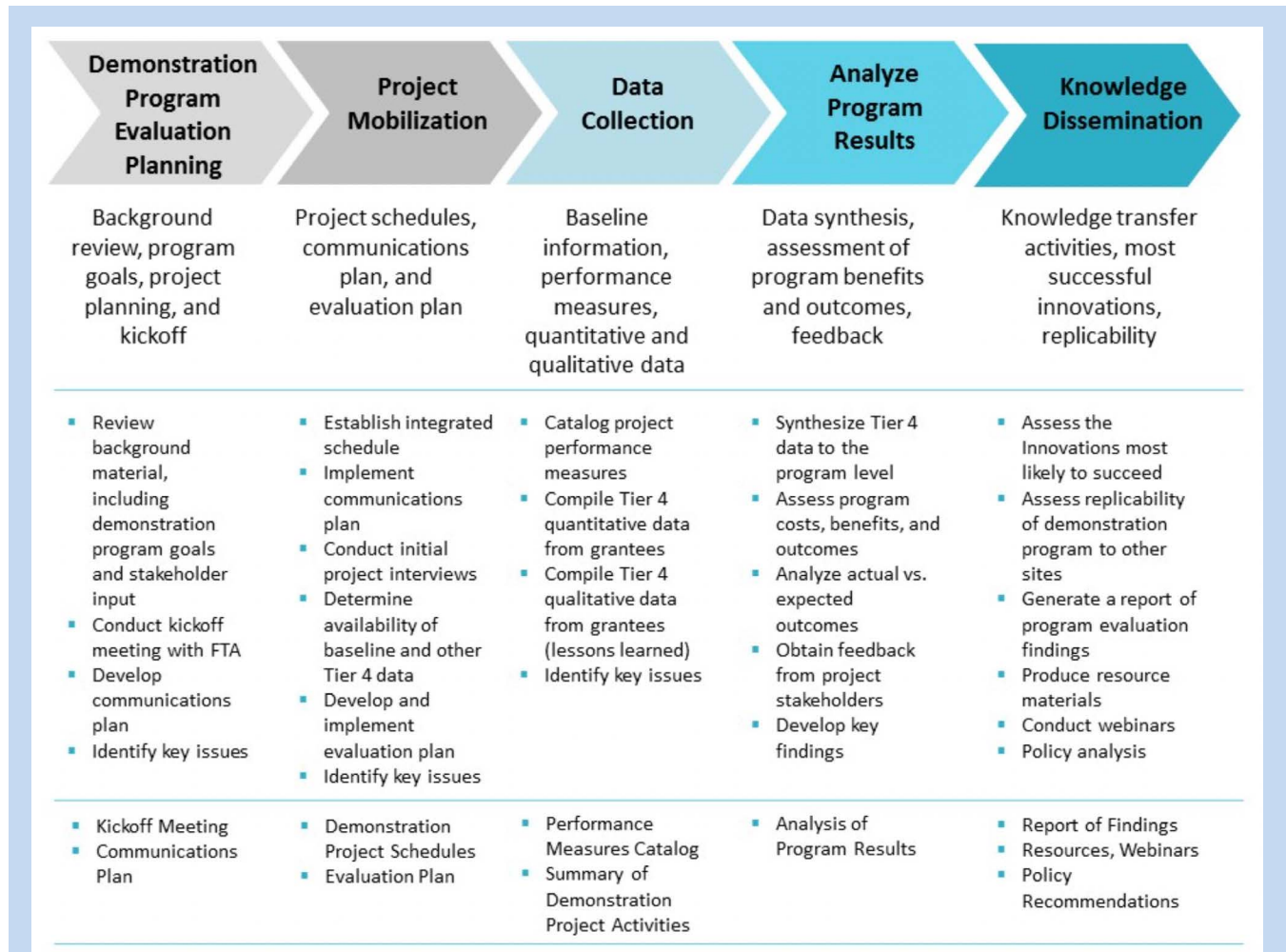g results of demonstration programs at the national level. The process comprises five basic steps: Step 1) demonstration program evaluation planning; Step 2) project mobilization; Step 3) data collection; Step 4) program results analysis; and Step 5) knowledge dissemination. Following the five steps will assist in evaluating the benefits and outcomes of the Transit and Health Access Initiative Demonstration Grants Program.

Title: *Information Dissemination and Outreach Program*

Recipient: University of South Florida (USF) Center for Urban Transportation Research (CUTR)

Project Description:

This program assists FTA in the wide distribution of research outputs, outcomes, and impacts in a consistent and accessible way to all key stakeholders. It also assists FTA in remaining at the forefront of information accessibility by ensuring that the Administration's dissemination efforts achieve the following goals: 1) edit, design, and produce consistent, accessible, high-quality research products and other supporting materials; 2) expand upon current methods of disseminating FTA research outputs, outcomes, and impacts to all key stakeholders; and 3) assist FTA with improving the management of ongoing FTA research and technology projects. These efforts ensure that the transit industry and communities continue to receive access to high-quality research products. Consequently, FTA aims to enhance the recognition and broaden the impact of its funded research, which helps to position transit research as central to topical special interests.

Results:

Ongoing activities include production of reports, circulars, reports to Congress, and other FTA documents. It also includes text editing/rewriting, cover design; development of report and presentation templates and guidelines; and development and enhancement of graphics, photos, and other elements for agency use. Outputs from the project in FY 2019 include:

- FTA documents: Published 20 reports, including 3 reports to Congress, with an additional 9 reports in progress. FTA reports completed under this program can be accessed at https://www/transit.dot.gov/research-innovation/fta-reports-and-publications. In addition to published reports, FTA drafted research circulars, report templates and submission guidelines for FTA project managers and recipients, and research charts, graphs, covers, photos, etc., for agency use.

The efforts under this program provided more efficient use of resources by allowing FTA program managers and recipients to focus more on the technical content of reports rather than the report production process. All reports produced for web publication under this program are Section 508-compliant, meeting Federal requirements for accessibility.

FTA Funding: $1,100,000

Title: *Research Evaluation Implementation Plan*

Recipient: University of South Florida (USF) Center for Urban Transportation Research (CUTR)

Project Description:

The purpose of this project is to develop an implementation plan for FTA's Nested Research Evaluation Framework. The framework was designed to meet the statutory requirement for the evaluation of demonstration programs. Federal public transportation law (49 U.S.C. § 5312 (e)(4)) requires FTA to conduct a comprehensive evaluation of demonstration projects not later than two years after the date on which a project receives assistance. The framework, represented in Figure 27, was finalized in May 2018.

The goal of this project is to provide FTA program managers with a comprehensive mechanism to independently evaluate the benefits, outcomes, and return on investment (ROI) of FTA-funded research programs and projects. Evaluation of program accomplishments also provides external accountability for the use of public resources and enables FTA to fund and prioritize research in a strategic manner. Thus, the implementation plan will be used not only to meet the statutory requirement for evaluation of demonstration programs, but to optimize the success of FTA's entire research program.

Results:

Results under this effort in FY 2019 include:

- CUTR began a synthesis of the results of FTA's research projects and existing research and demonstration program performance measures. CUTR also began a gap analysis of the performance measures in the FTA Annual Modal Research Plan for FY 2019, including analysis on whether existing performance measures are sufficient and what new measures should be implemented. This synthesis of Tier 3of FTA's Nested Research Evaluation Framework allows CUTR to create methods and recommendations for Tier 1 and a research evaluation guidance document that will incorporate the measures, methods, and recommendations for Tiers 1 and 2.

CUTR will finalize methods and recommendations for Tier 1. The goal is to ensure that evaluations at the Tier 1 level are rooted in objective quantification and strategic goals, yet able to articulate the impact of FTA's research program in the form of compelling stories. Inquiry will rely on the concept of research to practice to assess the degree to which FTA develops and deploys innovative solutions that have a demonstrable impact on the industry. CUTR will also apply the Framework to a full year of evaluation for FY 2019. Based on the results of this evaluation, CUTR will produce a guidebook on how to implement the Framework on an annual basis.

FTA Funding: $480,000

Figure 26 *Nested Research Evaluation Framework*
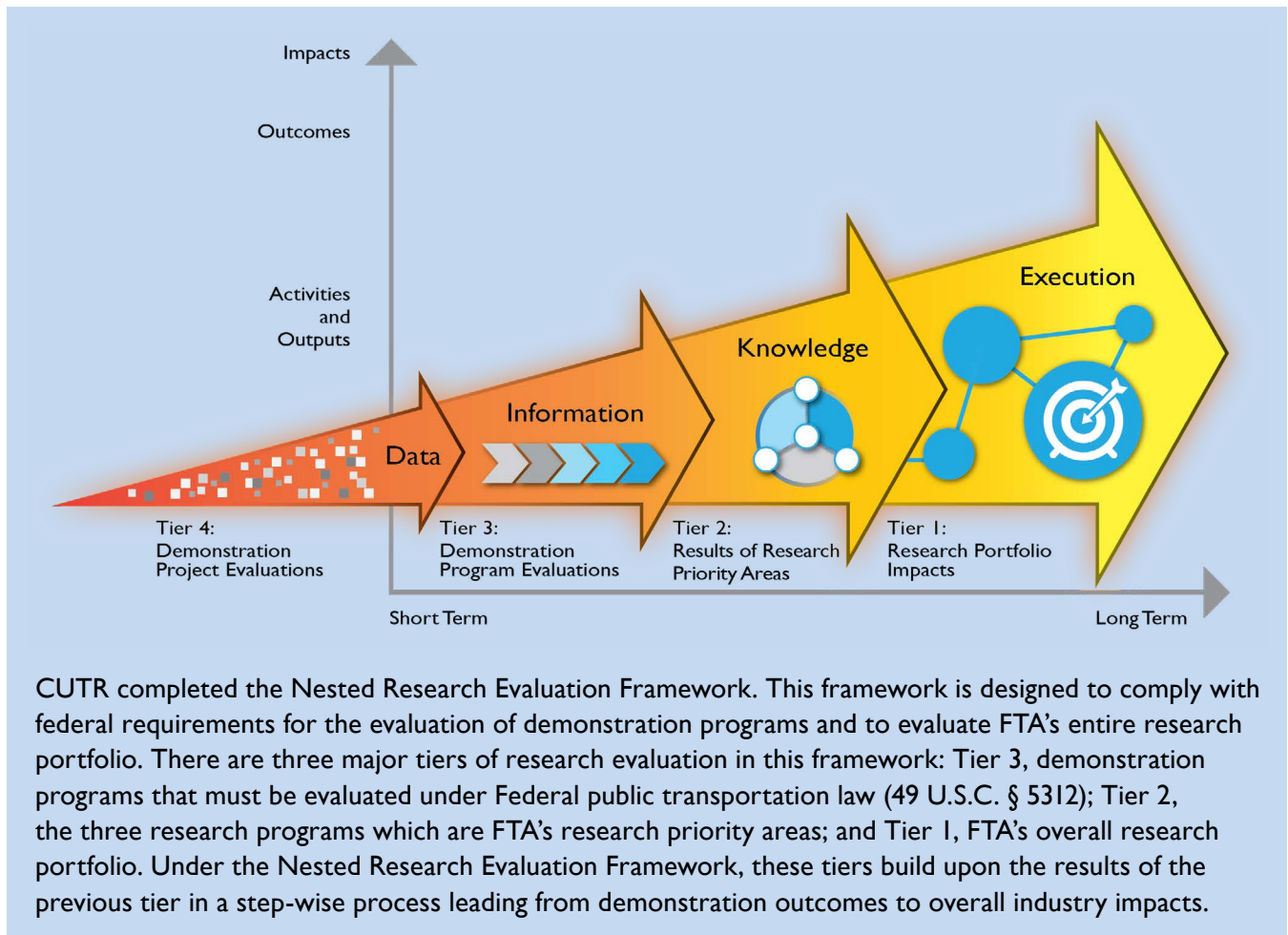
CUTR completed the Nested Research Evaluation Framework. This framework is designed to comply with federal requirements for the evaluation of demonstration programs and to evaluate FTA's entire research portfolio. There are three major tiers of research evaluation in this framework: Tier 3, demonstration programs that must be evaluated under Federal public transportation law (49 U.S.C. § 5312); Tier 2, the three research programs which are FTA's research priority areas; and Tier 1, FTA's overall research portfolio. Under the Nested Research Evaluation Framework, these tiers build upon the results of the previous tier in a step-wise process leading from demonstration outcomes to overall industry impacts.

Title: *Transit Data Research/Secure Data Commons System (SDC)*

Recipient: Intelligent Transportation Systems (ITS) Joint Program Office (JPO)
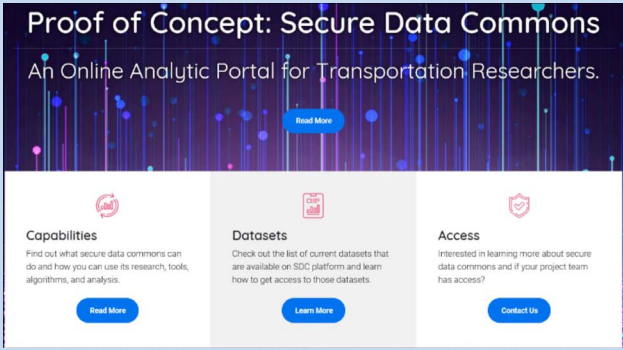
Project Description:

The purpose of this interagency agreement is to provide funding to the JPO for Phase II of the Secure Data Commons (SDC). The SDC is a common platform for innovative data analysis and sharing of results that cuts across the DOT's data silos. It enables collaborative but controlled integration and analysis of research data while protecting Personal Identifying Information (PII) and Confidential Business Information (CBI). The SDC reduces the time from data collection to insight by allowing for real-time analysis and for project evaluators to start their analysis earlier and build on each other's work.

Results:

In June 2019, FTA invited organizations applying for its Integrated Mobility Innovation (IMI) Notice of Funding Opportunity to use the SDC to house and analyze data from their projects, should they be selected for IMI funding. The SDC will enable DOT and partners to evaluate the IMI demonstration programs and gain insights from the work FTA is sponsoring on mobility on demand, automated vehicles, integrated fare payment, and related topics.

FTA Funding: $100,000

Figure 27 *Secure Data Commons (SDC)*

The Secure Data Commons (SDC) was developed by the Intelligent Transportation Systems Joint Programs Office. The concept of the secure data commons points to additional information that researchers can access to learn more about the platform's capabilities, datasets, and access. The SDC is a cloud-based analytics platform that enables access to traffic engineers, researchers, and data scientists to various transportation related datasets. The objective of this prototype is to provide a secure platform, which will enable DOT and the broader transportation sector to share and collaborate their research, tools, algorithms, analysis, and more around sensitive datasets using modern, commercially available tools without the need to install tools or software locally.

Title: *Workforce Development Program Evaluation and Dissemination*

Recipient: Axiom Corporation

Project Description:

In FY 2011, FY 2012, and FY 2015, FTA awarded a combined total of $20 million in competitively awarded grants that promoted the development and implementation of diverse and innovative successful Workforce Development models and programs. This project conducts evaluations for FTA's Workforce Development Program and assists with developing materials to disseminate successful workforce models. The goals of the evaluation are to: 1) determine if the individual projects met the deliverables and goals set for each activity; 2) determine the recipient's ability to leverage investments of strategic partners to sustain the programs; and 3) make policy recommendations that will assist FTA in refining, planning, and enhancing the overall Workforce Program and the recipients' potential impact on local or national transit workforce development needs. This evaluation determines how the recipients achieved performance measures and goals relating

to recruitment, retention, and development of career pathways that support movement of targeted populations into career opportunities within transit.

Results:

This evaluation project was active in FY 2019, providing the following results:

- 2015 Summative Evaluation Report: Axiom Corporation completed and submitted to FTA the *Innovative Transit Workforce Development Projects of 2015 Summative Evaluation Report.* The report highlighted the value of FTA investment on recruitment, retention, and development of career pathways, leading to career opportunities within transit. The report provided conclusions of the 2015 funded projects, including: recipients generally met, and often exceeded, their goals; FTA's Workforce Development Program for 2015 was successful at identifying promising approaches for workforce development; and transit, workforce, and education together make very strong partnerships. This report also met the goal to showcase successful and replicable workforce development models and lessons learned. The report can be accessed at https://www.transit.dot.gov/research-innovation/fta-reports-and-publications.

- Key Lessons Learned Report: Axiom Corporation submitted to FTA the *Innovative Transit Workforce Development Program: Key Lessons Learned* report. The report is accessible at https://www.transit.dot.gov/research-innovation/fta-reports-and-publications.

- FY 2015 Project Interviews: Axiom commenced their evaluation of the FY 2015-funded workforce projects that FTA awarded in May 2017, using telephone interviews. The telephone interviews were completed in December 2018, with 16 award recipients. These interviews were conducted to determine each project's success in meeting its individual project goals. The interviews benefited the overall Workforce Development Program because they enabled the recipients to share their lessons learned and success stories that are not otherwise published in monthly reports. An additional advantage to hosting the telephone interviews included the cost savings to the recipients and FTA for travel and printed surveys. Hosting an intimate, one-on-one telephone interview enabled the recipients time to continue focusing on their projects, while meeting the requirements of the Workforce Program to participate in an evaluation.

This project enabled FTA to gain a return on its $20 million investment in more than 40 Workforce Development projects. Performing these evaluations supports DOT's strategic goals of Infrastructure and Accountability. This effort also demonstrates that programs and projects met the nation's transportation workforce needs and provided a framework for reducing burdens and greater efficiency and effectiveness of Federal funds and programs.

FTA Funding: $250,000

Figure 28 *Innovative Transit Workforce Development Program: Key Lessons Learned*

Innovative Transit Workforce Development Program: Key Lessons Learned provides a summary of lessons learned from the evaluation of the Innovative Transit Workforce Development Program projects by FTA. At FTA, developing and maintaining human capital is as important as the investment in physical capital. Transit systems face a number of challenges, including rapidly-changing technologies (to vehicles, right-of-way, and customer information services), an aging workforce, and increasing ridership. These challenges make attracting and preparing new talent increasingly important. This report provides key lessons learned from the projects funded by FTA in 2011, 2012, and 2015. They can guide future decision-making regarding workforce development programs by FTA. This report also provides an assessment of the overall program, addresses the impacts of individual projects on identified transit workforce needs, and develops recommendations for the continuation or improvement of FTA's workforce development efforts.

Title: *Transit Cooperative Research Program (TCRP)*

Recipient: National Academies of Sciences, Engineering, and Medicine (NAS)

Project Description:

TCRP is a statutory program authorized under Federal public transportation law (49 U.S.C. § 5312(i)). It is conducted through a cooperative agreement with NAS through the Transportation Research Board (TRB) and in partnership with the Transit Development Corporation, the non-profit training arm of APTA. TCRP is an applied research program with the goal of developing near-term, practical solutions to problems facing public transportation and has an established reputation for providing useful reports and other tools to help public transportation practitioners solve problems and inform decision makers.

TCRP's mission is to promote, select, and conduct research and disseminate research findings to improve the practice and performance of public transportation. The selection of research projects is the responsibility of the TCRP Oversight and Project Selection (TOPS) Committee, which consists of industry executives, representing the primary beneficiaries of TCRP research. The TOPS Committee functions as the TCRP governing board and sets research priorities, and TCRP includes FTA's strategic research goals as criteria for screening and selecting projects, helping to further extend FTA's reach.

TCRP's cooperative nature is further reflected in the development of expert practitioner panels assigned to each project. The panels refine project scopes, review contractor bids, and select and guide contractor teams as they conduct research and develop the report. The rationale for having the public transportation community at the table from the beginning is to ensure that products are responsive to the needs of the public transportation field and are most likely to have buy-in for implementation.

Results:

In FY 2019, TCRP completed 11 reports and selected 22 new research projects. Most TCRP studies extended beyond a 12-month period. TCRP staff currently manage a portfolio of approximately 67 project panels on projects that extend across multiple fiscal years. Each active project also includes FTA Liaison to support coordination and information-sharing. Following are significant results of the TCRP program in FY 2019:

- <u>TCRP Day</u>: APTA sponsored the second TCRP Day on June 13, 2019, to raise awareness about the value TCRP provides to the public transportation industry through a series of locally based events across the country. More than 35 transit organizations hosted events. Full details are available on the TCRP Day Tool Kit website at https://www.apta.com/research-technical-resources/tcrp/tcrp-day/.

- <u>TOPS Committee</u>: During its summer meeting in June 2019, the TOPS reviewed TCRP progress against its programmatic goals. Also, the findings from four TCRP research studies were presented:

  - *Dialysis Transportation – The Intersection of Transportation and Healthcare*: Presents the current and projected demand and costs associated with transportation for kidney dialysis in the United States and identifies current and effective practices and new strategies for funding and providing transportation to dialysis treatments.

  - *Microtransit: Evolving Trends in Demand Response Transit*: Provides an overview of microtransit services provided by transit agencies for the general public made possible by new technologies.

  - *Fast-Tracked: A Tactical Transit Study*: Developed guidance to assist transit agencies and other key stakeholders such as cities, and state and local DOTs to develop and implement quick-build projects that improve bus transportation services including speed, reliability, access, and quality of service.

- <u>LookingBus</u>: Is a Smart City system that helps people with disabilities ride public transportation. Specifically, people with visual impairments depend heavily on public transit as an essential service for engaging in daily life and social activities. By utilizing Smart City technology, LookingBus provides drivers with advanced notifications of riders with disabilities at their

upcoming stops to ensure that drivers can assist the riders as they board the correct bus. Likewise, the driver gets a notification when the rider needs to get off the bus. The researchers were awarded $100,000 to test the performance of the LookingBus prototype in a field operation.

- Annual report: TCRP released its *Annual Report of Progress* in December 2018, which highlights the year's major accomplishments and activities. The report can be accessed at http://www.trb.org/main/blurbs/178569.aspx.

- Research studies: In October 2018, the TOPS Committee selected five research studies in addition to delegated committees' selection of seven synthesis projects, four quick response projects, five legal digests, and two IDEA projects. TCRP received 72 research problem statements from public, private, and non-profit entities, frequently in cooperation with one or more TRB committees.

- Publications and reports: In the first half of FY 2019, TCRP completed 11 publications, including 5 research reports and 6 synthesis reports; all are available at https://www.nap.edu/author/TCRP/transportation-research-board/transit-cooperative-research-program. In addition to publication downloads from the National Academies Press, webinar attendance is a key indicator of how many people are accessing TCRP products. Communicating results is a necessary first step to facilitate the research to practice pipeline. Webinars offer a relatively resource-efficient and interactive environment where attendees can hear directly from the report authors, ask clarifying questions, and receive feedback that might make a proposed solution more relevant to their particular environment. In total, 303 people participated in Contracting Commuter Rail Systems, 656 people attended Dialysis Transportation: The Intersection of Transportation and Healthcare (both hosted by TRB on February 12 and May 13, respectively), 99 people attended Addressing Difficult Customer Situations, and 108 people attended College Student Transit Pass Programs.

Over the last 26 years, TCRP's influence expanded from a national to a global scale. With $5 million authorized and appropriated annually, TCRP supported the public transportation industry and community through conferences, webinars, and project panels, maintaining a high level of public transportation industry and stakeholder engagement. The program selected high-priority research projects through the TOPS Committee process and noted public transportation problems in needs of applied research by inviting the submission of research needs from the public transportation industry and stakeholders. TCRP reports and studies are important resources to public transit agencies that improves operations and service.

FTA Funding: $5,000,000

Figure 29 *TCRP Publications*

The goal of the TCRP Program is to provide well-researched, useful publications that can contribute to the growth and development of the nation's the public transportation industry. TCRP publications help improve public transportation's administrative practices, develop safer and more effective operational techniques, and increase performance efficiency. The most frequently reported uses of TCRP publications include using the publication as a guidance document, recommending or making management decisions, and recommending or making changes to standards, specifications, operations, or guidance documents. Consumers of TCRP publications include a diverse audience of public transportation practitioners, consultants, government employees, educational institutions, private organizations, and the general public. The most frequently reported impacts resulting from implementing TCRP publications include the improvement of operational efficiency, safety, and compliance with regulations. TCRP reports are accessible at http://www.trb.org/TCRP/TCRP.aspx.

Title: *Small Business Innovation Research (SBIR) Program*

Recipient: The Volpe Center

Project Description:

The purpose of the SBIR Program is to help small businesses grow by funding product development research in strategic areas such as safety, operations, maintenance, and other topics important to transit. FTA is one of eight operating administrations within DOT that funds SBIR research. Federal law (15 U.S.C. § 638) mandates that each operating administration set aside a portion of its annual research budgets to fund SBIR grants. FTA contributes 3.2% of its yearly research discretionary funding to SBIR grants. FTA's FY 2019 discretionary funding amount for SBIR is $640,000. This provides a consistent stream of funding that FTA can use as a vehicle to provide seed money for promising projects. A key component for a small business proposed innovation is its potential for commercialization. The goals of SBIR are to: 1) stimulate technological innovation; 2) meet Federal research and development needs; 3) foster and encourage participation in innovation and entrepreneurship by women and socially or economically disadvantaged persons; and 4) increase private-sector commercialization of innovations derived from Federal research and development funding.

There are two types of SBIR grants: Phase I grants develop proof-of-concept and commercial potential in strategically important areas like safety or innovation, and Phase I grants are for a maximum of $150,000 for a six-month period. Phase II grants further refine and develop successful Phase I-funded products or solutions. For Phase II investments, the expectation is that the small business

will derive future revenue from a commercially available product or solution developed through the program. Phase II grants are typically awarded for approximately $750,000 for a two-year period.

Results:

During FY 2019, FTA had more than $1.6 million in active SBIR projects —two Phase II projects that are still active and one Phase I project that ended in March 2019. In FY 2019, SBIR produced the following results:

- Independent Travel Aid: In FY 2019, Design Interactive, Inc. completed Phase I activities, which resulted in a demonstration-based prototype titled Guided Augmented Independence Travel Aid (GAIT-Aid). The GAIT-Aid prototype was developed in Phase I to explore ways to customize trip planning and navigation for persons with mild cognitive impairments (MCI) using augmented reality technology. The development of this proof-of-concept sets the foundation for Phase II efforts in developing a low-cost, personalized travel aide tool for persons with functional disabilities. The potential is to provide a trip planning, wayfinding, and navigation tool customized to the traveler's abilities, while also providing safety and accessibility to places currently off limits. In March 2019, Design Interactive, Inc. submitted a final internal report, summarizing Phase I results. This independent travel aid is an example of how FTA's SBIR program is meeting its goal of stimulating technological innovation.

- Passenger Counting and Tracking System: Between October 2018 and June 2019, Migma improved the sensors accuracy using a GPS sensor and developed a new signature for tracking passengers. The GPS sensor notifies the system when the bus stops or departs a station, indicating when passengers alight bus. In addition, Migma developed a new head-body width signature that allows the system to identify passengers boarding bus efficiently. Migma submitted a final internal report in July 2019. With transit agencies facing major issues in rider utilization and travel patterns, Migma's passenger counting and re-identification sensor system has the potential to alleviate these issues. This passenger counting and tracking system is another example of how FTA's SBIR program is stimulating technological innovation.

- Pedestrian and Cyclist Detection Devices for Transit Buses: Novateur Research Solutions continued work on its Phase II Pedestrian and Cyclist Detection Devices for Transit Buses. During October to December 2018, Novateur continued improving system performance by generating new training data, improving detection models, and updating modules for object detection, tracking, and data fusion. Data fusion combines detections from video and Light Detection and Ranging (LIDAR) sensors, providing full situational awareness for bus drivers. Novateur Research Solutions conducted a live demonstration for FTA in June 2019 and will conduct live beta testing on a bus with a final demo and prototype in July 2020. This

detection device is an example of how FTA's research investments are meeting federal research and development needs to further DOT strategic goals such as improving safety across our nation's transportation systems.

Design Interactives Phase II efforts began in October 2019. These projects will result in small business growth and technological innovation. SBIR projects are expected to drive new business development and solve pressing issues in the transportation industry.

FTA Funding: $3,494,756

Table 14 *Small Business Innovation Research (SBIR) Projects Receiving Assistance from FTA, FY 2019*

Project Title	Project Recipient	City and State	FTA Award
Pedestrian and Cyclist Detection Devices for Buses	Novateur	Sterling, VA	$749,994
A Reliable Transit Passenger Counting and Re-Identification System Using Occlusion-Proof Biometrics	Migma Systems	Walpole, MA	$749,999
Guided Augmented Independence Travel Aid (GAIT-Aid)	Design Interactive, Inc.	Orlando, FL	$143,990
FTA Interagency Agreement with the Volpe Center for new Phase I project	Volpe Center	Cambridge, MA	$1,850,773
		Total	$3,494,756

Figure 30 *Pedestrian Detection and Collision Warning System*

The Small Business Innovation Research (SBIR) Program helps small businesses like Novateur Research Solutions grow by funding research in strategic areas like safety. For example, Novateur is developing an effective collision warning system for transit buses that can address many of the incidents related to pedestrians and have the potential to save both lives and costs. Several industry studies have determined that a large percentage of pedestrian accidents involving transit buses are avoidable if the threat is detected early and the driver is alerted. Novateur Research Solutions installed several the sensors. The next step will be to conduct live beta testing on a bus in an uncontrolled environment. During the process of beta testing, Novateur has also developed an initial software version of the Driver Alert Interface. Drivers can use any device, such as a tablet or a projection on a translucent or semi-transparent screen. Novateur plans to use a tablet during beta testing.
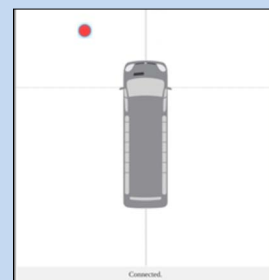
Acronyms and Abbreviations

ATTRI	Accessible Transportation Technology Research Initiative
BEERD	Bus Efficiency Enhancements Research and Demonstrations
CTE	Center for Transportation and the Environment
CUTR	Center for Urban Transportation Research at the University of South Florida
DBE	Disadvantaged Business Enterprise
DOE	Department of Energy
DOT	Department of Transportation
FAST	Fixing America's Surface Transportation Act (Public Law 114-94)
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FY	Fiscal Year
GHG	Greenhouse Gases
HMD	Health and Medicine Division
HST	Human Service Transportation
ITS	Intelligent Transportation Systems
LoNo	Low or No Emission
MAP-21	Moving Ahead for Progress in the 21st Century Act, (Public Law 112-141)
MARTA	Metropolitan Atlanta Rapid Transit Authority
MOD	Mobility on Demand
MSAA	Mobility Services for All Americans
NAS	National Academy of Sciences
NFCBP	National Fuel Cell Bus Program
NREL	National Renewable Energy Laboratory
R&D	Research and Development
R/R&D	Research/Research and Development R2ZE Race to Zero Emissions
REIL	Reduced Engine Idle Load
ROW	Right-of-Way
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (Public Law 109-59)
SBC	Small Business Company
SBIR	Small Business Innovation Research
SOW	Statement of Work
SRD	Safety Research and Demonstration
SRER	Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery Program
TCRP	Transportation Cooperative Research Program
TERM	Transit Economic Requirements Model
TMCC	Travel Management Coordination Center
TRAC	Transit Research Analysis Committee
TRB	Transportation Research Board
TRI	FTA's Office of Research, Demonstration, and Innovation
TSO	FTA's Office of Safety and Oversight
TVM	Transit Vehicle Manufacturer
VAA	Vehicle Assist and Automation
VTCLI	Veterans Transportation and Community Living Initiative

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