

FTA

FEDERAL TRANSIT ADMINISTRATION

FTA Annual Report on Public Transportation Innovation Research Projects for FY 2018

FEBRUARY 2019

FTA Report No. 0129
Federal Transit Administration

PREPARED BY
Federal Transit Administration



U.S. Department of Transportation
Federal Transit Administration

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Courtesy of Edwin Adilson Rodriguez, Federal Transit Administration

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Federal Transit Administration
Office of Research, Demonstration and Innovation
U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, DC 20590

AVAILABLE ONLINE

<https://www.transit.dot.gov/about/research-innovation>

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
ft³	cubic feet	0.028	cubic meters	m ³
yd³	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)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C

REPORT DOCUMENTATION PAGE		Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.			
1. AGENCY USE ONLY	2. REPORT DATE February 2019	3. REPORT TYPE AND DATES COVERED October 1, 2017 - September 30, 2018	
4. TITLE AND SUBTITLE FTA Annual Report on Public Transportation Innovation Research Projects for FY 2018		5. FUNDING NUMBERS	
6. AUTHOR(S) Edwin Adilson Rodriguez Office of Research Management, Innovation, and Outreach Federal Transit Administration			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Federal Transit Administration US Department of Transportation Research, Demonstration and Innovation 1200 New Jersey Ave., SE Washington, DC 20590		8. PERFORMING ORGANIZATION REPORT NUMBER FTA Report No. 0129	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Federal Transit Administration Office of Research, Demonstration and Innovation East Building 1200 New Jersey Avenue, SE Washington, DC 20590		10. SPONSORING/MONITORING AGENCY REPORT NUMBER FTA Report No. 0129	
11. SUPPLEMENTARY NOTES [https://www.transit.dot.gov/about/research-innovation]			
12A. DISTRIBUTION/AVAILABILITY STATEMENT Available from: National Technical Information Service (NTIS), Springfield, VA 22161. Phone 703.605.6000, Fax 703.605.6900, email [orders@ntis.gov]		12B. DISTRIBUTION CODE TRI-30	
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 2018 promoted research, innovation and development, demonstration and deployment, and evaluation.			
14. SUBJECT TERMS Public transportation, Federal public transportation law, public transportation research, FTA appropriations, FTA research, FTA demonstration and deployment, FTA innovation, FTA evaluation		15. NUMBER OF PAGES 67	
16. PRICE CODE			
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT

TABLE OF CONTENTS

1	Executive Summary
6	Requirements for this Report
7	Program and Project Descriptions
7	Safety
18	Mobility Innovation
39	Infrastructure
55	Supporting Programs and Other Initiatives
65	Acronyms and Abbreviations

LIST OF TABLES

2	Table 1:	FTA Research Program Priorities and USDOT's Strategic Goals and Objectives, FY 2018
4	Table 2:	Complete List of FTA Research Program and Projects, 2018
8	Table 3:	Safety Programs Receiving Assistance from FTA, FY 2018
10	Table 4:	SRER Research Demonstrations Projects Receiving Assistance from FTA, FY 2018
14	Table 5:	Safety Research and Demonstration (SRD) Projects that Received Assistance from FTA, FY 2018
18	Table 6:	Mobility Innovation Programs Receiving Assistance from FTA, FY 2018
21	Table 7:	Mobility on Demand (MOD) Projects Receiving Assistance from FTA, FY 2018
35	Table 8:	Transit and Health Access Projects Receiving Assistance from FTA, FY 2018
38	Table 9:	MSAA Projects Receiving Assistance from FTA, FY 2018
40	Table 10:	Infrastructure Programs Receiving Assistance from FTA, FY 2018
49	Table 11:	BEERD Projects Receiving Assistance from FTA during FY 2018
54	Table 12:	LoNo Projects Receiving Assistance from FTA, FY 2018
55	Table 13:	Supporting Programs and Initiatives Receiving Assistance from FTA, FY 2018
63	Table 14:	SBIR Projects Receiving Assistance from FTA, FY 2018

LIST OF FIGURES

3	Figure 1:	FTA Research Projects and Programs by Priority Areas
11	Figure 2:	Example of Impact of SRER on Safety
15	Figure 3:	Impact of SRD on Public Transportation Industry
17	Figure 4:	Safety Standards Strategic Plan
22	Figure 5:	Mobility on Demand (MOD) Demonstration
24	Figure 6:	Dallas Area Rapid Transit (DART) MOD Sandbox Demonstration Evaluation Plan
25	Figure 7:	New Generation of Mobility Performance Indicators – For Mobility on Demand & Beyond
27	Figure 8:	MOD Community of Practice Workshop Plenary Breakfast
30	Figure 9:	Strategic Transit Automation Research Plan
33	Figure 10:	(ATTRI) Complete Trip Fundamentals: Smart Wayfinding and Navigation service (SWaN) Prototype
36	Figure 11:	Delaware County Connections – A Rural Volunteer Based Transit Service
39	Figure 12:	Reference Manual for Planning and Design of a Travel Management Coordination Center (TMCC)
44	Figure 13:	Forecasting Capital Cost
45	Figure 14:	Lifecycle-Based Management
47	Figure 15:	2018 Bus Technology Evaluation Report
51	Figure 16:	Statutory Reports Produced Under TERM
54	Figure 17:	Example of Impact of LoNo Program
57	Figure 18:	Nested Research Evaluation Framework, FY 2018
61	Figure 19:	Improving the Resilience of Transit Systems Threatened by Natural Disasters
64	Figure 20:	Counting Passengers through Body Height Curve



U.S. Department
of Transportation

**Federal Transit
Administration**

Dear Colleague:

I am pleased to provide the Federal Transit Administration's (FTA) Annual Report on Public Transportation Innovation Research Projects for Fiscal Year (FY) 2018. This report describes innovative public transportation research and development in accordance with Federal public transportation law (49 U.S.C § 5312). FTA's research programs and portfolio provide public transit agencies essential information to help them ensure efficiencies today and prepare for tomorrow.

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 that enhance effectiveness, increase efficiency, expand quality, promote safety, and ultimately improve the transit rider's experience. FTA research programs are in alignment with the Secretary's top priorities: safety, mobility innovation, and infrastructure.

This report explains how FTA actively managed \$79 million in research funding during FY 2018 including \$38 million for safety research; \$14 million for infrastructure research; \$17 million for mobility innovation research; and \$10 million for supportive services and other activities. This report also includes information on a \$77 million research initiative for the Low or No Emission Vehicle Deployment (LoNo) Program, funded from FY 2013 – FY 2015 under Federal public transportation law (49 U.S.C. § 5312) – because this program became a statutory program in FY 2016, we account for the total separately from the other \$79 million in research projects.

This report provides descriptions and results to date for FTA-assisted projects active during FY 2018. FTA is proud of these research activities, and looks forward to seeing the results put into practice to enhance public transit industry services. Thank you for your continued support of public transportation innovation research.

Sincerely,

A handwritten signature in blue ink, appearing to read "K. Jane Williams".

K. Jane Williams
Acting Administrator

EXECUTIVE SUMMARY

This report provides information on active FY 2018 research projects funded by the Federal Transit Administration (FTA) as authorized in Federal public transportation law (49 U.S.C. § 5312). 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. The practices and technologies enhance effectiveness, increase efficiency, expand quality, promote safety, and, ultimately, improve the transit rider's experience. In support of this mission and vision, FTA's research program drives public transportation innovation by funding projects in a four-phase research-to-practice pipeline process, moving from early research of promising ideas to evaluation and implementation.

Pipeline Phased Approach



In FY 2018, FTA continued to focus on three broad research priority areas: Safety, Infrastructure, and Mobility Innovation. These research program areas mirrored and supported the goals of the Department of Transportation (USDOT) of Safety, Infrastructure, and Innovation. FTA research activities supported USDOT's strategic goals in the following ways:

- **Safety** – Researched new products and ways to improve safety culture, identify risks, and assess processes that can help transit agencies operate public systems in a safer manner to reduce injuries and fatalities.
- **Infrastructure** – Stimulated economic growth and evaluated methods, transit vehicles, service approaches, maintenance strategies, and practices that hold promise to improve lifecycle maintenance and systems operations and performance.
- **Mobility Innovation** – Led in the development and deployment of new technologies and practices aimed to enhance transit operational efficiency, increase mobility and accessibility, and reduce costs. Core objectives in this research furthered public/private partnerships, research, collaboration, and coordination.

In addition, all FTA research programs supported USDOT's fourth strategic goal of accountability and its two objectives: regulatory reform and mission efficiency. Mission efficiency was furthered through strategies to improve program

performance. FTA also conducted supporting programs and other activities in FY 2018, including those that evaluate the effectiveness of research programs, aid in dissemination, and support research to practice. Other activities include the statutorily-required Transportation Cooperative Research Program (TCRP), a public transportation industry cooperative research program authorized at \$5 million annually. Additionally, 3.2% of discretionary research funds are allocated each year for the statutorily-required Small Business Innovation Research (SBIR) (§ 9 of the Small Business Act, 15 U.S.C. § 638). Table 1 provides a clear connection of FTA research activities with USDOT's strategic goals.

Table 1 FTA Research Program Priorities and USDOT's Strategic Goals and Objectives, FY 2018

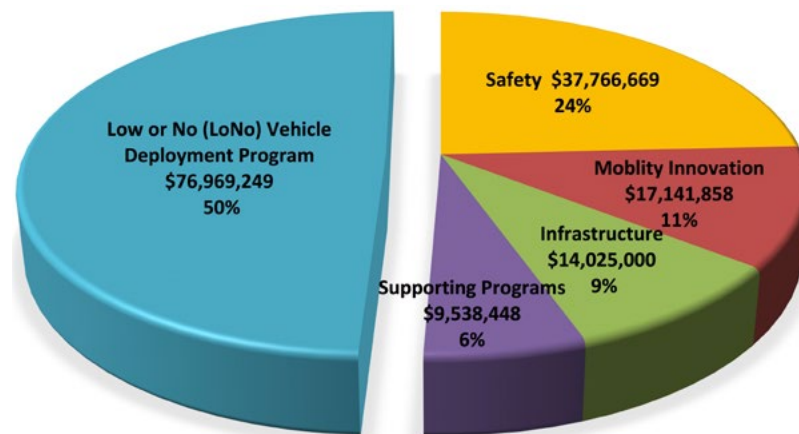
US DOT Strategic Plan Goals and Objectives Aligned to FTA Research		FTA Research Programs								
		Mobility Innovation Projects				Infrastructure Projects		Safety Projects		TCRP
USDOT Strategic Goal	DOT Strategic Objective	Mobility on Demand	Transit Automation	Multi-modal Payment System	ATTRI	Asset Management and Asset Innovation	Advanced Propulsion Research	Safety Standards	Safety Research Demonstrations	TCRP
Safety	Systemic Safety Approach		✓		✓			✓	✓	✓
Infrastructure	Project Delivery, Planning, Environment, Funding and Finance					✓	✓			✓
	Life Cycle and Preventive Maintenance					✓	✓			✓
	System Operations and Performance	✓	✓	✓		✓	✓			✓
	Economic Competitiveness and Workforce	✓	✓			✓	✓			✓
Innovation	Development of Innovation	✓	✓	✓	✓		✓			✓
	Deployment of Innovation	✓	✓	✓	✓		✓			✓
Accountability	Regulatory Reform	✓	✓	✓	✓	✓	✓	✓		
	Mission Efficiency and Support					✓		✓		

Research programs and projects that received FTA assistance in FY 2018 totaled \$78,968,293. FTA also managed the Low or No Emission Vehicle Deployment (LoNo) Program under this section. The LoNo Program awarded \$76,969,249 in FTA funding from FY 2013 – FY 2015 under Federal public transportation law (49 U.S.C. § 5312). The technology matured and developed, and in FY 2016 this

became a statutory program called the Low and No Emission Bus Program (49 U.S.C. § 5339(c)). Now, each year, FTA manages the program through competitively awarded grants.

Of the total research programs managed by FTA in FY 2018, 24% of projects (\$38 million) were associated with safety; 9% (\$14 million) were associated with infrastructure; 11% (\$17 million) were associated with mobility innovation; 6% (\$10 million) were for supportive services and other activities; and 50% (\$77 million) were associated with the LoNo Program. Although the LoNo Program was funded under this section, the program is primarily managed by FTA regional offices as a capital program. Figure 1 provides the percentage of funding of FTA research programs and projects by program areas.

Figure 1
FTA Research Projects and Programs by Priority Areas



Public transportation law (49 U.S.C. § 5312) authorizes four types of statutorily eligible projects: research, innovation and development, demonstration and deployment, and evaluation and implementation. FTA invested the most funding to test promising approaches to public transportation innovation through demonstration programs – 50% of active projects fell into this area. The breakout of funding across the four types of eligible projects in FY 2018 is as follows:

- **Research** – \$19 million (26%) for public transportation research projects that develop and deploy new and innovative ideas, practices, and approaches; this includes the Transit Cooperative Research Program (TCRP).
- **Innovation and Development** – \$17 million (21%) for projects were used to improve public transportation systems nationwide to provide more efficient and effective delivery of public transportation services, including through technology and technological capacity improvements; this includes the Small Business Innovation Program (SBIR).
- **Demonstration and Deployment** – \$40 million (50%) enabled and promoted early deployment and demonstration of innovation in public transportation that has broad applicability.

- **Evaluation and Implementation** – \$3 million (3%) analyzed project results and disseminated findings.

FTA managed an extensive portfolio of research programs and projects. Table 2 provides a complete list of all FTA research programs and projects that received assistance in FY 2018.

Table 2 Complete List of FY 2018 Active FTA Research Program and Projects

Research Priority	Type of Project	Project Title	FTA Funding
Safety	Demonstration & Deployment	Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery Research Demonstrations (SRER)	\$24,000,000
Safety	Innovation & Development	FTA Employee Safety Reporting Pilot Program	\$3,000,000
Safety	Demonstration & Deployment	Safety Research and Demonstration Program (SRD)	\$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	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	\$1,450,000
Mobility Innovation	Research	Accessible Transportation Technologies Research Initiative (ATTRI)	\$2,500,000
Mobility Innovation	Research	Transit and Health Access Initiative	\$2,865,233
Mobility Innovation	Innovation & Development	Mobility Services for All Americans (MSAA)	\$795,545
Infrastructure	Research	Low or No (LoNo) Emission Component Assessment Program	\$3,000,000
Infrastructure	Demonstration & Deployment	Track Asset Management Demonstration	\$4,225,000
Infrastructure	Research	Effects of Capital Cost Forecasting Study and Research	\$200,000
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
Infrastructure	Innovation & Development	Transit Economic Requirements Model	\$2,000,000
Infrastructure	Demonstration & Deployment	Low or No Emission Vehicle Deployment Program (LoNo) Program*	<\$76,969,249>
Supporting Programs	Evaluation & Implementation	Information Dissemination and Evaluation Program	\$1,439,692
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 (SBIR)	\$2,854,766
Total FTA Funding			\$78,477,985*

* The LoNo Program matured from a research program to a capital discretionary program authorized by Federal public transportation law (49 U.S.C. § 5339(c)). The amount of \$76,969,249 is in brackets to indicate that we are breaking out this program separately from the total of actively managed research projects.

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.

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

In this section of the report are detailed descriptions of programs and projects that received assistance in FY 2018. This assistance included the award of a new project, management of an existing project, or significant planning activities in support of an upcoming approved project. Information is categorized by 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, grantee(s), performance indicators (results), evaluation, and FTA funding.

Safety

Description:

USDOT's Safety goal seeks to reduce transportation-related fatalities and serious injuries across the transportation system, and FTA's research addressed this goal in public transit systems. The mission of FTA's Safety research program is to provide leadership and vision in the development and management of initiatives that improve the safety of passengers, employees, emergency responders, and all others who encounter the public transportation system. FTA supported research on new safety technologies that can reduce fatalities and injuries.

Objectives:

FTA Safety research sought to:

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

FTA had four active Safety projects in FY 2018, as listed in Table 3.

Table 3
*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 Research Demonstrations (SRER)	\$24,000,000
Innovation & Development	FTA Employee Safety Reporting Pilot Program	\$3,000,000
Demonstration & Deployment	Safety Research and Demonstration Program (SRD)	\$8,516,669
Demonstration & Deployment	Safety Research and Demonstration (SRD) Program Evaluation	\$750,000
Research	Safety Standards Strategic Plan Development and Data Collection Strategy	\$1,500,000
Total		\$37,766,670

Title: *Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Program*

Grantee: Local governments, transit authorities, educational institutions, and private firms

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 three program goals. The goals are: 1) operational safety, 2) infrastructure or equipment resiliency, and 3) all-hazards emergency response and recovery methods. Under operational safety, SRER is developing and testing new or substantially-improved technologies, methods, practices, and techniques 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 systems that are hardened against natural disasters and/or catastrophic events. Under all-hazards emergency response and recovery, SRER is investigating technologies, methods, practices, and techniques 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 2018. Examples of outputs of SRER projects with significant results in FY 2018 include:

- Metropolitan Atlanta Rapid Transit Authority (MARTA): completed fabrication, installation, and configuration of the secondary track worker safety system along six miles of MARTA’s rail system. Reached out to industry to present project progress, held site visits at six industry events,

including 2017 APTA Expo, 2017 APTA Safety Conference, 2018 TRB Annual Conference, and others. Currently commissioning the system by testing all hardware and software deployed. These efforts are making MARTA track inspectors and workers safer by lowering possibilities of injuries and fatalities for employees during maintenance work on rail tracks. The project met the SRER goal of operational safety by exploring technologies to prevent transit vehicle collisions with track maintenance workers and evaluating the cost-effectiveness and practicality of the system.

- New York Metropolitan Transportation Authority (NYMTA): completed vehicle and track instrumentation, testing, data collection and analysis early in 2018. Conducted multiple outreach efforts to showcase the innovative solutions for improving the effectiveness of rail track maintenance. Included a webinar in April 2018 and published a magazine article in *Trains* magazine in October 2017. The project benefits NYMTA by optimizing its track and vehicle inspection and maintenance process toward the goal of identifying a better and more effective way of maintaining rail track infrastructure.
- New Orleans Regional Transit Authority (RTA) Evacuation and Return Pilot: successfully conducted a full-scale New Orleans City Assisted Evacuation tabletop exercise that coordinated with local emergency management, U.S. National Guard, American Red Cross, local transit agencies, and several emergency management services partners. Completed an After-Action Report/Improvement Plan that identified several areas of improvements needed; lessons learned will be provided in the final report. Provided financial and technical support to enable New Orleans Regional Transit Authority to conduct a tabletop exercise with appropriate local emergency management agencies to coordinate and enhance its existing all-hazard emergency management and recovery plan. This effort met the SRER goal of preparing all-hazards emergency responses and recovery methods. A final report is expected to be submitted in the winter 2018.
- Smart, Shared and Social: Enhancing All-Hazards Recovery Plans with Demand Management Technologies Demonstration: developed and tested an emergency recovery plan for Portland, Oregon with local transit agencies and emergency management transportation groups of five counties from Oregon and Washington. Successfully completed six workshops in other regions of the U.S. using lessons learned from emergency recovery plan development in conjunction with the Association of Metropolitan Planning Organizations (AMPO) in Savannah, GA; El Paso, TX; Tampa, FL; Broward, FL; Lake Charles, LA; and Rochester, NH. A total of 198 individuals in the areas of transportation, safety, and/or emergency management roles took part in the trainings. The project provided financial and technical support to develop an emergency recovery plan for the Portland region, and training materials were developed and six workshops provided throughout the U.S. Efforts in FY 2018 met the SRER goal of operational safety. The final report is expected in Winter 2018.

- Connected Vehicle (CV) Infrastructure - Urban Bus Operational Safety Platform: completed installation of 24 Greater Cleveland Regional Transit Authority buses and three intersections with connected vehicle (CV) technology to provide bus drivers with alerts to avoid likely collisions with pedestrians. Revenue service demonstration began in February 2018 with buses operating on 6 routes, consisting of 16 80-ft articulated buses and 8 30-ft trolley buses. The research benefits the transit agency and traveling public by allowing buses to avoid collisions with other vehicles and pedestrians crossing the streets. The project met the goal of mitigating safety hazards identified by the transit agency.

Throughout the duration of the program, each project sponsor was required to conduct outreach and transfer knowledge via workshops, conference presentations, webinars, etc. Final reports are expected from each project after their completion. All final reports should be submitted to FTA in Fall 2018 and Fall 2019. In addition, final evaluation reports will be provided to FTA describing the effectiveness of the proposed technology, method, and/or practice. 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 project sponsors 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.

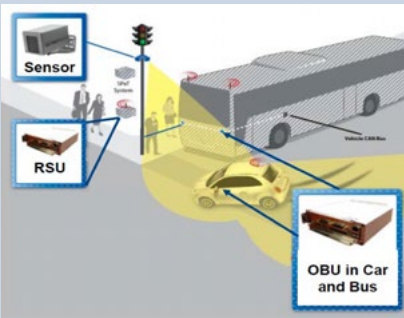
FTA Funding: \$24,000,000

Table 4 *SRED Research Demonstrations Projects Receiving Assistance from FTA, FY 2018*

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	MARTA	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	\$2,741,617
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			\$24,000,000

Figure 2 Example of Impact of SRER on Safety



Connected Vehicle Infrastructure for Urban Bus Operational Safety – FTA worked with Battelle and developed an enhanced version of the Transit Safety Retrofit Package (TRP) system that was originally part of the USDOT Safety Pilot Model Deployment. The enhanced TRP (E-TRP) is based on experience gained and lessons learned from the earlier system, with the current focus on reducing pedestrian and vehicle conflicts with transit buses in the greater Cleveland metro area. The E-TRP features enhanced versions of the Pedestrian Crossing Warning (PCW) and Vehicle Turning Right in Front of Bus Warning (VTRW) applications.

Key technologies deployed include Dedicated Short Range Communications (DSRC) for vehicle-to-vehicle and vehicle-to-infrastructure communication, GPS for vehicle tracking, and state-of-the-art cameras for enhanced pedestrian detection. The E-TRP was installed on 24 transit buses for field testing at 3 locations – 1 signalized intersection, 1 non-signalized intersection, and 1 mid-block crossing. The buses operated in revenue service for six months to collect data for evaluation of the performance of the system and safety applications, safety impacts, and lessons learned. The demonstration and the evaluation are expected to be completed in August 2018; results and lessons learned will be presented at industry conferences.

Title: *FTA Employee Safety Reporting Pilot Program*

Grantee: The Volpe Center

Project Description:

This program develops guidance for the transit industry to comply with a regulation requiring the use of employee reporting systems as a part of developing safety management systems plans. The guidance will provide transit organizations with a roadmap for developing and implementing an employee reporting system. The program also will conduct a demonstration of reporting systems at transit organization to learn about the particular needs and challenges to implementing employee safety reporting systems. The lessons learned from

the demonstrations will be added to the guidance document made available to the transit industry.

Results:

In March 2018, the Volpe Center produced an internal white paper titled “How Third Parties Can Improve Employee Safety Reporting.” This document assisted the Stakeholder Review Panel to focus on its review of voluntary standards and partner with industry and APTA to support the development and implementation of sound, solid, employee reporting system practices as part of the Safety Management System (SMS) program.

Once completed, this program will submit to FTA a guidance document for agencies to implement an Employee Safety Reporting system, and an evaluation of the program effectiveness of each pilot site. Delivery of the guidance document is expected in early 2019. To date, this project is collecting relevant information that assists FTA improve the safety culture at transit agencies, supporting stakeholder coordination, and conducting outreach. The impact of the program is that it will support the development of transit safety standards, protocols, and best practices.

FTA Funding: \$3,000,000

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

Grantee: Transit authorities partnering with local governments, educational institutions, and/or private entities

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 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. Several projects concluded in FY 2018.

Results:

The seven demonstration projects shown in Table 5 were active in FY 2018. The projects yielded data on the effectiveness of various technological approaches to enhancing safety in collision warning and avoidance and transit employee safety protection. Significant outputs for SRD in FY 2018 included:

- Maryland Transit Administration Fixed-Mounted Train Detection and Worker Warning System Demonstration: completed installation of secondary worker warning units to the entire Maryland Transit Administration yellow line; completed radio-mesh network for the system. Currently adjusting calibration of sensors and validating communication network for demonstration phase, which will document safety improvements to track workers, evaluate system effectiveness, and document return on investment. Efforts under these projects are beneficial to the industry by making the work environment for workers safer. This project meets the SRD goal of exploring technologies to prevent transit vehicle collisions with track maintenance workers and evaluating the cost-effectiveness and practicability of the systems.
- Washington Metropolitan Area Transit Agency (WMATA) Track Inspector Location Awareness System: successfully completed procurement of the secondary wayside system and is installing 182 ranging wayside units at 12 locations throughout the rail system identified as representing high risk for roadway workers. WMATA is developing a test/demonstration schedule to evaluate the system. This project is making WMATA safer in high risk areas, thus lowering the possibilities of injuries and fatalities for employees. This project meets the SRD goal of exploring technologies to prevent transit vehicle collisions with track maintenance workers, evaluating the cost-effectiveness, and practicability of the systems.
- New York City Transit (NYCT) Bus Mirror Configuration Project: successfully established an industry advisory panel and completed three focus groups sessions in the Bronx and Manhattan. Via an expert advisory panel and focus groups, established preliminary visibility requirements for transit bus operators, completed benchmarking of representative samples of NYCT bus fleet. 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 goal of enhancing the safety of transit bus services by incorporating safer design elements and evaluating the cost-effectiveness and practicability of the design.
- Sacramento Regional Transit Enhanced Secondary Warning System for Track Worker Protection Pilot: successfully completed procurement of all secondary wayside systems, currently installing the units on entire fleet of Light Rail Vehicles. Currently developing test/demonstration schedule and validating units as installation progresses. Efforts under this project are making

the system safer in identified high-risk areas, lowering the possibilities of injuries and fatalities for employees during track inspection and maintenance. The project supports the SRD goal to explore technologies to prevent transit vehicle collisions with track maintenance workers and evaluate the cost-effectiveness and practicability of the system.

Final reports are expected to be submitted to FTA in FY 2019. They will detail specific outputs and evaluation of each demonstration project.

Project/Program Evaluation:

The Center for Urban Transportation Research (CUTR) at the University of South Florida (USF) is serving as the independent evaluator and is working with FTA project managers and grantees to evaluate each project on safety improvements, system effectiveness, and return on investment. Performance metrics were determined for each project, and data collection plans for all the projects under the program are completed. The SRD Program evaluation is described in detail under the SRD Program Evaluation.

FTA Funding: \$8,516,669

Table 5 *Safety Research and Demonstration (SRD) Projects that Received Assistance from FTA, FY 2018*

Project Title	Project Recipient	City and State	FTA Award
Pierce Transit Collision Avoidance and Mitigation Safety Demonstration	Pierce Transit	Lakewood, WA	\$1,664,894
Transit Bus Mirror Configuration Research and Development	NY 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	LA 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			\$24,000,000

Figure 3 *Impact of SRD on Public Transportation Industry*



Per the Fatality Analysis Reporting System, a census of fatal motor vehicle crashes in the U.S. from 2010–2014 indicated approximately 35 fatal pedestrian crashes and 96 serious crashes with transit buses each year. Approximately 48% of pedestrian fatalities and 40% of serious pedestrian crashes occurred when the bus was traveling straight, and, of 7 annual bicyclist fatalities, 67% occurred when the bus was traveling straight. FTA is partnering with NYCT to make design changes to the layout of the operator compartment—in particular, the placement and size of the operator mirrors—to prevent and minimize obscuration and provide drivers with an optimal view of pedestrians, bicyclists, and customers. Current regulations related to bus mirror configurations on transit buses are minimal compared to those for other vehicles. FTA is working with multiple partners within the transit industry to create a set of guidelines to ensure that transit bus operators have optimal views and can easily spot potential hazards around the vehicle. It is critical to improve the visibility in the zone obstructed by the street-side A-pillar and mirror. The design and demonstration of an optimized mirror solution set for street-side mirrors on low-floor transit buses could reduce the number of serious crashes and enhance the effectiveness of transit vehicle visibility systems.

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

Grantee: The Center for Urban Transportation Research (CUTR)

Project Description:

This project supports FTA’s Safety Research and Demonstration (SRD) Program and the project is necessary to meet the statutory requirement of 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 demonstration projects; 2) assess the contribution of each project towards advancing FTA’s SRD programmatic goals of improved collision avoidance and increased workers 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 2018. The evaluator produced the following relevant outputs:

- Performance metrics and data collection: the SRD Program Evaluation team worked with the SRD grantees and the project managers to establish a set of individual performance metrics for all three evaluation areas. The three evaluation areas are safety improvements, system effectiveness, and return on investment. The SRD Program Evaluation team completed 7 data

collection plans. The team is currently working with SRD grantees to manage and monitor the progress of the data collection effort by each grantee and project. The goal is to provide a data driven approach to these projects and ultimately inform the industry about the viability of these technologies to improve safety. The data collection plans developed evaluate the effectiveness of the projects and determine if the SRD projects are meeting the program goals.

Once completed, the evaluation will provide valuable information regarding the effectiveness of the technologies demonstrated in the research program, regarding collision avoidance and transit worker safety; 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.

FTA Funding: \$750,000

Title: *Safety Standards Research*

Grantee: The 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) develop a strategic plan that notes possible gaps in safety standards. The research conducted for this project aims to provide background information and strategic direction 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 (49 U.S.C. § 5314).

Results:

FTA used the results of this research to identify key safety focus areas for new transit standards, guidance, or advisories for the transit industry. Results in FY 2018 were as follows:

- Strategic plan: a final internal Safety Standards Strategic Plan was developed that provided research to FTA about existing transit safety areas and gaps. The plan also 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 recommendations to FTA for further research to close the identified gaps. The strategic plan met the goals to review of current transit safety standards for this project and conduct data analysis.

- Comprehensive list of current safety standards: for the public transportation industry on transit safety standards and protocols, published in the Federal Register (81 FR 30605) in May 2016 and accessible on FTA’s website at <https://www.transit.dot.gov/regulations-and-guidance/safety/compendium-transit-safety-standards>. This document provides value to the industry and FTA by listing a comprehensive reference about the existence and lack of standards in each transit safety area and met the goals of review of current transit safety standards for this project and conduct data analysis.
- Final report: a report titled “Review and Evaluation of Public Transportation Safety Standards” was published on FTA’s website in January 2017 and is accessible at <https://www.transit.dot.gov/research-innovation/review-and-evaluation-public-transportation-safety-standards-fta-report-no-0103>. The document provides research, data, analyses, and information about public transportation safety standards and protocols and their effectiveness in making public transit safer and met the goals of reviewing current transit safety standards and conducting data analysis.

Documents produced under this project 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. The outputs of this project also highlighted the need for new minimum safety standards to ensure public transit is safe, and provided information to inform standards development activities funded from other FTA programs.

FTA Funding: \$1,500,000

Figure 4 *Safety Standards Strategic Plan*

FTA finalized the “Safety Standards Strategic Plan” in May 2018. 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 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 USDOT’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 technical/ technological capabilities.

Objectives:

The primary objectives of FTA’s Mobility 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 five active Mobility Innovation programs in FY 2018, as shown in Table 6.

Table 6 *Mobility Innovation Programs Receiving Assistance from FTA, FY 2018*

Mobility Innovation Programs		
Type of Project	Project Title	FTA Funding
Innovation & Development	Mobility on Demand (MOD) Sandbox	\$7,931,080
Innovation & Development	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 Plans Development	\$1,450,000
Research	Accessible Transportation Technologies Research Initiative (ATTRI)	\$2,500,000
Research	Transit and Health Access Initiative	\$2,865,233
Innovation & Development	Mobility Services for All Americans (MSAA)	\$795,545
Total		\$17,141,858

Title: *Mobility on Demand (MOD) Sandbox*

Grantee: Transit agencies, local governments, non-profit organizations, and private firms

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 through a smart phone 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; its 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 USDOT'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.

The MOD Sandbox consists of 11 pilot projects selected in late 2016 to demonstrate different approaches and technologies. Transit organizations lead project efforts in partnership with mobility providers, research organizations, or state and local governments. All project teams are now working to launch the demonstration efforts, several of which are already operational.

Results:

All MOD Sandbox projects were active in FY 2018, and work is in progress. The outputs of the current Sandbox projects, shown in Table 7, are already helping inform FTA and the industry on MOD-related policies, and what technologies and business models work best and resonate with every community. 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. The following are relevant and significant results of the MOD Sandbox projects:

- Vermont Agency of Transportation (VTrans): introduced the GoVermont Flexible Trip Planner Project in February 2018. The trip planner, accessible to the public at <https://plan.vermont.gov/>, is the first trip planner capable of presenting all public transit services in Vermont, connecting users in multimodal journeys that offer viable transit solutions, even in rural regions without fixed-route networks. These new features include routing for Dial-a-Ride, Hail and Ride, and Deviated Fixed services, all especially common in the rural areas that other trip planner technologies have failed to serve effectively.
- San Francisco Bay Transit Authority (BART): demonstrated an integrated carpool to transit pilot program that matches carpool users traveling to BART stations and provides a way to reserve and pay for sought-after parking at the stations, improving access to transit stations. Information on this MOD project is accessible at <https://511.org/carpool-vanpool/carpool/bart>. The project has enabled enhancements to the Scoop app platform that improve the experience for BART commuters and has successfully expanded the demonstration to 17 stations. The project is exploring the feasibility and effectiveness of this innovative first/last mile solution to connect riders to transit at multiple locations within one system and is providing insights into how to implement successful MOD solutions more broadly.
- Valley Metro Rail of Phoenix: implemented a smart phone mobility platform called Pass2Go that integrates mobile ticketing and multimodal trip planning. The network included a range of mobility providers, including ride-hailing, allowing people at all levels of income, age, and disability to have access to an integrated, connected multimodal transportation system. Phase I, which includes a basic trip planner and full-day fare mobile ticketing with visual validation, was launched in March 2018. The project will explore an approach to MOD solutions that integrates, through a transit agency's app, mobile ticketing, multi-modal trip planning and links to other app-based transportation options to make travel within Phoenix more seamless.
- Dallas Area Rapid Transit (DART): phased-in an upgraded GoPass regional mobile app that integrates microtransit, dynamic carpooling, and hailing services. It solved first/last mile issues, particularly in non-walkable areas not well served by transit. Phase I, which integrated microtransit (GoLink) and dynamic carpooling (GoPool), was launched in May 2018. The project is exploring innovative approaches to linking multiple mobility options in an account-based system that enable travelers to choose. Travel modes that best serve their needs based on price, travel time and wait time.

To date, the MOD Program achieved the following measurable outcomes:

- Expanded options for communities and transit agencies to provide MOD-based transportation solutions.
- Enhanced transit capacity and readiness to adopt MOD solutions.

- Identified innovative business models that support high-quality, seamless and equitable mobility.
- FTA adoption of flexible, responsive policies on shared mobility support for transit agencies, communities, and individual travelers.
- Supported traveler-centric, carefree, and effective transportation that is reflective of MOD guiding principles of system integration, partnership-driven, innovative and equitable.
- Supported the emerging U.S. mobility industry.
- Enabled a more efficient robust and responsive transportation system.

Project/Program Evaluation:

MOD Sandbox demonstration projects require an evaluation, and FTA is working with a contractor to complete evaluations of each projects to provide a comprehensive assessment of the efforts at the conclusion of the pilot demonstrations. These evaluations will inform how MOD solutions integrate with transit service and provide lessons learned for other transit agencies seeking to use MOD solutions to improve mobility in their communities.

FTA Funding: \$7,931,080

Table 7 *Mobility on Demand (MOD) Projects Receiving Assistance from FTA, FY 2018*

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 Corp.	Lakewood, WA	\$205,922
Total			\$7,931,080

Figure 5 *Mobility on Demand (MOD) Demonstration*

The Vermont Agency of Transportation (VTrans) began the demonstration phase of the GoVermont Flexible Trip Planner in February 2018 (<https://plan.vermont.org/>). This MOD Sandbox project shows creative connections between fixed routes and the flexible services that connect users to every household in Vermont. The new features include routing for Dial-a-Ride, Hail and Ride, and Deviated Fixed route services, all especially common in the rural areas that other trip planner technologies have failed to effectively serve. This project promotes flexible transit options in rural Vermont, connects people to jobs and services, promotes economic development and access to health care, and more. The GoVermont Flexible Trip Planner is also an example of a solution other agencies and regions across the U.S. can implement.



Title: *MOD Sandbox Evaluation*

Grantee: Booz Allen Hamilton

Project Description:

This project supports FTA’s MOD Program and is conducting a comprehensive independent evaluation of the MOD Sandbox Demonstrations as required by Public transportation law (49 U.S.C. § 5312(e)(4)). The goals of the evaluation are to: 1) identify and analyze the project impacts from performance measures identified by the independent evaluator and 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 the 11 MOD Sandbox grantees to conduct the required evaluation of each demonstration project. In FY 2018, the following outputs were completed:

- Evaluation Framework Report: included a description of each project and identified the key stakeholders committed to the success of the project. It also provided critical linkage between the purpose of the project, overall MOD program goals, and assessed the overall potential to measure the institutional, business, customer service, costs and operational impacts of the demonstration. This report meets the goal of identifying and analyzing the

project impacts from performance measures identified by the independent evaluator.

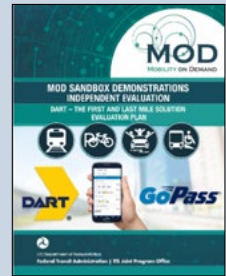
- Logic Models: completed for the II MOD Sandbox demonstration sites. The logic models meet both goals of this effort. Each project-specific logic model contained the following elements that stipulated the key sequencing of the evaluation tasks:
 - MOD Sandbox Project – denoted the specific MOD Sandbox project.
 - Project Goals – denoted each of the project goals for the specific MOD Sandbox project that capture what each MOD Sandbox project is trying to achieve.
 - Evaluation Hypothesis – denoted each of the evaluation hypotheses for the specific MOD Sandbox project, which flow from the project-specific goals.
 - Performance Metric – denoted the performance metrics used to measure impact in line with the evaluation hypotheses for the specific MOD Sandbox project.
 - Data Sources – denoted each of the data sources used for the identified performance metrics.
 - Method of Evaluation – denoted the quantitative and qualitative evaluation methods used.
- Evaluation plans: developed for the II sites to 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 will coordinate 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.

This effort will continue with data collection analysis, development of evaluation reports for the II sites, a synthesis report, and knowledge transfer activities and materials. Results from the evaluation will advance public transportation in the U.S. by identifying impacts (e.g., benefits) of MOD alternative transportation services and applying 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 6 Dallas Area Rapid Transit (DART) MOD Sandbox Demonstration Evaluation Plan

Dallas Area Rapid Transit (DART) is demonstrating a phased, upgraded GoPass regional mobile app that integrates microtransit, dynamic carpooling, and ride-hailing services with DART's fixed-route service to solve first/last mile issues, and provide service in underserved locations. The project will improve ease of access to DART stations, particularly in non-walkable areas not well served by transit. The evaluation plan outlines the evaluation approach and methodology with hypotheses, performance metrics, data requirements, roles and responsibilities, and timelines.



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

Grantee: TransitCenter, Inc.

Project Description:

The purpose of this project is to research current and future performance measurement needs for the integrated mobility environment and develop supplemental performance metrics as part of FTA's MOD Program. A goal of this research is to examine how transit agencies need to reorient their approach to meeting their objectives and goals in light of potential collaboration with mobility providers. Examples include bike/scooter sharing, car sharing, micro-transit, ride-hailing, transportation network companies (TNCs), peer-to-peer car sharing, paratransit, demand response, and human service transportation (HST). Another goal is to recommend performance metrics for FTA, and transit agencies, to evaluate progress toward MOD goals. Research includes a literature review of existing transportation goals and performance metrics.

Results:

In FY 2018, the TransitCenter and team member Shared Use Mobility Center (SUMC) prepared three case studies and conducted a literature review. Built upon this initial research, SUMC developed a research document with recommended performance indicators. Notable outputs in FY 2018 included:

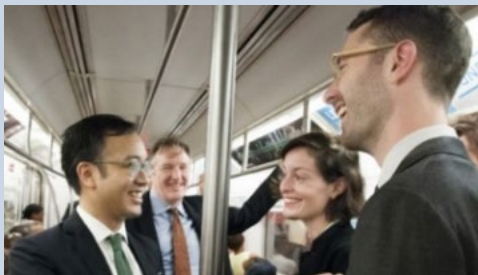
- Case studies: were prepared and used as input in understanding needs within the integrated mobility environments and developing a set of measurement metrics to capture their performance.
 - Valley Metro Mobility Platform: A Scenario Describing the Project and Its Planning Phase - Valley Metro's MOD Sandbox Project – built the foundation for a unified, comprehensive mobility platform for all users, including those with disabilities. Building blocks—customer facing interfaces designed for universal access and dynamic databases that support all individuals as they plan, take, and pay for multi-modal trips—are being set into place.

- Pinellas Suncoast Transit Authority’s (PSTA’s) Public-Private-Partnership for Paratransit Mobility on Demand Demonstration – created a paratransit platform for on demand rides hosted by government agencies. The PSTA-run platform is also designed to bring ride providers into competition with each other, empowering users by giving choices at the time the ride is ordered.
- LA Metro Mobility on Demand Sandbox Project (draft) – developed a pilot program with four main features: 1) TNCs, where drivers provide the vehicles for first/last mile service, 2) payment integration with Metro’s TAP card including fare subsidies, 3) Wheelchair-Accessible Vehicles (WAVs), and 4) for travel within geo-fenced areas around selected stops and station.
- Gap analysis: was performed, with findings documented in “Evaluating Emerging Mobility Partnerships: A Performance Evaluation Framework for the FTA Mobility on Demand Sandbox.”

The input from preparatory work (literature review, case studies, and gap analysis) was used to develop performance measures, summarized in an internal document titled “New Generation of Mobility Performance Indicators – For Mobility on Demand & Beyond.” This final document provides a performance measurement approach, the operational, planning, safety, and financial performance envisioned integrated mobility environments. The final report is in the draft stage and is expected to be completed Summer 2019.

FTA Funding: \$750,000

Figure 7 *New Generation of Mobility Performance Indicators - For Mobility on Demand & Beyond*



Emerging mobility services such as bikeshare, carshare, e-hail taxis, and on-demand transit are changing the way people get around cities, with important implications for public transportation. The prospect of autonomous vehicles also has implications for the future. The efforts under the Metrics and Studies project is identifying an updated set of performance indicators to reflect agency mobility goals and guide the implementation of the MOD solutions.

Title: *MOD Information and Knowledge Accelerator (IKA)*

Grantee: Shared Use Mobility Center (SUMC)

Project Description:

The MOD Information and Knowledge Accelerator (IKA) enhances mobility by creating a structured, supported learning and information exchange system. It also supports a community of practice for the MOD Program. 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 U.S., and build a body of knowledge. Key strategies are to convene stakeholders, facilitate discussions, summarize learning, and disseminate knowledge in this rapidly-evolving area.

Results:

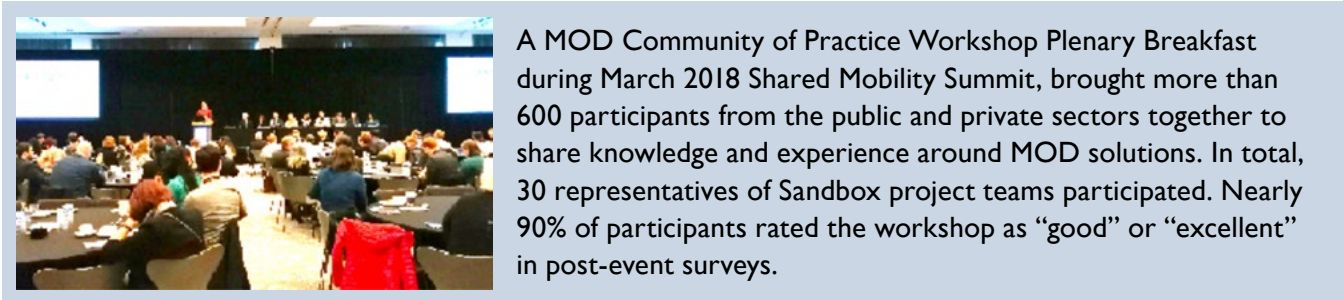
The IKA project hosted bi-annual MOD Community of Practice open workshops with public and private sector stakeholders. These venues promoted information exchange and shared key lessons learned. The IKA project produced the following outputs:

- MOD Community of Practice Workshops: the first workshop was held in October 2017 in Atlanta with 70 attendees, of which 40 were from MOD Sandbox projects. It provided a venue for frank discussions between Sandbox grantees and their private sector partners. The workshop also provided presentations on innovative procurement models, and strategies to remove barriers around proprietary systems and compatibility issues. MOD Sandbox grantees shared ongoing project updates and challenges in a grantees-only session. The second community of practice workshop was held in March 2018 in Chicago in partnership with the Shared Mobility Summit, with 90 attendees, including 30 from MOD Sandbox projects. Several Sandbox project representatives spoke at a breakfast plenary attended by approximately 600 attendees of the Shared Mobility Summit. The meeting shared results and findings with others pursuing similar projects. the exchange covered legal issues, examples of public-private data sharing, and approaches being considered or implemented to overcome challenges. Discussions also probed topics such as gamification, scaling MOD, engaging emerging mobility providers, and first/last-mile operations.
- Private online resource: was developed for Sandbox grantees to share project documents and other tools. Examples include service provision and data sharing contracts, data management plans, and acquisition documents for the provision of wheelchair accessible service in MOD Sandbox demonstration projects. The resource includes a searchable policy database to support the dissemination of MOD-related practices. In FY 2018, nearly 400 records were added to the database, allowing those interested in MOD to find examples of programs indexed by geography, program purpose, and tools. More than 500 people are registered to use the database.
- Webinars: conducted webinars to disseminate information and practices on MOD projects, including:
 - Marketing Successful Mobility on Demand Pilot Projects, December 2017 (<http://policies.sharedusemobilitycenter.org/#!/analysis/68>) with 218 live attendees; webpage was viewed 225 times during FY 2018.

- Shared Mobility for People with Disabilities—Challenges and Opportunities for Paratransit, September 2017 (<http://policies.sharedusemobilitycenter.org/#/analysis/65>) held in FY 2017 with 397 live attendees, viewed 428 times in FY 2018.
- Reports: were completed to share in-depth information on MOD projects, both within and outside the Sandbox program, produced brief reports on:
 - Contracting for MOD services, featuring the City of Arlington, Texas, January 2018 (<http://policies.sharedusemobilitycenter.org/#/analysis/71>).
 - Marketing MOD services, featuring projects in Florida, Colorado, and California, January 2018 (<http://policies.sharedusemobilitycenter.org/#/analysis/69>).
 - Boston area public-private partnership for on-demand ADA complementary paratransit service, November 2017 (<http://policies.sharedusemobilitycenter.org/#/analysis/67>).
 - Kansas City paratransit/micotransit pilot program “RideKC Freedom,” November 2017 (<http://policies.sharedusemobilitycenter.org/#/analysis/66>).

FTA Funding: \$600,000

Figure 8 *March 2018 MOD Community of Practice Workshop Plenary Breakfast*



Title: *Transit Automation Analysis and Research Plan Development*

Grantee: The Volpe Center

Project Description:

The purpose of this project is to develop the Strategic Transit Automation Research (STAR) Plan for FTA and to begin implementing 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 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 (e.g., human factors, federal policy, costs and benefits, etc.). 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 is based on a series of research studies and coordination with internal and external stakeholders. Studies included in-depth literature reviews, qualitative analyses, and benefit-cost analyses. Information from these studies was supported by interviews with subject matter experts and stakeholders. The synthesized results identified research needs in the areas of safety and security, operations and economics, passenger experience, and policy research.

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 SAE International (https://www.sae.org/standards/content/j3016_201609/). The technology packages respond to stakeholder needs and include transit bus advanced driver assistance systems (ADAS), automated shuttles, automated maintenance and yard operations, automated mobility-on-demand service, and automated bus rapid transit (BRT). These technology packages comprise the demonstrations outlined in the Integrated Demonstrations work area of the plan.

Results:

To date, this project completed:

- **Final STAR Plan:** published in May 2018 on the FTA public website at https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/114661/strategic-transit-automation-research-report-no-0116_0.pdf. This document defines a five-year research plan with a research and demonstration framework. The plan provides numerous benefit by enabling research, identifying, and resolving barriers. It leads to the deployment and leveraging

technologies from other sectors. It also demonstrates market-ready technologies, and transfers knowledge to the transit stakeholder community. Implementation of the plan will help accelerate development and deployment of transit bus automation operations. Anticipated benefits of transit automation include improved safety, increased efficiency and productivity, reduced costs, increased traveler convenience and comfort through improved service frequency, flexibility, and reliability, expanded service hours and area, and increased overall customer satisfaction.

- **Webinar:** conducted to introduce the draft plan and gather feedback (https://www.pcb.its.dot.gov/t3/s171205_FTA_Strategic_Transit_Automation_Research_Plan.aspx), on December 5, 2017 with 435 participants. This effort built awareness to socialize automation for transit stakeholders.
- **Reports:** content completed for two reports and final drafts were submitted for FTA review. The report titled “Application of Light and Commercial Vehicle Automation Technology to Transit Bus Automation,” was approved by FTA and it is available at <https://www.transit.dot.gov/research-innovation/transit-bus-automation-project-transferability-automation-technologies-final>. This report leveraged technologies, applications, and lessons learned from the light and commercial vehicle transportation sectors, which are further along in vehicle automation than transit. The public transportation industry can use the report to inform its assessment as to whether and the extent to which various automation technologies being developed by others may be applicable in transit environment. The second report, titled “Transit Bus Automation Test Facilities Requirements,” is under FTA review and it will be published late Spring 2019. This report identifies test facility characteristics that transit bus automation developers need to conduct (such as research and development testing of transit bus automation capabilities) prior to operations on public roadways. Both reports help to accomplish the goals of conducting enabling research, leveraging technologies from other sectors, conducting enabling research, and demonstrating market-ready technologies.
- **Interim Policy Review Memorandum:** summarized a preliminary review of key federal policies, regulations, and guidance that may pose challenges to the deployment of transit bus automation. It identified statutory, regulatory, and policy barriers to transit bus automation and potential changes. The memorandum supported the goal of conducting enabling research and identifying and resolving barriers.

Throughout the duration of the project, additional activities will be completed with published deliverables. These activities include the following:

- Knowledge transfer activities and materials, such as presentations, webinars, fact sheets, journal articles, videos, etc., to help the transit industry implement transit bus automation.

- User Acceptance Study and Human Factors Research, a component of all proposed demonstrations, will support the development of useful transit bus automation capabilities.

The public will adopt and feel comfortable using the STAR Plan as a useful communication for planning and executing USDOT-sponsored transit automation projects, and FTA research programs that include elements of automation. The STAR Plan will also help transit agencies accelerate the deployment of automation or partial automation in transit operations.

FTA Funding: \$1,450,000

Figure 9 *Strategic Transit Automation Research Plan*

FTA finalized the Strategic Transit Automation Research Plan and made it available to the public at https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/114661/strategic-transit-automation-research-report-no-0116_0.pdf. The purpose of this document is to define a five-year research plan with a research and demonstration framework to move the transit industry forward with transit automation. Key components of the plan include conducting enabling research, identifying and resolving barriers to deployment, leveraging technologies from other sectors, demonstrating market-ready technologies, and transferring knowledge to the transit stakeholder community. Transit automation could deliver many potential benefits, but transit agencies need additional research and policy guidance to make informed deployment decisions.



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

Grantee: State departments of transportation, 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. This need is growing; by 2045, 84 million Americans will be over age 65—nearly twice as many as today. More than half of these older adults will have some form of disability, and one in three will have trouble getting needed transportation. 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 2017, ATTRI announced the award of six contracts to develop prototype applications in the areas of wayfinding and navigation, safe intersection crossing, pre-trip concierge and, visualization under a two-phased development plan. In FY 2018, funded projects made significant progress in their development activities. The applications were evaluated in Summer 2018 for readiness to advance to Phase II. Those determined to have met their earlier phase goals, advanced to the demonstration phase. Applications in the target technology areas of Wayfinding and Navigation, Pre-Trip Concierge and Virtualization, and Safe Intersection Crossing are:

- Wayfinding and Navigation Technologies: ATTRI had the following outcomes and activities in FY 2018 with significant impacts to the areas served:
 - Smart Cane for Assistive Navigation (SCAN) – A robotic white cane for blind persons and based on previous ISANA and Co-Robotic-Cane applications developed by City College of New York (CCNY). Developed system documentation in Spring of 2018. developed a first and second prototype of the robo-cane hardware in Summer of 2018.
 - Specialized Media for Assisting Route Travel (SMART) – An open wayfinding media standard and infrastructure developed by AbleLink Technologies, Inc. Created a steering committee in late 2017 to guide application development, finalized a systems requirement document in October 2017, developed a draft wayfinding standard in March 2018, and demonstrated the initial application in April 2018.
 - AccessPath – A wayfinding tool for wheelchair users and people with visual disabilities developed by Pathway Accessibility Solutions, Inc. (d/b/a pathVu). Delivered a map containing 40 miles of data on sidewalks, crosswalks, and points of interest (bus stops, train stations, etc.) in February 2018. Developed a step-by-step wayfinding/navigation application prototype in March 2018, and conducted desktop computer-based demonstration of prototype functionality in June 2018.
 - NEON® Smart Wayfinding and Navigation Service (SWaN) – Sensor-based indoor navigation using high accuracy 3D location technology and NEON sensor fusion and mapping technology developed by TRX Systems, Inc. The System Requirements Document and Traceability Matrix was finalized and accepted at USDOT in Fall of 2017. In January

2018, TRX Systems successfully deployed its technology at the FHWA Turner-Fairbank Highway Research Center (TFHRC), testing navigation requirements to provide travelers with real-time location, en-route assistance and situational awareness indoors. The second phase of prototype demonstrations was completed in Summer 2018.

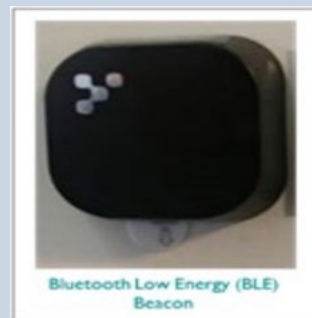
- Pre-Trip Concierge and Virtualization Technologies: Smart Travel Concierge System (STCS) – A suite of tools to support independent travel for individuals with cognitive disabilities developed by AbleLink Technologies, Inc. Demonstrated initial development of the application for the travel assessment and learning module content in April 2018.
- Safe Intersection Crossing Technology: Adaptive Safe Intersection Crossing – A tool developed by Carnegie Mellon University (CMU) to connect smart phone devices of pedestrians with disabilities to traffic signal controllers so the system can provide adaptive signal timing for people with different abilities.
- Prototype Development Webinar Series: shared prototype work to date, including Pre-Trip Concierge & Virtualization (November 7, 2017), Wayfinding and Navigation (December 13, 2017), Wayfinding and Navigation (January 16, 2018), Safe Intersection Crossing (February 8, 2018).
- General Industry Outreach: presented to a range of audiences, including 2018 Transportation Research Board Annual Meeting (January 2018), APA Annual Conference (April 2018), Virginia Association for Education and Rehabilitation of the Blind and Visually Impaired (July 2018), ADA Symposium (June 2018), Automated Vehicle Symposium (July 2018). ATTRI showcased the capabilities of applications in development and provided updates on the program's overall goal at other events.

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 (NIDILRR). During FY 2018, ATTRI showcased the capabilities of applications in development and provided updates on the program's overall work at several industry events such as the American Planning Association (APA) National Planning Conference, Automated Vehicle Symposium, and the USDOT and NIDILRR Joint Symposia, and a series of webinars and workshops with target audiences/stakeholders. 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 https://www.its.dot.gov/research_areas/attri/index.htm. ATTRI promoted the development of technologies that support its goals through a range of outreach activities to spread knowledge of the program's resources, and inspire developers across the public, private and academic sectors.

FTA Funding: \$2,500,000

Figure 10 (ATTRI) Complete Trip Fundamentals: Smart Wayfinding and Navigation service (SWaN) Prototype

As part of its ATTRI-funded research, TRX Systems successfully deployed and demonstrated the functionality of Ultrawide Band and Bluetooth Low Energy beacons at the Turner-Fairbank Highway Research Center on January 26, 2018. These beacons are components of a system to support the ATTRI Wayfinding and Navigation requirements to provide travelers with real-time location, en-route assistance, and situational awareness indoors and out. The technology enables users to safely navigate and travel independently.



Title: *Transit and Health Access Initiative*

Grantee(s): Competitively selected Transit and Health Access demonstration grant recipients and CUTR

Project Description:

The Transit and Health Access Initiative (formerly known as “Rides to Wellness”) is building partnerships, stimulating investment, and driving 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.

Transit and Health Access demonstration grants are providing funding to communities implementing healthcare access solutions. The primary purpose is to find and test promising, replicable public transportation healthcare access solutions that support the Transit and Health Access Initiative goals of increased access to care, improved health outcomes, and reduced healthcare costs. FTA funded more than \$7.2 million across 19 projects. Demand for this program exceeded available funds, as FTA received 78 project proposals from 34 states requesting \$28 million.

FTA’s selected projects are diverse and piloting innovative concepts. Grantees are collecting data to prove the value of linking transportation options with healthcare appointments. Projects are assessing new technology innovations, piloting more efficient ways to schedule a ride, leveraging creative community partnerships, testing systems for coordinating trips, and demonstrating and deploying real-world solutions. Eight of the 19 projects include operating assistance and were funded at \$2,865,233, as shown in Table 8. The remaining 11 projects, which are capital-only, were funded under the CCAM pilot program for Innovative Coordinated Access and Mobility (ICAM) grants. An annual report on

the ICAM grant is made publicly available on the FTA Reports and Publications website: <https://www.transit.dot.gov/research-innovation/fta-reports-and-publications>.

Results:

The Transit and Health Access demonstration grants are 18-month projects that began implementation between late 2017 and 2018. Grantees will submit a final report on results within 90 days of project completion. Seven of the eight demonstration grant projects were active in FY 2018, and FTA is providing technical assistance to the one project not yet implemented (required local match to be secured). The output of the currently active demonstration projects is informing the CCAM and industry on how to approach transit and health-related partnerships, and show the positive financial benefit to such partnerships. The following are relevant results of the demonstration projects:

- San Diego Association of Governments (SANDAG) – embedded mobility management into hospital discharge planning, helping patients learn about how to attend healthcare appointments using public transportation. The Rides to Wellness: Coordinating Inpatient Medical Transportation for San Diego County project started implementation in 2018 and is collecting the following performance measures: 1) increased access to care—reduction of emergency room wait times, reduction in time between written discharge orders and actual discharge, and reduction in readmissions; 2) improved health outcomes—tracking readmission rates among patients using transportation services, monitoring access to pharmacies and other post-discharge services, linking patients to Community-based Care Transitions Program, and expanding beyond Medicare patients to include all at-risk patients; 3) reduced healthcare costs—reduced bed days and hours. Partners: SANDAG, Facilitating Access to Coordinated Transportation, and Tri-City Medical Center.
- Riverside County Transportation Commission (RCTC)’s “Blythe Wellness Express (BWE), A Coordinated Partnership to Pilot Health Access and Long-distance Regional Transportation” – started July 2017, coordinated partnerships between transit and healthcare providers to pilot a multi-faceted transportation program providing regional access for geographically-isolated Blythe to healthcare across inland Southern California. Performance measures include: 1) evaluation of health-related outcomes using baseline health status (self-reported by individuals during registration) and self-reported data by individuals during trip surveys. This allows responses to be tracked over time; 2) increased access to care (ability to make and keep appointments)—defined as the percent of trips that are health-related, rider access to a vehicle, rider ability to drive, how trip would have been made prior to BWE, and whether riders previously missed a healthcare appointment due to lack of transportation; 3) improved health outcomes—

change in health status; 4) reduced healthcare costs—increase in number of routine appointments, decrease in number of hospitalizations since last routine appointment, increase in number of ER visits since last routine appointment. Partners are Palo Verde Valley Transportation Authority, Palo Verde Hospital, SunLine Transit Agency, Independent Living Partnership-TRIP and Blythe Salud Clinic (existing volunteer driver programs), Blythe Cancer Resource Center, and AMMA Transit Planning.

Project/Program Evaluation:

For all federally funded Transit and Health Access grants, FTA is providing evaluation support through a cooperative agreement with CUTR, which began the evaluations in May 2017. FTA received a draft evaluation report in June 2018 that included transcripts from interviews with the grantees and performance measures.

FTA Funding: \$2,865,233

Table 8 *Transit and Health Access Projects Receiving Assistance from FTA, FY 2018*

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			\$2,865,233

Figure 11 Delaware County Connections – A Rural Volunteer Based Transit Service

The mission of the Delaware–Dubuque–Jackson County Regional Transit Authority (RTA) is “Connecting people to life’s destinations.” It is enhancing the quality of life of residents in Delaware County through a new rural volunteer based transit service that started in July 2017. Performance measures include no-show rates, miles, rides, hours, and costs, and partners include Delaware County Supervisors, the City of Manchester, Chamber of Commerce, Economic Development, Veteran’s Administration, Police Department, and Regional Medical Center. The project positively impacted the lives of people like Vernon, who began taking the Delaware County Connections van to his dialysis appointments at Manchester’s Regional Medical Center since July 31, 2017. He finds the van ideal because it allows him time to eat breakfast closer to the time of his appointment. “They’ve worked well with me that way. My family is busy working, and my social service worker said they will pick you up at the farm. I said okay, I’ll do that! They’ve been great to me! And I like the van because I’ve had surgery and it’s really comfortable to ride in.”



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

Grantee: State departments of transportation and transit authorities (see Table 9)

Project Description:

MSAA increases 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 these travelers with disabilities, including veterans and older adults. MSAA assists communities of any size and includes public entities currently establishing, operating, coordinating, or brokering general public transportation and HST. Types of communities include public transit agencies, state and local government departments of transportation, health and human service agencies, federally-recognized Indian tribes, and metropolitan planning organizations (MPOs). MSAA provides the opportunity to design a replicable, scalable, and interoperable Travel Management Coordination Center (TMCC). It allows agencies to use a coordinated system to share trip requests and schedules to easily book rides and transfers for customers across service areas, thus improving the customer experience and minimizing duplication. The projects build 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 apply ITS solutions to advance HST delivery, overcome technical and institutional barriers to promote system interoperability, and showcase promising technologies and practices that improve travel planning and coordination for people who need specialized transportation and who are transportation disadvantaged and 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.

To reach these goals, the objectives of the MSAA deployment planning efforts aimed to fulfill the objectives of involving at least two human service transportation programs and providers, establishing operational data sharing and coordination between multiple technology platforms, and demonstrating functional common fleet information platform to, at a minimum, view each other's trip scheduling and vehicle location information in real time.

Results:

All the MSAA grantees were active in FY 2018 and provided the following outputs in alignment with reaching the stated objectives of the MSAA deployment planning efforts:

- Technical assistance to MSAA planning and development grantees in Atlanta, Denver, San Luis Obispo (CA), and Madison (WI). Held periodic project progress meetings and participating in stakeholder conference calls. Provided systems engineering support and assisted in the development of deployment planning documents such as user needs and system requirements documents, providing input in developing phased implementation plans. Provided assistance in identifying resources for sustainable funding strategies for deployment, operation, and maintenance of the planned systems. Each of the four recipients completed deployment planning documentation and they are ready to move to the next implementation phase of the planned systems.
- Reference manual titled "Reference Manual for Planning and Design of a Travel Management Coordination Center," published in December 2017. It guides agencies through the systematic process of planning, documentation, procurement, and integration of TMCC systems and provides essential information in reaching one of the MSAA Program goals of operational data sharing and coordination between multiple technology platforms. The report is available at <https://www.transit.dot.gov/research-innovation/reference-manual-planning-and-design-travel-management-coordination-center-tmcc>.
- Comprehensive lessons learned document developed, "Road to Coordination: Lessons Learned while Developing the San Luis Obispo County Travel Management and Coordination Center (TMCC)" in May 2018 with United Cerebral Palsy of San Luis Obispo County & Ride-On Transportation

that documents their experience throughout stakeholder engagement and outreach process. It supports MSAA’s goal of providing guidance about the interaction process between at least two human service transportation programs and providers. This document was also distributed to the attendees of the Coordinated Transportation Association of America (CTAA) annual meeting in June 2018. The report is available at <https://www.transit.dot.gov/research-innovation/road-coordination-lessons-learned-while-developing-san-luis-obispo-county-travel>.

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 transportation services, thus providing travelers more options for destinations, schedules, fees, and service frequency. Some locations have already improved their systems based on the concepts proposed by MSAA; others completed the process of planning and developing their systems in Spring 2018.

FTA Funding: \$795,545

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			\$795,545

Figure 12 Reference Manual for Planning and Design of a Travel Management Coordination Center (TMCC)



This manual provides a reference for planning and designing a TMCC using ITS and other technologies to enhance the coordination of mobility services for the transportation-disadvantaged. The manual is intended to facilitate and encourage local efforts to pursue technology for this purpose. ITS and other technologies can serve a valuable role in the coordination of mobility services for the transportation-disadvantaged as provided by transit, paratransit, and human service transportation providers. These technologies are integrated through the concept of a TMCC, and this concept was developed and demonstrated through the USDOT MSAA Initiative. The objective of this reference manual is to build on the experience gained from the MSAA Initiative and provide guidance on how

to plan and design a TMCC. The manual identifies four major steps: assessment of barriers and key unmet needs, development of a vision of the desirable customer experience, development of a TMCC Vision among stakeholders defining key organizational and technological choices across the nine stages of the provision of service, and the conduct of an ITS Systems Engineering project process. The manual also outlines key lessons learned from the MSAA Initiative as they relate to the institutional foundation needed to develop and sustain a TMCC and identifies many resources to assist those planning a TMCC. The report can be accessed at <https://www.transit.dot.gov/research-innovation/reference-manual-planning-and-design-travel-management-coordination-center-tmcc>.

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 practice 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 11 active Infrastructure projects in FY 2018, as shown in Table 10.

Table 10 Infrastructure Programs Receiving Assistance from FTA, FY 2018

Infrastructure Programs		
Type of Project	Project Title	FTA Funding
Research	Low or No (LoNo) Emission Component Assessment Program	\$3,000,000
Demonstration & Deployment	Track Asset Management Demonstration	\$4,225,000
Research	Effects of Capital Cost Forecasting Study and Research	\$200,000
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
Innovation & Development	Transit Economic Requirements Model	\$2,000,000
Demonstration & Deployment	Low or No Emission Vehicle Deployment Program (LoNo) Program*	<\$76,969,249>
Total		\$14,025,000

* The LoNo Program matured from a research program to a capital formula program authorized by Federal public transportation law (49 U.S.C. § 5339). The amount of \$76,969,249 is in brackets to indicate that we are breaking out this program separately from the total of actively managed research projects.

Title: Low or No (LoNo) Emission Component Assessment Program

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

Project Description:

The purpose of the Low or No Emission Component Assessment Program (LoNo-CAP) is to meet the requirement by Federal public transportation law (49 U.S.C. § 5312 (h)). The program provides financial assistance annually to The Ohio State University and Auburn University. The goals of the program are to: 1) develop component tests; 2) set up facilities; and 3) complete assessment tests. The program conducts assessment tests of LoNo components submitted voluntarily for testing by the component manufacturers. It also provides data and assessment reports for each test. Assessing low or no emission components directly supports FTA’s ongoing low and no emission transit bus capital programs by providing objective unbiased assessments of components used for low or no emission transit buses.

Results:

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

- The Ohio State University subcontracted CALSTART for the outreach and marketing of LoNo-CAP program. The University and its partner, CALSTART, are currently engaged in marketing and outreach efforts to

educate the transit industry on benefits of participation in the LoNo-CAP program. The University anticipates conducting its first LoNo-CAP testing during the first quarter of 2019.

- Auburn University is in the process of engaging the Center for Transportation and the Environment (CTE) for its marketing and outreach effort for the LoNo-CAP program. Auburn University anticipates conducting its first LoNo-CAP testing during the first quarter of 2019.

Successful completion of the LoNo-CAP annual program 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: \$3,000,000

Title: *Track Asset Management Demonstration*

Grantee: Metropolitan Area Rapid Transit Authority (MARTA), Atlanta

Project Description:

The purpose of this project is the demonstration of an autonomous track inspection system (ATIS) 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 major 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); 3) and evaluate the return on investment of the system at MARTA.

Results:

MARTA selected a technology vendor, ENSCO, and an independent evaluator, Transportation Technology Center, Inc. (TTCI), to assist with the project, launched in September, 2017. In FY 2018, the project completed all tasks and objectives to finalize the system design and develop two reports:

- Evaluation and Assessment Report: Phase I – held conceptual design meetings in November and December 2017. Electrical and final design reviews were completed in June 2018. Hardware and software integration effort started

in June and will be complete in November 2018. All completed objectives allowed the project to keep the schedules and not impact the Phase I final report due date. The project goal is to successfully demonstrate an easily transferrable autonomous system for transit that can assess track conditions and its overall state of good repair.

- Evaluation and Assessment Final Report: Phases I and II – held pre-design meetings in June 2018. Project will begin design in September 2019, as the Phase II is dependent on a working Phase I system.

Both reports will be available on FTA's website when the Phase II report is completed in 2021. The project goal 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. This project will be the first deployment of this technology on a transit system in the US. 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 requires an independent and continuous evaluation during the project performance period. TTCI led the conceptual, test and final design reviews that began in October 2017 and has conducted multiple pre-design and design reviews with ENSCO and MARTA. It also reviewed all design documents, provided detailed comments and made certain all issues were resolved. Additionally, it produced design reports for MARTA, and provided final approval so ENSCO could start testing. Copies of reviews and meeting minutes are uploaded on the project shared website, managed by ENSCO. TTCI will include the design report in its final evaluation report. The final project report will include a separate section for the evaluation report, due to FTA in August 2021.

FTA Funding: \$4,225,000

Title: *Effects of Capital Cost Forecasting Study and Research*

Grantee: PricewaterhouseCoopers (PwC)

Project Description:

This project reviews lump sum cost data for more than 100 New Starts projects and conducts focused cost reviews on a select sample of projects. This research evaluates transit cost estimates versus bid pricing across the period of 1995–2015, which spans two significant periods of economic turmoil and a large range of project conditions. Federal funding for transit capital projects is based on cost estimates provided by project sponsors and reviewed by FTA,

usually before construction bids are received. Accurate estimating is required to reliably establish these Federal grants. The goals of this project are to determine drivers behind cost growth from the transit industry perspective and identify tools, processes, and recommendations for improving FTA's ability to provide technical guidance during early project development, specifically related to cost estimation and risk management. Anecdotal evidence exists and shows that overall economic conditions or patterns of project conditions may affect the ability of cost estimators to accurately forecast project costs. Cost estimating depends upon historical costs adjusted using traditional methods that may not reflect unusual economic or project conditions. Indicators and recommendations for rational adjustments during significant economic variance or under certain project conditions will produce more accurate estimates.

Results:

A final report documenting research data, analysis, findings, and recommendations is complete, and publication expected in November 2018. Other relevant outputs under this project included:

- Recommendations: findings recommend enhancing current FTA practices in guiding development of the project estimate by taking the following actions: 1) refresh FTA workshops with emphasis on cost estimation best practices and lessons learned, 2) develop and provide enhanced cost estimating guidance to all Grantees, 3) require grantees to collect key/major bids prior to finalizing FFGA budget, 4) update operating procedure 30 (Value Engineering and Constructability Review) to require independent constructability review prior to FFGA, 5) update Operating Procedure 40 (Risk and Contingency Review) to require an independent economic advisor to review market assumptions, and 6) update P-value used to establish FFGA budget provided other recommendations in this report are implemented. Based on data findings, the project provided three recommendation focus areas for FTA to consider: 1) enhance current FTA practices in guiding development of the project estimate, 2) enhance management and control of the project budget during execution, and 3) enhance its emphasis on creating an environment of continuous improvement.
- Suggestions: findings suggested enhancing management and control of the project budget during execution, taking the following actions: 1) update Operating Procedure 40 to enable PMOCs/FTA to better assess risks and address the unknown unknowns; 2) update Operating Procedure 25 (Recurring Oversight and Related Reports) to strengthen requirements related to PMOC project data tracking, consideration of project risks and consistency of reporting to FTA; 3) create a consistent evaluation framework to assess a grantee's preparedness to undertake and manage the specific project; and 4) apply analytics to risk data to assess project management effectiveness during project execution.

Transit agencies and FTA will realize significant benefits from enacting the above-mentioned recommendations. The research impact has national significance because it will improve cost estimating by the transit industry. The project accurately estimates more effective application of Federal funds, reduced instances of breaches of Federal funding agreements, and reduced funding stress by local transit agencies. Outcomes will include Federal guidance to public agencies to improve project cost forecasting, increased precision of Federal oversight, increased accuracy of project risk assessments, and reduction of project risk at the local agency level.

FTA Funding: \$200,000

Figure 13 *Forecasting Capital Cost*



The accuracy, precision, and reliability of grantee and contractor technical inputs have become more critical due to the increased number of active projects. With finite resources, FTA is becoming increasingly challenged with cost estimate validation and cost growth management within its existing portfolios. FTA projects have encountered project-specific conditions that have driven cost growth and delayed schedules, and these issues are likely to persist. This report summarizes FTA efforts to identify practical measures for avoiding cost growth issues.

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

Grantee: The Volpe Center

Project Description:

The purpose of this research is to identify and incorporate best practices in lifecycle management applicable to public transportation projects. 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 reports the continued increases in actual capital cost vs. budgeted costs are not consistent, which creates sizeable funding gaps. Better use of current transit assets by improving reliability and maximizing lifecycles will positively impact 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. If 1% of these costs are reduced, the return on investment would be strong.

Results:

Activities under this project for FY 2018 include:

- **Literature review:** conducted on methods used by public capital institution managers in other industries, especially the airline and railroad industry that addressed and resolved reliability, supportability, maintainability, and sustainability challenges throughout capital project development. Additional activities conducted original research and 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. It began with concept definition and continued through design, engineering construction, fielding, and sustainment.
- **Reports:** completed and finalized a report documenting research data, analysis, findings, and recommendations for next steps, delivered for FTA review in May 2018.
- **Pilot Program:** examined six diverse public transportation agencies with diverse modal options in Spring 2018 regarding their life-cycle cost strategies. Developed a pilot program to further explore innovative strategies related to lifecycle cost management.

The outcomes of this project assisted FTA in determining what analytical tools and processes can significantly aid in extending the life of transit assets. FTA discovered effective practices from transit and other industries, specifically in foreign countries that maintain transit facilities. FTA also discovered the impact of specific policies and initiatives on maintaining assets. Improvements in contracting/procurement, cross agency teaming, standards & requirements development, management processes, procedures and tools, incentivizing more reliable and maintainable products (especially vehicles and track) through encouraging more efficient life-cycle-focused design and product manufacture of transit systems were identified. 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 14 *Lifecycle-Based Management*



Literature review regarding methods used by public capital institution managers in other industries were considered when learning how to effectively address and resolve reliability, supportability, maintainability, and sustainability challenges throughout capital project development. This research examined six diverse public transportation entities regarding their lifecycle cost management practices and documents the findings.

Title: *Bus Propulsion Evaluation and Support*

Grantee: National Renewable Energy Laboratory (NREL) under US Department of Energy

Project Description:

The goal of this project is to evaluate the performance of new bus technology in real-world applications. The project provides unbiased and comprehensive assessments of new bus technology in revenue service so transit agencies can make more informed decisions about the suitability of the technology for bus revenue service. The project measures 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 covered. 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) running similar routes and service. This ensures new technology is assessed against known technology as well as against all local climate and seasonal variables. The project is funded through an interagency agreement with the US Department of Energy, which owns NREL. NREL is an independent third-party with no institutional or financial interest in the outcome, ensuring unbiased results accepted across the industry. The project ensures 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. This effort continues work begun under FTA's National Fuel Cell Bus Program expanded to include evaluations of advanced technology propulsion projects awarded under other FTA and USDOT programs.

Results:

In FY 2018, the project made key advancements in the industry's understanding of the performance of new bus technology in real-world applications. Examples include the following:

- **Final Report:** published in March 2018. The final report of the evaluation of battery electric buses at King County Metro (KCM) presented detailed data about their performance. The report provides information about the actual cost and reliability of electric bus technology in comparison to other types of bus propulsion technology. This information will help transit agencies understand how electric buses might be expected to perform. Over a one-year period, data were collected and analyzed on a sample of 10 buses from KCM's diesel hybrid fleet and 3 buses from the standard diesel fleet for baseline comparison to the three-bus battery electric bus (BEB) fleet. The report can be accessed at <https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/115086/zero-emission-bus-evaluation-results-king-county-metro-battery-electric-buses-fta-report-no-0118.pdf>.

- Evaluation meetings: in May 2018, the NREL evaluation team met with the Duluth Transit Authority to prepare for one year of data collection on six battery electric buses soon to be delivered to Duluth under FTA’s LoNo Program. This meeting was important because it allowed the NREL staff to explain to the Duluth bus operators the types of data needed during the upcoming evaluation. This ensures the staff in Duluth are fully prepared and have the right systems in place to collect the necessary data in the required format over the course of the year-long evaluation. If the Duluth staff were unfamiliar with how to collect the data or unsure of what data to collect, it could cause errors in the evaluation process, making the evaluation unreliable and potentially worthless. Therefore, the meeting was critical in creating the foundation for a successful evaluation. Duluth offers an excellent opportunity to evaluate the performance of electric buses in a rigorous cold weather environment. Environmental extremes present unique challenges to electric bus operations and this evaluation is critical to understanding the present capability of electric bus technology.

The reports and data developed with FTA support by NREL are the most significant source of data available to US transit agencies about the performance of new bus technology in real-world bus service. TCRP recently published a synthesis on battery electric buses that drew substantially from NREL’s work (<http://www.trb.org/Main/Blurbs/177400.aspx>).

FTA Funding: \$1,400,000

Figure 15 2018 Bus Technology Evaluation Report

NREL recently completed a year-long evaluation of a fleet of battery-electric buses in service at King County Metro in Seattle that began operation in February 2016. The focus of the analysis is on one year of data from April 2016 through March 2017. The buses are fast-charge, composite buses built by Proterra. KC Metro and NREL selected three conventional technologies for comparison: standard diesel buses from Gillig, diesel hybrid buses on New Flyer’s Xcelsior platform, and electric trolley buses on New Flyer’s Xcelsior platform. Buses are all 40-foot, model year 2015 buses.



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

Grantees: Center for Transportation and the Environment (CTE) and Maryland Transit Administration (MTA), Baltimore

Project Description:

The purpose of the BEERD Program is to reduce energy use by transit buses. The program also aims to have favorable impacts on meeting the needs of the riding public, public transportation operators, and the American bus industry and its supplier base, while simultaneously advancing the USDOT's research goals. The goals of the program are to: 1) improve safety, 2) enhance the state of good repair of transit systems, 3) provide more effective and efficient public transportation service, 4) increase capital and operating efficiencies, 5) develop and deploy advanced vehicle designs and technology, 5) reduce harmful emissions, and 6) increase energy efficiency. BEERD supports FTA's goal of developing and deploying new and innovative ideas, practices, and approaches for transit industries.

Results:

All BEERD projects were active in FY 2018. Outputs of program include:

- Testing: completed testing of thermoelectric generator (TEG) modules and the assembled system in March 2018. The TEG is already installed on the demonstration bus and demonstration was completed in July 2018. The results of the tests will be summarized and reported, and a Reduced Engine Idle Load (REIL) market evaluation and trade study will be delivered.
- Prototype: The first prototype paratransit bus incorporating a high-power alternator and electrical energy storage to enable paratransit buses to provide comfortable cabin air, lights, and wheelchair ramp/lift operation during engine-off stops was delivered in July 2017 after completing a 1,400-mile road endurance test in hot conditions. This bus entered the demonstration period in August 2017. The second bus, incorporating lessons learned from the first, was modified and entered service in November 2017. The demonstration will be completed by the end of December 2018.

The BEERD program led to the development of a TEG sized to generate 1000W of 24V electrical power to support bus systems, recovering energy that would otherwise be wasted as heat escaping the exhaust pipe. All hardware was procured for a prototype REIL system that enabled bus systems to operate for up to 30 minutes while the main engine is off, and the team has set up dynamometer and engine test pods for system-level testing and performance evaluation. BEERD supported demonstrations of four different technologies expected to help American transit bus manufacturers and component suppliers achieve greater competitiveness by offering highly desirable advanced technologies. These

technologies substantially improve operating costs and energy efficiency, while supporting a pathway to greater electrification of transit and paratransit bus powertrains. A TEG can recover energy that would otherwise be wasted as heat leaving the exhaust pipe. A one-time cost to install a TEG on a new bus or to retrofit an existing bus can produce ongoing savings in operating costs, fuel use, and emissions. Paratransit buses may spend even more time idling than transit buses, and often in particularly sensitive areas like hospitals and nursing homes. Electrifying the cabin climate control, lights, ADA lift/ramp, and other accessory systems on paratransit buses enables continued provision of cabin comfort to riders while the engine is shut off for up to 30 minutes during waiting and while loading and unloading, significantly reducing operating costs, fuel consumption, and local pollution and noise impacts. Retrofitting of beltless alternators to hybrid-electric buses results in substantial fuel economy improvements of up to 20% and more than \$6,000 per year per bus in combined fuel and maintenance savings.

Project/Program Evaluation:

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

FTA Funding: \$3,000,000

Table 11 *BEERD Projects Receiving Assistance from FTA during FY 2018*

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

Title: *Transit Economic Requirements Model (TERM)*

Grantee: Booz Allen Hamilton, Inc.

Project Description:

The purpose of this project is to produce the transit portion of the statutorily required Conditions and Performance (C&P) Report to Congress. The goals of this project are to maintain, enhance, and run the Transit Economic Requirements Model (TERM) tool. This tool forecasts transit capital needs over a 20-year period under various distinct investment scenarios. It also produces the transit portion needed for the C&P Report to Congress based on its data

output. The C&P report is intended to provide Congress and decision-makers with an objective appraisal of the physical conditions, operational performances, and financing mechanisms of highways, bridges, and transit systems based on the current state of these systems and their projected future state under a set of alternative future investment scenarios.

The transit portion of the C&P report is developed every two years by FTA and includes estimates of the U.S. public transportation state-of-good-repair backlog and the public transportation capital investment needs over the next 20 years. The information provided by FTA is combined with information from FHWA for the final biannual report. The final report includes future capital investment needs of US highway and transit systems for a period of 20 years and incorporates highway, bridge, and transit information required by Federal transportation law (23 U.S.C. § 503(b)(8) and 49 U.S.C. § 308(e)). FHWA compiles the final report, including highways, freight, and transit.

The execution of this project requires expert knowledge of economic modeling theory, statistics, hands-on, broad experience supporting and developing capital investment programs of large transit agencies, and very specific knowledge of TERM, including code, features, and limitations. The project also supports tasks for enhancements of TERM, data management, maintenance, and documentation of the model. TERM estimates the condition of Assets (good, standard, below SGR, etc.) based on decay curves modeled by age and inspections of large samples of assets owned and managed by agencies throughout the United States. These decay curves are currently going through a revamp process aimed at updating parameters and consolidating curves considering the new Asset Module of National Transit Database.

Results:

For FY 2018, the project performed the following tasks and outputs:

- Model development and support: developed model and IT enhancements for TERM. These enhancements resulted in more accurate estimates of capital investment needs and faster processing times. In addition, updated the National Asset Inventory Database that feeds into TERM with more current data from transit agencies. This updated database resulted in a more realistic assessment of the current condition of the National assets. Provided support and help-desk for users of TERM-Lite.
- Framework and forecasts: produced and delivered the outline and framework of the 2018 edition of the C&P. Supported FTA in addressing issues raised by stakeholders, both internally and externally, related to TERM and the C&P. Produced TERM forecasts quantifying capital investment projections for 3 key investment scenarios for inclusion in the 2018 C&P:

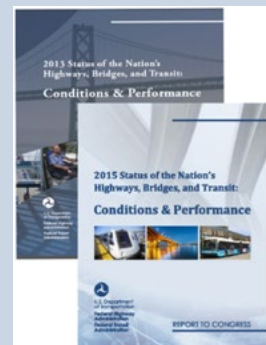
- Maintain recent capital expenses – If the U.S. maintained the level of investment in transit constrained at the average capital expenses at the last five-year level, what would be the effect in the condition and backlog of the national assets by the end of the project horizon, year 20 compared to the current condition?
- State of good repair – How much would the U.S. would need to invest to eliminate the national backlog over a 20-year horizon?
- Ridership growth – How much would the U.S. need to invest to eliminate the national backlog and expand the national asset base to support a projected ridership growth over a 20-year horizon?

The C&P report is produced biannually through a joint effort of FTA and FHWA. The next report is expected to be sent to Congress in 2019 and will be available on USDOT’s website.

FTA Funding: \$2,000,000

Figure 16 *Statutory Reports Produced Under TERM*

FTA contributes information needed for the completion of the statutorily-required Conditions and Performance (C&P) Report to Congress. This document is intended to provide decision-makers with an objective appraisal of the physical conditions, operational performance, and financing mechanisms of highways, bridges, and transit systems based on their current state and their projected future state under a set of alternative future investment scenarios. The report offers a comprehensive, data-driven background context to support the development and evaluation of legislative, program, and budget options at all levels of government, and serves as a primary source of information for national and international news media, transportation associations, and industry. The C&P report consolidates conditions, performance, and financial data provided by states, local governments, and public transit operators to present a national-level summary.



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

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

Project Description:

FTA’s LoNo Program deploys the latest new technology transit buses. The goal of the program is to support transit agencies willing to demonstrate small fleets (at least five buses) of new bus models largely proven in testing and demonstrations but not yet widely deployed in transit fleets. The LoNo Program provides funding to transit agencies for capital acquisitions and leases of next generation transit buses, as well as acquisition, construction, and leasing of related charging, refueling, and maintenance facilities. 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 US 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 US 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.

Results:

Currently, all 17 projects are active. The following are examples of outputs with significant results:

- Southeast Pennsylvania Transit Authority (SEPTA): delivery and introduction of 25 battery electric buses is underway with final delivery complete as of 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 US. The operation at SEPTA is being evaluated under a separate FTA project being 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. This is important because of the Congressional requirement to report on the impact of the program. Without data on how the technology performs, the impact of the program will be more difficult to determine.
- Worcester Regional Transit Authority in Worcester, MA: is successfully running a fleet of six battery electric buses thanks to additional fast-charge infrastructure purchased through the LoNo program. Since the goal of the program is to support transit agencies willing to demonstrate small fleets (at least five buses) of new bus models largely proven in testing and demonstrations but not yet widely deployed in transit fleets, this example shows that, in the case of the WRTA, the program has met its goal.
- Lextran, the Transit Authority of Lexington, Kentucky: continues to successfully operate its five battery electric buses purchased under the LoNo program. A video of the Lextran buses produced by Motorweek is available

on YouTube at <https://www.youtube.com/watch?v=ycbjg3D0k7Q>. As the goal of the LoNo program is to support transit agencies willing to demonstrate small fleets (at least five buses) of new bus models largely proven in testing and demonstrations but not yet widely deployed in transit fleets, this example shows that, in the case of Lextran, the program met its goal.

As buses purchased under LoNo are delivered and made operational, the evaluation of the program continues to assist the US transit industry in understanding how to adopt new technology buses in transit service. The impact of the program is an increased understanding of the strengths and weaknesses of electric buses and an improved understanding 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. 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, under new legislation, the LoNo program was authorized as a capital 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 Capital Program Office and "LoNo" is renamed "Low-No."

Project/Program Evaluation:

FTA is supporting the technology evaluations of a cross-section of LoNo project sites through an interagency agreement with NREL, part of the U.S. Department of Energy (DoE). 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 King County, WA; Canton, OH; Duluth, MN; and Philadelphia, PA. Additional technology evaluations will be performed as buses are deployed and funding is available. For more detail about the NREL work, see the Bus Propulsion Evaluation and Support description of this report.

FTA Funding: \$76,969,249

Table 12 *LoNo Projects Receiving Assistance from FTA, FY 2018*

Project	Transit Agency	City and State	FTA Award
Five fuel cell electric buses	Sunline	Thousand Palms, CA	\$9,803,860
Five fuel cell electric buses	Stark Area Regional Transit Authority	Canton, OH	\$8,877,405
17 E-series hybrid buses	Red Rose Transit Authority	Lancaster, PA	\$2,638,400
Five 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
Charging station for battery-electric buses	Worcester Regional Transit Authority	Worcester, MA	\$1,002,600
5 battery-electric buses	Los Angeles County MTA	Los Angeles, CA	\$4,275,000
Deploy charging infrastructure for existing fleet of battery-electric buses	Foothill Transit	Greater Los Angeles, CA	\$1,310,000
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 (SEPTA)	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			\$76,969,249

Figure 17 *Example of Impact of LoNo Program*



The Stark Area Regional Transit Authority (SARTA) provides public transportation in the greater Canton, Ohio, area with 34 bus routes in the communities of Alliance, Akron, Canton, Cleveland, Hartville, Jackson Township, Louisville, Massillon, North Canton, and Uniontown. As a result of the LoNo Program, SARTA received eight fuel cell electric buses from El Dorado-National. Fuel cell electric buses are similar

to battery-electric buses, but they also have a hydrogen fuel cell that recharges the batteries, extending the buses range and eliminating the need to recharge the buses overnight. With the new buses, SARTA 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 technology is expected to be available in 2019.

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 four supporting programs and initiatives active in FY 2017, as shown in Table 13.

Table 13 *Supporting Programs and Initiatives Receiving Assistance from FTA, FY 2018*

Supporting Programs and Initiatives		
Type of Project	Project Title	FTA Funding
Evaluation & Implementation	Information Dissemination and Evaluation Program	\$1,439,692
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)	\$2,854,766
Total		\$9,544,458

Title: *Information Dissemination and Evaluation Program*

Grantee: USF Center for Urban Transportation Research (CUTR)

Project Description:

This program assists FTA with communication, dissemination, and evaluation of research. The communication and dissemination component of the project is ongoing and produces communication tools used by FTA that are consistent, professionally edited, and Section 508-compliant downloadable versions of FTA final reports made available on FTA's website. This results in the dissemination of FTA research information in clear, concise, and consistent formats.

The evaluation component of the project helped FTA conduct a comprehensive evaluation of the USDOT–FTA-funded Transit and Health Access Initiative (formerly referred as Rides to Wellness) Demonstration Grants Program and created a multi-tiered evaluation framework to assess results and outcomes of FTA's research programs at the project, portfolio, and program levels. The evaluation framework draws upon the research priorities, goals, and objectives defined during program planning and from lessons learned during the Transit and Health Access Initiative pilot evaluation.

Results:

Outputs from the project in FY 2018 include:

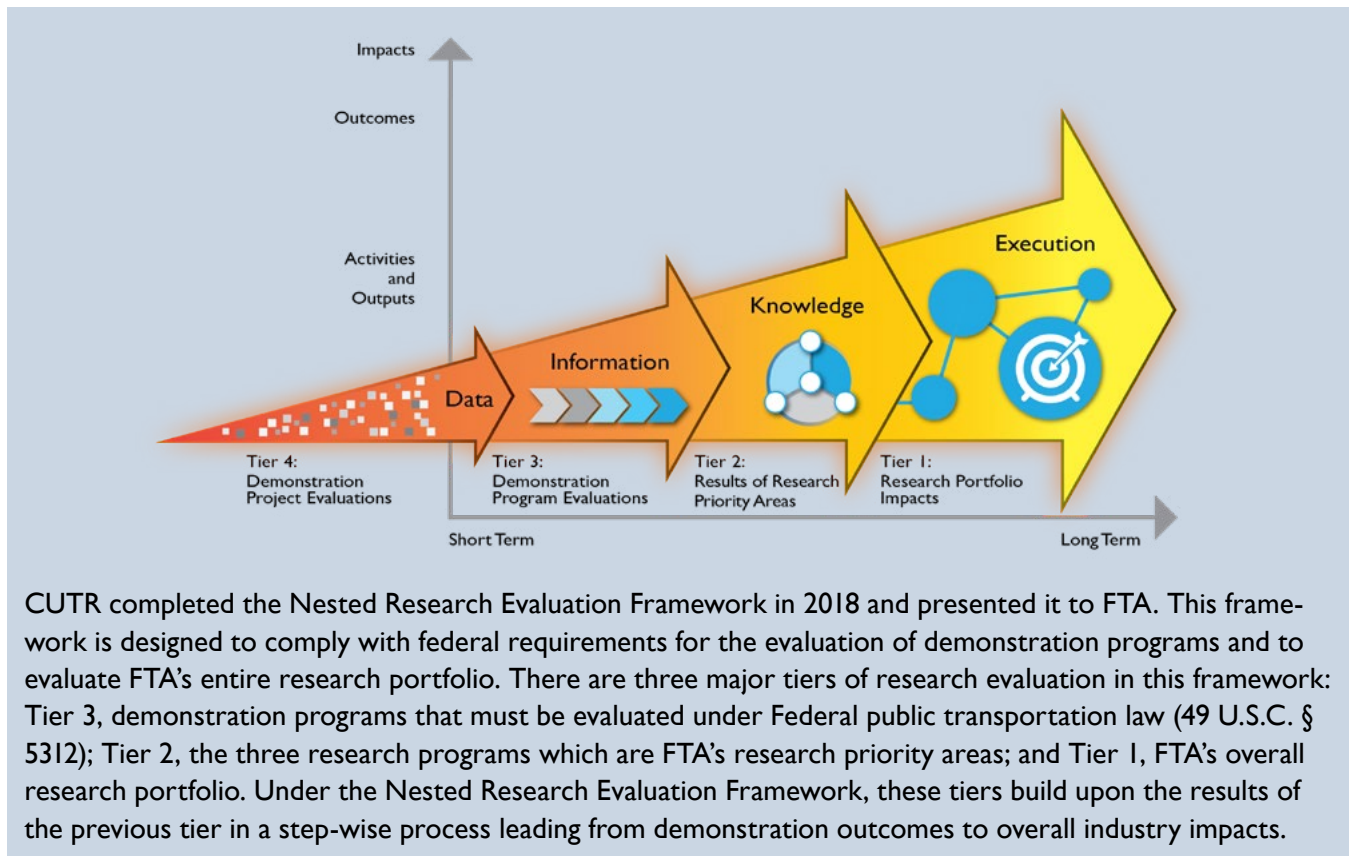
- Editing, design, and accessibility of FTA documents: edited, designed, and made 508-compliant 21 FTA reports (research reports and reports to Congress) with an additional 10 reports in progress. All FTA reports completed under this program can be accessed at <https://www.transit.dot.gov/research-innovation/fta-reports-and-publications>.
- Evaluation of Transit and Health Access Initiative Grants: conducted webinars and evaluation interviews with the Transit and Health Access Initiative from May–July 2017. CUTR created a catalog of grantee performance measures, developed a draft evaluation plan, and created a formal communications plan. Monitored 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, 2019.
- Tiered evaluation framework: completed the development of a tiered evaluation framework to assess research results and outcomes at the project, portfolio, and program levels. The final draft of the tiered evaluation was approved by FTA in March 2018 and it is expected to be finalized in December 2018.

The materials produced under this program ensure that all web-based materials are Section 508 compliant, meeting federal requirements for accessibility. This

also allows FTA program managers and grantees to focus more resources on the technical content of reports rather than time-consuming report production.

FTA Funding: \$1,439,692

Figure 18 *Nested Research Evaluation Framework, FY 2018*



CUTR completed the Nested Research Evaluation Framework in 2018 and presented it to FTA. 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: *Workforce Development Program Evaluation and Dissemination*

Grantee: Axiom Corporation

Project Description:

In FYs 2011, 2012, and 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 grantee’s ability to leverage investments of strategic partners to sustain the programs, and

3) to make policy recommendations that will assist the FTA in refining, planning and enhancing the overall Workforce Program and their potential impact on local or national transit workforce development needs. This evaluation determines where the recipients have 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 2018, providing the following outcomes:

- Summary Report: completed and submitted to FTA in January 2018 “Innovative Transit Workforce Development Projects of 2012 Summative Evaluation Report.” The report highlights the value of FTA investment on recruitment, retention, and development of career pathways, leading to career opportunities within transit. This report also met the goal to showcase successful and replicable workforce development models and lessons learned.
- Telephone interviews: completed in December 2017 with 14 of the 16 award recipients to determine their success in meeting their individual project goals. The interviews benefit the overall Workforce Development Program because they determine if the individual projects are meeting deliverables and goals. The interviews are also assisting the grantees to share their lessons learned and success stories.

This project enabled FTA to gain a return on its \$20 million investment in more than 40 Workforce Development projects. Axiom conducted two evaluations of FTA’s first groupings of Workforce Development projects that covered the FY 2011 workforce projects and was published in 2016. The second report evaluates the FY 2012 Workforce projects and will be published once approved and finalized by FTA. Individual interviews of the FY 2015 Workforce Recipients are currently underway. The third and final evaluation report is currently being compiled and will be completed no later than March 2019.

FTA Funding: \$250,000

Title: *Transit Cooperative Research Program (TCRP)*

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

Project Description:

TCRP is a statutory program conducted through a cooperative agreement with NAS through 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 the first half of FY 2018, TCRP completed 12 reports and selected 22 new research projects. Most TCRP studies extend beyond a 12-month period. TCRP staff currently manage a portfolio of approximately 45 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:

- **TCRP Day:** APTA launched the first TCRP Day on June 6, 2018, 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 50 transit organizations hosted events. Full details are available on the TCRP Day Tool Kit website at <https://www.apta.com/resources/tcrp/Pages/TCRP-Day-Toolkit.aspx>.
- **TOSP Committee:** during its summer meeting in June 2018, the TOPS Committee adopted a new set of program performance measures to improve TCRP's ability to track progress against its programmatic goals and communicate to a diverse audience of interested parties.
- **New website:** The program introduced a new website in April 2018 to improve its visual appeal, streamline communications, and make navigation more intuitive for a diverse audience of users, available at <http://www.trb.org/TCRP/TCRP.aspx>.

- Annual report: TCRP released its Annual Report of Progress in December 2017, which highlights the year's major accomplishments and activities; can be accessed at <http://www.trb.org/Publications/Blurbs/176943.aspx>.
- Research studies: in October 2017, the TOPS Committee selected five research studies in addition to delegated committees' selections of seven synthesis projects, four quick response projects, four legal digests, and two IDEA projects. TCRP received 59 research problem statements from public, private, and non-profit entities, frequently in cooperation with one or more TRB committees.

In the first half of FY 2018, TCRP completed 12 publications, including 4 research reports, 4 synthesis reports, 1 research digest, and 1 legal digest; all are available at <https://www.nap.edu/author/TCRP/transportation-research-board/transit-cooperative-research-program>.

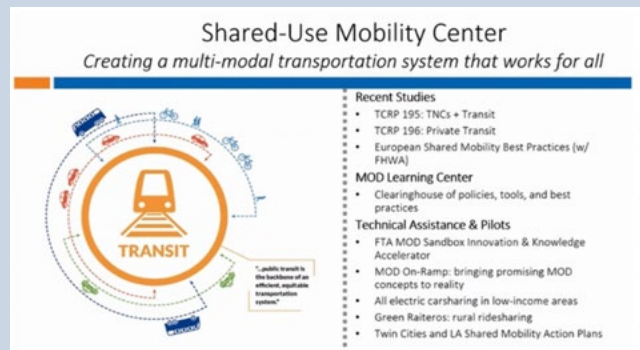
In addition to publication downloads from the National Academies Press, webinars attendance is a key indicator of how many people are accessing TCRP products. Communicating results is a necessary first step to facilitate research to practice pipeline. Webinars offer a relatively resource-efficient and 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. For the first time, TRB's webinar system hit its registration capacity when 1,300 people signed up for Broadening Understanding of the Interplay between Public Transit, Shared Mobility, and Personal Automobiles (hosted by TRB on May 15); 665 people participated in Improving the Resilience of Transit Systems Threatened by Natural Disasters (hosted by TRB on March 12); 212 people participated in Knowledge Management Resources to Support Strategic Workforce Development for Transit (cohosted through the National Transit Institute on March 27); and 591 people attended Impacts of Laws and Regulations on CV and AV Technology Introduction in Transit Operations (hosted by TRB on a transit-related product from the National Cooperative Highway Research Program on November 16).

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 19 *Improving the Resilience of Transit Systems Threatened by Natural Disasters*

TCRP was the first program to hit TRB's webinar registration cap, with over 1,300 people seeking to attend "Who's Riding TNCs and What Does It Mean for Public Agencies?" The webinar featured research from the TCRP Report 95 (available at <http://www.trb.org/Main/Blurbs/177451.aspx>) and explored how Transportation Network Companies (TNCs) such as Uber and Lyft are affecting the use of public transit and personal automobiles in several regions by drawing on several sources, including one of the first uses of TNC trip origin-destination data. The webinar outlined key findings and insights from this research about how, when, and where TNCs are most frequently used, and the relationship between this use, public transit usage, and driving commutes. The presenters also provided a range of recommendations that may assist public transit agencies and other public entities attempting to engage with TNC services in large, midsized, and smaller urban areas.



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

Grantee: Volpe National Transportation Systems 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. 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 operations. 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.

FTA is one of eight operating administrations within USDOT that funds SBIR research. Federal law mandates that each OA 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 2018 discretionary funding amount for SBIR is \$640,000.

Results:

All projects shown in Table 14 are active. During FY 2018, FTA had more than \$1.6 million in active SBIR projects—two Phase II projects and one Phase I project that was announced in July 2018. Outputs of selected SBIR projects currently in progress with significant results are:

- Transit vehicle passenger counting: in FY 2018, Migma Systems continued work on its Phase II transit vehicle passenger counting and re-identification sensor system. During November 2017, Migma conducted a performance evaluation on the system using data collected over a seven-hour span of passengers boarding and alighting bus. The test resulted in an accuracy of 99% for passengers boarding bus and an accuracy of 96% for passengers alighting bus. An internal report was submitted to FTA in December 2017. Passenger monitoring is essential for the management of any transit system and with this sensor system, it has the capability to re-identify each passenger to understand his or her boarding and alighting locations. This can optimize vehicle schedules to maximize transit capacity and reduce delay time. This sensor system is an example of how FTA's SBIR program is meeting its goal of stimulating technological innovation.
- Sensors for trains: in May 2018, Migma developed two new sensors for trains, and an internal report was submitted to FTA in June 2018. The development of the two sensors for trains allowed Migma to proceed with testing the systems accuracy in counting and re-identifying passengers boarding. It also allowed for alighting trains in a crowded environment during peak hours. 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 sensor system is another example of how FTA's SBIR program is stimulating technological innovation.
- Pedestrian and Cyclist Detection Devices for Transit Buses: in FY 2018, Novateur Research Solutions continued work on its Phase II Pedestrian and Cyclist Detection Devices for Transit Buses. During December 2017, Novateur completed the first version of the prototype system with the capability to gather data from multiple sensors, process data streams from both Infrared and LIDAR sensors, detect pedestrians and cyclist, and predict probability of collision. During January to March 2018, Novateur worked to improve system software so that it is robust enough for long term operations onboard a vehicle. Internal reports were submitted to FTA in January 2018 and April 2018. With transit buses involved in approximately 100,000 collisions each year and nearly 100 fatalities and 7,500 injuries, this system is designed improve pedestrian and cyclist safety. This effort is an

example of how FTA’s research investments are meeting federal research and development needs to further USDOT strategic goals such as improving safety across our nation’s transportation systems.

- **Bus testing system:** in April 2018, Novateur live-tested the prototype system by installing the sensors on a vehicle and driving the vehicle in Pittsburgh at different times of the day and in a variety of real and simulated settings. Data was collected to be used for analysis and further testing of the system. An internal report was submitted to FTA in May 2018. The benefit of live-testing the system will allow Novateur to make system improvements and test on actual transit buses. The live-testing of Novateur’s detection system is an example of how FTA’s SBIR program is helping stimulate technological innovation. In June 2018, Novateur presented Year I progress to FTA staff on the current state-of-the-art, technical and operational challenges, and how Novateur’s methodology tackles these challenges. In addition, Novateur discussed the technical details of system, the latest results of testing and integration efforts, and its future plans for its proposed system. This provided an opportunity for FTA to provide comments and questions and engage in productive dialogue with small business. An internal presentation was submitted to FTA in June 2018. Novateur’s Year I progress presentation is an example of how FTA’s SBIR program is fostering and encouraging participation in innovation and entrepreneurship and stimulating technological innovation.

Each grantee will submit a final project report upon project completion in Fall 2019 and Fall 2020. The final reports will describe the effectiveness of the proposed solution and product. These projects will result in small business growth and technological innovation. SBIR projects are expected to new drive new business development and solve pressing issues in the transportation industry.

FTA Funding: \$2,848,756

Table 14 SBIR Projects Receiving Assistance from FTA, FY 2018

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	\$1,204,773
Total			\$2,848,756

Figure 20 *Counting Passengers through Body Height Curve*



Traditionally, tracking the origin and destination of riders was done using labor-intensive and costly origin and destination surveys, usually using only small sample of riders. For transit vehicle passenger counting and re-identification, it is important to have accurate results under any condition. FTA's investment in Migma Systems' Passenger Counting and Re-Identification System will allow transit agencies to count and re-identify passengers with efficiency and accuracy. Using reliable biometrics, Migma Systems is using the passenger's hair or hat color along with their shoulder

cloth color and body height to accurately count and re-identify passengers boarding and alighting vehicle. The trifecta of all three biometrics can count and re-identify transit passengers with an accuracy of 95 percent or greater. This provides great value to the transit industry because it will not only provide exceptional accuracy but it will save money and time for transit agencies that would normally need staff to manually count passengers alighting at transit stops.

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
USDOT	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 Research Demonstrations
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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