

# FTA RESEARCH

FEDERAL TRANSIT ADMINISTRATION

## FTA Annual Report on Public Transportation Innovation Research Projects for FY 2017

FEBRUARY 2018

FTA Report No. 0120  
Federal Transit Administration

PREPARED BY  
Federal Transit Administration



U.S. Department of Transportation  
Federal Transit Administration

## COVER PHOTO

*Courtesy of Edwin Adilson Rodriguez, Federal Transit Administration*

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Federal Transit Administration  
Office of Research Management, Innovation, and Outreach  
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
<b>LENGTH</b>				
<b>in</b>	inches	25.4	millimeters	mm
<b>ft</b>	feet	0.305	meters	m
<b>yd</b>	yards	0.914	meters	m
<b>mi</b>	miles	1.61	kilometers	km
<b>VOLUME</b>				
<b>fl oz</b>	fluid ounces	29.57	milliliters	mL
<b>gal</b>	gallons	3.785	liters	L
<b>ft<sup>3</sup></b>	cubic feet	0.028	cubic meters	m <sup>3</sup>
<b>yd<sup>3</sup></b>	cubic yards	0.765	cubic meters	m <sup>3</sup>
NOTE: volumes greater than 1000 L shall be shown in m <sup>3</sup>				
<b>MASS</b>				
<b>oz</b>	ounces	28.35	grams	g
<b>lb</b>	pounds	0.454	kilograms	kg
<b>T</b>	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
<b>TEMPERATURE (exact degrees)</b>				
<b>°F</b>	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C

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U.S. Department  
of Transportation  
**Federal Transit  
Administration**

Dear Colleague:

I am pleased to provide the Federal Transit Administration's (FTA) Annual Report on Research for Fiscal Year (FY) 2017. The programs and projects discussed in this report advance innovative public transportation research and development in accordance with the Federal Public Transportation Innovation program (49 U.S.C. § 5312). FTA actively managed projects with more than \$159 million in Federal funding during FY 2017. FTA's research mission is to advance public transportation innovation by leading research, development, demonstration, deployment, evaluation, implementation practices, and technologies to enhance effectiveness, increase efficiency, expand quality, promote safety, and, ultimately, improve the transit rider experience.

FTA has three research priorities that mirror the goals of the Department of Transportation (DOT): safety, mobility innovation, and infrastructure. For active projects in FY 2017, 24% (\$38 million) were associated with safety; 59% (\$94 million) were associated with infrastructure; 11% (\$17 million) were associated with mobility; and 6% (\$10 million) were for supportive services and other activities. One of these activities, the Small Business Innovation Research (SBIR) Program, provides statutorily required seed funding to help small businesses develop new and innovative products for the public transportation industry – with over \$3 million invested in active SBIR projects. Another key activity is the statutorily required Transit Cooperative Research Program (TCRP) funded at \$5 million per year.

This report provides descriptions and results to date for projects active during FY 2017 with FTA assistance. 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

## Abstract

This report provides information on FY 2017 active research projects funded by the Federal Transit Administration (FTA) authorized in Federal public transportation law (49 U.S.C. § 5312). Projects that received FTA assistance in FY 2017 totaled \$159 million. FTA focused eligible projects in three strategic priority areas: Safety, Infrastructure, and Mobility Innovation. Projects in these areas promoted public transportation innovation to improve operations, infrastructure, and the traveler's experience. In FY 2017, 24% of projects (\$38 million) were associated with safety; 59% (\$94 million) were associated with infrastructure; 11% (\$17 million) were associated with mobility innovation; and 6% (\$10 million) were for supportive services and other activities.

The Public Transportation Innovation program (49 U.S.C. § 5312) authorizes four types of statutorily eligible projects: research, innovation and development, demonstration and deployment, and evaluation and implementation. FTA invests the most funding to test promising approaches to public transportation innovation through demonstration programs – 75% of active projects fell into this area in FY 2017. The breakout of funding across the four types of eligible projects is:

- **Research** – \$19 million (12%) is for public transportation research projects that provide more effective and efficient public transportation service – this includes the Transit Cooperative Research Program.
- **Innovation and Development** – \$20 million (12%) is for projects 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.
- **Demonstration and Deployment** – \$119 million (75%) is to promote the early deployment and demonstration of innovation in public transportation that has broad applicability.
- **Evaluation and Implementation** – \$2 million (1%) is to analyze project results and disseminate findings.

## Introduction

FTA's mission is to improve public transportation for America's communities, and its vision is that America has a world-class public transportation system with access and mobility for all. 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:

### Pipeline Phased Approach



FTA's research vision is that innovative projects and partnerships promote mobility, enhance safety, improve infrastructure, and promote economic competitiveness. Thus, 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 experience. In addition, FTA's research priorities directly enhance the goals of the U.S. Department of Transportation (DOT) in the following ways:

- **Safety** – research to improve the safety of the nation's transportation system.
- **Infrastructure** – research to improve capital asset management and operational costs and reduce congestion through asset innovation.
- **Mobility Innovation** – research to increase quality of life in communities through new service models that effectively and efficiently leverage public and private assets.

In addition to these three research priority areas, FTA has supporting programs and other activities. Supporting programs include those that evaluate the effectiveness of research programs, aid in dissemination, and support research to practice. Other activities include the statutorily required Transit Cooperative Research Program (TCRP) – a public transportation industry cooperative research program authorized at \$5 million annually; and FTA invests anywhere from 2.9% to 5% of discretionary research funds each year for another statutory program, the Small Business Innovation Research (SBIR) Program (§ 9 of the Small Business Act, 15 U.S.C. § 638).

## Requirements for this Report

Federal public transportation law (49 U.S.C. § 5312) 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

Following are detailed descriptions of programs and projects that received assistance in FY 2017. This assistance includes 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 the supporting programs and other initiatives. Each priority section notes the overall objective for that priority and provides a detailed description with a list of projects, outputs, and outcomes or impacts. Individual project descriptions include project title, grantee(s), performance indicators (outputs), performance goals (outcomes), project or program impacts, and FTA funding.

### Safety

#### Description:

FTA oversees research necessary for the safe, efficient, and effective operations of services for transit customers, employees, and others. The U.S. economy depends on a safe and secure public transit system for millions of Americans to get to important daily activities such as work, social engagements, education, and healthcare. FTA is funding innovative research to explore new technologies that improve the safety of public transit systems. The goals of FTA's Safety research are to improve public transportation safety, inform FTA regulations, and develop a safety oversight framework. It also aims to improve public safety by reducing transit-related injuries, fatalities, accidents, and system reliability.

#### Objectives:

FTA Safety research seeks to:

- Operate systems in a safer manner through improved application of advanced technologies and innovative practices, safety cultures, and human factors.
- Reduce injuries and fatalities by using innovative technologies to improve worker and rider safety.

#### Outcome/Impact:

Safety research demonstrates the feasibility of innovative solutions and technologies to improve the safety of transit operations. Through this research priority, agencies share their successes, such as the reduction in the number of crashes, fatalities, and injuries, to help other agencies adopt promising practices. Specific anticipated outcomes include the following:

- Achieve a 2% annual increase in the demonstration and deployment of innovative practices or technologies at transit agencies.
- Promote the adoption of employee safety reporting systems across the U.S. and the use of data to improve transit agency safety policies and practices.

List of Projects:

FTA had four active Safety projects in FY 2017, as listed in Table I.

**Table 1**  
Safety Programs  
Receiving Assistance  
from FTA, FY 2017

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)	\$9,266,670
Research	Safety Standards Strategic Plan Development and Data Collection Strategy	\$1,500,000
<b>Total</b>		<b>\$37,766,670</b>

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

**Grantee:** Local governments, transit authorities, educational institutions, and private firms (see Table 2)

**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 in three areas: (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. Under resiliency, the projects are identifying, developing, and testing technologies, methods, practices, and techniques to increase the ability of public transportation systems to survive natural disasters and other emergencies that result from external causes such as a catastrophic weather event. 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. Resiliency projects are seeking to identify the most promising methods and/or technologies to deploy in a public transit operational environment to restore transit services.

## Outputs

All the SRER projects shown in Table 2 are active and, after completion, will yield data on the effectiveness of various approaches to enhancing safety in operational safety, infrastructure resiliency, and all-hazards emergency response and recovery. Examples of outputs of three SRER projects in progress that have had significant results include the following:

- **Metropolitan Atlanta Rapid Transit Authority (MARTA)** is currently deploying a secondary track worker safety system along six miles of MARTA's rail system to be tested and validated. This innovative wayside system can potentially reduce, if not eliminate, injuries and fatalities due to rail vehicles colliding with rail track inspectors and maintenance crews.
- **New York Metropolitan Transportation Authority (NYMTA)** is testing a condition monitoring system to assess rail track and wheel conditions. The system can potentially improve the effectiveness and efficiency of rail vehicle and track maintenance by moving the transit agency from schedule-based maintenance to condition-based maintenance.
- **Sacramento Regional Transit and Applied Research Associates, Inc.**, is developing and demonstrating a light rail vehicle front end bumper that potentially can reduce injuries and minimize the impact of collisions between light rail vehicles and automobiles, pedestrians, and bicyclists. The prototype bumper has the potential to reduce head injury criteria up to 85% and thoracic trauma index up to 99% with a collision speed of 20 mph.

Throughout the duration of the program, each project sponsor is required to conduct outreach and transfer knowledge via workshops, conference presentations, webinars, etc., to ensure the deployment of the results of SRER such as those mentioned above.

## Outcomes/Impacts:

Final reports are expected from each project after all cooperative agreements are completed and are due 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. Projects are developing and demonstrating new or substantially improved technologies, methods, practices, and techniques that will increase the operational safety of public transportation services and reduce the risk of transit-related injuries and fatalities. The 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. FTA has made significant progress in identifying technologies that can increase safety in the public transportation industry.

**Project/Program Evaluation:**

All project sponsors are required to have an independent evaluator for their respective project who will work within the criteria of safety improvements, operational and capital efficiency, and return on investment. Evaluations are ongoing, and reports are expected to be completed at the end of each project.

**FTA Funding: \$24,000,000**

**Table 2** SRER Research Demonstrations Projects Receiving Assistance from FTA, FY 2017

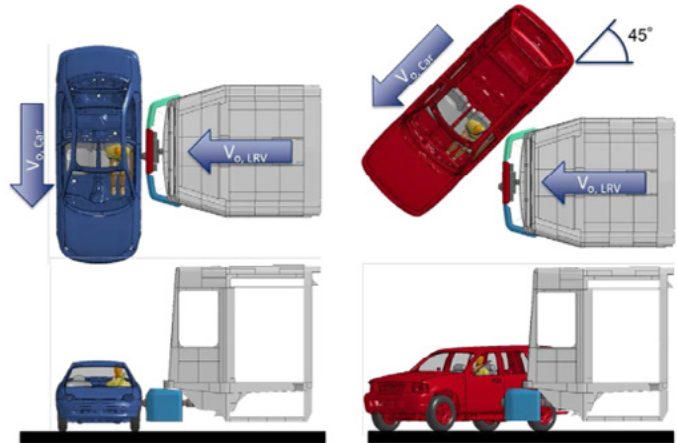
Project Title	Project Recipient	City and State	FTA Award
Demonstration and Commercialization of LRV Bumper for Enhanced Safety in Shared Right-of-Way Street Environments	Applied Research Associates	Albuquerque, NM	\$1,323,414
TrackSafe Phase II Demonstration Project	Metropolitan Atlanta Rapid Transit Authority	Atlanta, GA	\$4,233,865
Development of Bus Exportable Power System for Emergency Response	Center for Transportation and the Environment	Atlanta, GA	\$995,098
Coordinated Transit Response Planning and Operations Support Tools for Mitigating Impacts of All-Hazards Emergency Events	University of Chicago	Chicago, IL	\$2,890,600
Evacuation and Return: Increasing Safety and Reducing Risk	City of New Orleans	New Orleans, LA	\$500,329
Driver Assist System Technology to Support Robust, Flexible Bus-on-Shoulder and Narrow-Lane Operations for Robust Transit Service	Minnesota Valley Transit Authority	Burnsville, MN	\$1,790,014
New Jersey Transit Critical Infrastructure Storm Surge Warning System	New Jersey Transit Corporation	Newark, NJ	\$843,750
Connected Vehicle Infrastructure – Urban Bus Operational Safety Platform	Battelle Memorial Institute	Columbus, OH	\$2,741,617
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
<b>Total</b>			<b>\$24,000,000</b>



**Figure 1**

*Example of Impact of SRER on Safety*

From 2010 to 2014, there were approximately 35 fatal pedestrian crashes and 96 serious crashes with transit buses across the country. FTA is partnering with the New York Metropolitan Transportation Authority (NYMTA) to make design changes to the layout of the bus operator compartment—in particular, the placement and size of the operator mirrors—to prevent or minimize blind spots and provide the driver with an optimal view of pedestrians, bicyclists, and customers. In this project, FTA is working with NYMTA and the transit industry to develop a viable design and create a set of guidelines to minimize transit bus operators' blind spots, which could reduce the number of serious crashes.



**Title:** *FTA Employee Safety Reporting Pilot Program*

**Grantee:** Volpe National Transportation Systems Center

**Project Description:**

This program is launching several pilot Employee Safety Reporting systems in transit agencies with different modes and service conditions. FTA aims to demonstrate the effectiveness of these systems in a variety of transit operations that are representative of the transit industry and to produce a guidance document for the industry to use when agencies are setting up their own systems. This research project provides guidance to transit agencies nationwide to improve effectiveness in safety reporting with a how-to guide for setting up an Employee Safety Reporting system.

**Outputs:**

As of July 2017, a needs assessment plan was produced using the National Transit Database (NTD) to extract various demographic characteristics to document how the transit industry is structured. The program is expected to submit to FTA a how-to guidance document for setting up an Employee Safety Reporting system and an evaluation of the program and effectiveness of each pilot site. Outputs for this project include the following:

- Information gathered from pilot programs and data collected on the effectiveness of various Employee Safety Reporting systems.

- An evaluation report to be delivered to FTA approximately three years after the start of the pilot.
- Delivery of the guidance documents is expected in Fall 2018.

**Outcomes/Impacts:**

To date, this project is collecting relevant information that will assist FTA with improving 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 (see Table 3)

**Project Description:**

The SRD Program provides technical and financial support for transit agencies to pursue innovative approaches to eliminate or mitigate safety hazards and pursue cutting-edge technologies and innovative approaches to safety, focusing on demonstration of technologies and safer designs. SRD Program objectives are to explore advanced technologies to prevent transit vehicle collisions, enhance the safety of transit services by incorporating safer design elements, 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 SRD Program is intended to assess the practicality and effectiveness of potential solutions to improve safety as well as 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.

**Outputs:**

FTA awarded funds to each of the selected grantees, and each project is active. A final report is expected at the end of each project that details specific outputs. Each of the seven demonstration projects will yield data on the effectiveness of various technological approaches to enhancing safety in collision warning and avoidance as well as transit employee safety protection.

**Outcomes/Impacts:**

SRD Program projects will improve safety for the transit industry and advance the development of technologies and safer designs to reduce the number of

collisions and fatalities and mitigate the severity of transit-related injuries. The potential impacts of the project are improvement of the safety culture at transit agencies, support for stakeholder coordination, outreach for collision avoidance and mitigation, and support for the transit worker safety protection.

**Project/Program Evaluation:**

The Center for Urban Transportation Research (CUTR) at the University of South Florida (USF) will serve as the independent evaluator and will work with the grantees to evaluate each project on safety improvements, system effectiveness, and return on investment. The grantees have established performance metrics for each of these criteria in their statement of work.

**FTA Funding: \$9,266,670**

**Table 3** SRD Projects that Received Assistance from FTA, FY 2017

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, NY	\$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
SRD Program Evaluation	University of South Florida	Tampa, FL	\$750,000
<b>Total</b>			<b>\$9,266,670</b>

**Figure 2**

*Examples  
of 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 to 2014 there were approximately 35 fatal pedestrian crashes and 96 serious crashes with transit buses each year across the U.S. Approximately 48% of pedestrian fatalities and 40% of serious pedestrian crashes occurred when the bus was traveling straight. Of 7 annual bicyclist fatalities, 67% occurred when the bus was traveling straight. FTA is partnering with transit systems 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 the driver 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. In this project, FTA will work with the transit industry to create a set of guidelines to ensure that transit bus operators have optimal views, both direct and indirect, of potential hazards around the vehicle. These guidelines are needed for mirrors on both sides of low-floor transit and motorcoach buses. To reduce the frequency and severity of crashes with pedestrians, it is critical to improve visibility in the zone obstructed by the street-side A-pillar and mirror. The street side is the most problematic due to the object viewing distance from buses to pedestrians moving along the opposite side of the street. Also, the close proximity of the bus operator's eyes to the pillar structure and mirror is a problem. 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 Standards Strategic Plan Development and Data Collection Strategy***

**Grantee:** University of South Florida, Center for Urban Transportation Research (CUTR)

**Project Description:**

This project is reviewing current transit safety standards, conducting data analysis, and providing recommendations to assist FTA with its effort to develop transit safety standards, guidance, or advisories. Federal public transportation law (49 U.S.C. § 3020 (a)) requires the Secretary of Transportation to review public transportation safety standards and protocols to document existing standards and examine the efficacy of those standards and protocols. The research conducted for this project is providing background information and

strategic direction for FTA to implement the rulemaking authority on minimum safety performance standards. This project is identifying and recommending safety standards to help FTA roll out a plan for safety standards implementation. A final FTA Safety Standards Strategic Plan will be developed that will provide information to FTA about existing transit safety standards and gaps and propose new standards for use by the transit industry.

### **Outputs:**

As of July 2017, CUTR has produced the following results:

- A resource document for the public transportation industry of 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>.
- A report titled "Review and Evaluation of Public Transportation Safety Standards," published on FTA's website in January 2017 and accessible at <https://www.transit.dot.gov/research-innovation/review-and-evaluation-public-transportation-safety-standards-fta-report-no-0103>, which provides information required for review of public transportation safety standards and protocols to document existing standards and examine the efficacy of those standards and protocols.

A Final FTA Safety Standards Strategic Plan was submitted to FTA in December 2017 after completion of research. This document identified minimum transit safety standards and corresponding gap analyses and recommendations to FTA.

### **Outcomes/Impacts:**

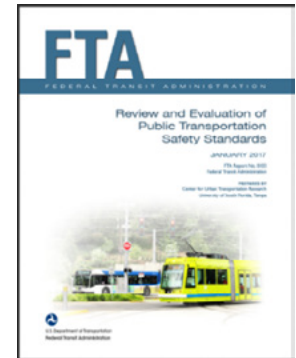
Project deliverables and research being conducted are assisting FTA in making the appropriate decisions regarding existing and new minimum safety standards to ensure public transit is safer. This project is identifying the standards and protocols that assist FTA and the public transportation industry to reduce accidents and fatalities.

**FTA Funding: \$1,500,000**

**Figure 3**

*“Review and Evaluation of Public Transportation Safety Standards”*

FTA published “Review and Evaluation of Public Transportation Safety Standards” in January 2017, which provides information to the industry about the review of safety standards and protocols, documents existing standards, and examines the efficacy of those standards and protocols. Included in the report is a detailed Compendium of Transit Safety Standards that lists consensus standards and codes, regulations, recommended practices, guides, guidance documents, and best practices from industry, standards development organizations, Federal and State standards, laws, regulations, and other model practices. This document assists FTA in making the appropriate decisions regarding existing and new minimum safety standards to ensure public transit is safer. The report can be accessed at [https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA\\_Report\\_No.\\_0103.pdf](https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA_Report_No._0103.pdf).



## Mobility Innovation

### Description:

Mobility Innovation strengthens the capacity of transit agencies and communities as they navigate the dynamic, evolving landscape of personal mobility. Demonstrations in this research priority area explore innovative business models, partnerships, and private-sector technological tools and solutions for enhanced and seamless mobility options for all travelers. Demonstrations complement emerging private-sector advancement in autonomous vehicle and mobility technology, potentially leading to job creation in new businesses and technologies, aligning with the White House research and development priority area of American Prosperity. The definition of mobility is dramatically evolving with the rise of transformative multimodal concepts, public/private partnerships, traveler expectations, and emerging technological capabilities. These fundamental changes in the way transportation service is offered also influence the form of our communities. Options such as mobile way-finding, bicycling and bike-sharing, on-demand ridesharing, and a future that could include autonomous vehicles mean that mobility options, particularly in urban areas, will alter the nature of public transportation.

FTA’s Mobility Innovation research also explores options to integrate flexible and customizable public transit improvements for enhanced mobility at a lower cost. The goals of FTA’s Mobility Innovation research are to examine the development and applicability of complementary and supplemental mobility options that enhance operational efficiency and the overall travel experience for public transportation riders, leading to the adoption of new, integrated, multimodal networks of mobility choices through both public and private resources.

### Objectives:

FTA’s Mobility Innovation research engages in advanced research and innovation, encourages the development of complementary and supplemental mobility options, and improves the overall experience for public transportation travelers, leading to the adoption of new, integrated, multimodal mobility options by public and private transportation providers. Mobility Innovation research focuses on the following objectives:

- Enhance transit operational efficiency and reduce costs by leveraging public and private assets and technologies.
- Advance personal mobility by identifying and facilitating speedy adoption of proven mobility solutions, partnerships, and business models from both the private and public sectors for enhanced mobility for all travelers.

### Outcome/Impact:

The traditional transportation split between public transit and the personal automobile will give way to a traveler-centric mobility portfolio that offers seamless service through peer auto-sharing schemes, on-demand taxi trips, demand-responsive paratransit, and other innovative transportation methods. The anticipated outcomes of FTA’s Mobility Innovation research are to:

- Improve transportation efficiency by promoting agile, responsive, accessible, and seamless multimodal service inclusive of transit through enabling technologies and innovative partnerships.
- Increase transportation effectiveness by ensuring that transit is fully integrated and a vital element of a regional transport network that provides consistent, reliable, and accessible service to every traveler.
- Enhance the customer experience by providing everyone with equitable, accessible, traveler-centric service, leveraging public transportation’s longstanding capability and traditional role in this respect.

### List of Projects:

FTA had five active Mobility Innovation programs in FY 2017, as shown in Table 4.

**Table 4**  
*Mobility Innovation Programs Receiving Assistance from FTA, FY 2017*

Type of Project	Project Title	FTA Funding
Innovation & Development	Mobility on Demand (MOD) Program	\$9,531,080
Research	Transit Automation Analysis and Research Plans Development	\$950,000
Research	Accessible Transportation Technologies Research Initiative (ATTRI)	\$2,500,000
Research	Rides to Wellness Initiative	\$3,355,541
Innovation & Development	Mobility Services for All Americans (MSAA)	\$795,545
<b>Total</b>		<b>\$17,132,166</b>

**Title:** *Mobility on Demand (MOD) Program*

**Grantee:** Transit agencies, local governments, non-profit organizations, and private firms (see Table 5)

**Project Description:**

MOD is a vision for an integrated and connected multimodal network of safe, affordable, and reliable transportation options that are available to all. The MOD Program is working to provide all travelers with enhanced mobility options, improved travel decision tools, and convenient and seamless travel and fare payment and to develop innovative new operational models such as solutions for first/last mile and transportation options that leverage private transportation investments and assets. FTA is working with MOD stakeholders to improve the transit industry's awareness and support readiness for MOD, and MOD research seeks to identify and understand impediments to implementation. MOD projects help to increase buy-in from local stakeholders and transportation companies needed for successful deployments of integrated public and private MOD solutions. New and innovative shared-use mobility concepts and solutions, from bike- and car-sharing systems to innovative demand-response bus services and smartphone traveler apps, are providing travelers with new travel options, which are already impacting the traditional transit market and could conceivably disrupt current public transit business and funding models. To understand the new travel options and their impact on the public transportation industry, FTA's MOD Program seeks to:

- Explore emerging technology solutions and new business approaches that have the potential to transform mobility services.
- Prepare the transportation industry to deliver innovative mobility solutions that will enhance transportation efficiency and effectiveness, improve customer service, and foster personal mobility.
- Enable the widespread deployment of integrated mobility solutions that are connected, equitable, and effective to enhance the personal mobility of everyone.

FTA conducts the following key activities under the MOD Program:

- **Sandbox Demonstration** projects explore technologies and approaches to integrating MOD with transit in a real-world environment.
- **Sandbox Independent Evaluation** informs how to best integrate MOD solutions with transit service and provide lessons learned.
- **Performance Metrics** develop new measures to provide a common language to understand the impacts of MOD solutions and practices.



- **Stakeholder Outreach** engages the broader transit industry and provides up-to-date information on MOD partnerships related to Section 5314 activity.
- **Innovation Knowledge Accelerator** creates a structured, supported learning and information exchange and community of practice for MOD sites.
- **Policy Compliance** provides clarity on how existing FTA and U.S. DOT policies apply to MOD partnerships.

The results of these projects will be widely applicable nationwide and help FTA's efforts to promote equitable, accessible, and safe mobility options for all travelers and leverage existing national investments in transit systems.

### Outputs:

MOD Sandbox projects were selected through a competitive process. All projects related to MOD are currently active, and work is in progress. Projects under the MOD Program are shown in Table 5. The following are relevant outputs of the MOD program with significant results:

- A total of 11 MOD Sandbox program projects are exploring technologies and approaches to integrating MOD with transit. All projects are active, and the project teams are working to implement the demonstration efforts. The demonstration phase began in February 2018 with the Vermont Agency of Transportation making the Flexible Trip Planner Project available to the public. The trip planner can be accessed at <https://plan.vermont.org/>. The other projects will start their demonstration phase in Summer and Fall 2018.
- FTA is evaluating all Sandbox demonstration efforts as required by Federal Public Transportation Law for demonstration research programs. FTA completed an evaluation framework to identify key elements to collect and analyze project outputs and worked with each of the sites to develop detailed evaluation plans for the demonstrations.
- FTA is working with the Shared Use Mobility Center in Chicago to help participants in the Sandbox and other communities share ideas, lessons learned, and research findings through structured information exchange. FTA initiated the MOD Community of Practice in FY 2017 with an initial meeting in April 2017 of Sandbox participants and other interested transit agencies. Other meetings are planned throughout the duration of the MOD Program.
- FTA published an FAQ document in response to increasing interest from the transit industry to partner with on-demand, shared mobility services such as ride-hailing companies. The document addresses shared mobility eligibility under FTA's grant programs, the Americans with Disabilities Act (ADA), and controlled substance and alcohol testing requirements with shared mobility initiatives; it is available at <https://www.transit.dot.gov/regulations-and-guidance/shared-mobility-frequently-asked-questions>.

- FTA is working with the Transit Center in New York to develop new MOD measures that will augment existing transit metrics and provide a common language to understand the impacts of MOD solutions and practices. In FY 2017, it worked with a group of industry representatives to develop ways to measure MOD goals and delivered an initial draft report on MOD metrics to FTA. FTA anticipates publication of a final report on these new passenger-centric metrics in FY 2018.

### **Outcomes/Impacts:**

Current Sandbox projects are already helping inform FTA and the industry on how to approach MOD-related policies and what technologies and business models work best. The Sandbox is helping through both the independent evaluations and FTA's work to develop a community of practice around MOD to support industry dialogue. MOD can provide travelers with enhanced mobility options, improved travel decision tools, and convenient and seamless travel and fare payment and can provide transit agencies with innovative new operational models such as solutions for first/last mile connections to transit and better leveraging of existing investments and improving service quality. To date, the MOD Program has made progress toward the following outcomes:

- Expanded options for communities and transit agencies to provide MOD-based transportation solutions.
- Enhanced transit capacity and readiness to adopt MOD solutions.
- Developed a better understanding of innovative business models to deliver high-quality, seamless and equitable mobility.
- Enabled FTA to adopt policies on shared mobility that better support transit agencies and communities.
- Provided support for a traveler-centric, carefree, effective transportation system that is reflective of MOD guiding principles of system integration, partnership-driven, innovative and equitable.

### **Project/Program Evaluation:**

MOD Sandbox demonstration projects require an evaluation. FTA is working with a contractor to complete an evaluation of each project and will provide a comprehensive assessment of the evaluation efforts by 2018. Evaluation of the Sandbox projects will inform how to best integrate MOD solutions with transit service and provide lessons learned for other transit agencies seeking to use MOD solutions to improve mobility in their communities.

**FTA Funding: \$9,531,080**

**Table 5** MOD Projects Receiving Assistance from FTA, FY 2017

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
MOD Metrics and Studies	Transit Center	New York, NY	\$750,000
MOD Information Knowledge Accelerator	Shared Use Mobility Center (SUMC)	Chicago, IL	\$600,000
MOD Sandbox Evaluation	Booz Allen Hamilton	Washington, DC	\$250,000
<b>Total</b>			<b>\$9,531,080</b>

**Figure 4**

*Mobility on Demand (MOD) Grantee Meeting*

FTA, in collaboration with the Shared Use Mobility Center, hosted an MOD Program meeting in Alexandria, Virginia, that was attended by all 11 selected MOD Sandbox recipients as well as other interested transit providers. All project recipients made presentations on their projects and discussed how they are meeting the MOD objectives and the expected deliverables and outcomes to FTA. The meeting also helped participants share ideas, lessons learned, and research findings through a structured information exchange.



**Title:** *Transit Automation Analysis and Research Plan Development***Grantee:** Volpe National Transportation Systems Center**Project Description:**

This project is developing a Strategic Transit Automation Research Plan for FTA aimed at identifying specific research activities for a five-year horizon. The core of the project includes identifying, analyzing, and prioritizing use-case scenarios for automating transit operations, such as Advanced Driver Assistance Systems (ADAS), circulator service, first/last-mile operations to high-capacity transit routes, bus yard operations, bus rapid transit (BRT), ADA paratransit service, and on-demand shared rides. The project engages transit stakeholders such as transit agencies, trade organizations, academia, bus manufacturers, technology suppliers, insurance organizations, metropolitan planning organizations, state departments of transportation, and other U.S. DOT modes to obtain their input and feedback on transit automation use cases and challenges. This stakeholder engagement, along with benefit and cost information, helps FTA prioritize transit automation development and demonstration projects, and other applicable research activities.

This project addresses transit agency interest in automating aspects of operations to improve mobility and safety of public transportation. The industry is reluctant to invest in automation procurements and deployments due to perceived risks, lack of information on costs and quantified benefits, lack of proven implementations, and other factors. This project investigates and addresses these factors, starting with specific needs and leading to field operational testing and evaluation, to help transit agencies successfully implement transit bus automation. Without U.S. DOT involvement, transit agencies could significantly lag behind the private sector in vehicle automation and may forgo automation for other aspects of transit operations, which would be a disadvantage to the transit community.

**Outputs:**

To date, this project has completed the following:

- A technology literature review, conducted in Spring 2017, on the latest automation technologies and vendors.
- A risks and barriers assessment to transit automation, completed in Spring 2017, and proposed potential solutions to address or mitigate the risks and barriers.
- A benefit-cost analysis, conducted in Spring 2017, for each use case, which produced a technical memo, assisting FTA to explore and identify the business case for each use case.

- Development of a knowledge transfer plan, completed in September 2017, which identifies stakeholder groups and information materials to be developed and provided to them.
- Draft of the Transit Automation Research Program Plan in September 2017.

Throughout the duration of the project, additional activities will be completed. Once all activities are completed, the project will produce a final project report.

### **Outcomes/Impacts:**

This effort has supported the U.S. DOT sharing of automation advances with the transportation industry. Once completed, the Strategic Transit Automation Research Plan and final report will be a useful communications tools that can be used for planning and executing U.S. DOT-sponsored transit automation development and demonstration projects and FTA research programs that include elements of automation. Transit agencies will be able to significantly accelerate deployment of automation or partial automation of transit operations.

### **FTA Funding: \$950,000**

## **Figure 5**

### *Automation Research Plan Stakeholder Workshop*

Participants in the first Automation Research Plan stakeholder workshop, held at U.S. DOT Headquarters in January 2017, provided feedback on straw-man transit automation use cases. In total, 24 people attended, representing transit agencies, trade organizations, academia, bus manufacturers, technology suppliers,



insurance organizations, metropolitan planning organizations, State departments of transportation, and U.S. DOT. The workshop provided feedback on draft transit automation use cases used to identify the research FTA needs to conduct with respect to public transportation operations. This knowledge transfer activity provided practical feedback and consensus from the transit industry to better channel FTA efforts in research for transit vehicle automation.

**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 in advancing accessible transportation and independent mobility. 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 leverages recent advances in vehicle, infrastructure, and pedestrian-based technologies as well as accessible data, mobile computing, robotics, artificial intelligence, object detection, and navigation to identify, develop, and implement transformative solutions in advancing accessible transportation and independent mobility.

Many of America's 57 million people with disabilities face a barrier 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, removing barriers to transportation.

**Outputs:**

ATTRI announced the award of six contracts to develop prototype applications in the areas of wayfinding and navigation, safe intersection crossing, and pre-trip concierge and visualization. ATTRI is yielding prototypes for future large-scale demonstration and deployment. Expected deliverable dates are pending completion of each project.

**Outcomes/Impacts:**

Successful development and utilization of technology solutions will reduce barriers to mobility, with performance goals tied to the number of technologies developed, tested, and successfully fielded. The impact of the project is reduced barriers to mobility for people with disabilities, including veterans and older adults. ATTRI solutions will leverage advances in transit and related industries, including vehicle and infrastructure-based technologies, automation, robotics, and wireless communications to ensure that the transportation network, including public and human service transportation, best serves the target populations.

**FTA Funding: \$2,500,000**

**Figure 6** ATTRI Complete Trip Fundamentals



ATTRI conducted extensive foundational research resulting in the definition of four key technology areas for exploration: Wayfinding and Navigation, Safe Intersection Crossing, Pre-Trip Concierge, and Automation and Robotics, as well as several key principles. This research, including the input of thousands of people with disabilities and industry experts, led to a focus on removing barriers experienced by those with vision, mobility, hearing, and cognitive disabilities and to the definition of a simple principle: If any part of a trip is inaccessible, the whole trip becomes inaccessible, as illustrated above. Because a complete trip solution cannot be achieved by any single entity, ATTRI has an important role as the integrator of various types of technologies to advance the vision of a fully accessible, complete trip. Currently, the program is developing prototypes to support enhanced wayfinding and navigation, safe intersection crossing, pre-trip planning and automation and robotics. Future activities will be tied to ongoing assessments of the state of technology and user needs.

**Title:** *Rides to Wellness Initiative*

**Grantee(s):** National Academies of Sciences, Engineering, and Medicine's Transportation Research Board and Health and Medicine Division; health outreach partners; competitively selected demonstration grant recipients; Center for Urban Transportation Research (see Table 6)

**Project Description:**

Rides to Wellness is building partnerships, stimulating investment, and driving change across the health and transportation sectors to ensure that everyone can reach health services. It is associated with activities supporting the Coordinated Council on Access and Mobility (CCAM), a federal interagency council established by Executive Order 13330 in 2004 and codified by Federal Public Transportation Law (Section 3006(c) of the FAST Act).

Rides to Wellness demonstration grants funds communities to implement solutions that integrate health and transportation. The primary purpose is to find and test promising, replicable public transportation healthcare access solutions that support the Rides to Wellness 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 are piloting innovative concepts and 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 listed in Table 6. 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 grants was made publicly available in December 2017 on the FTA website. The report can be accessed at <https://www.transit.dot.gov/funding/grants/grant-programs/annual-report-pilot-program-innovative-coordinated-access-and-mobility>.

**Outputs:**

The Transportation Research Board/Health and Medicine Division (TRB/HMD) project gathered data on the value of partnerships across the health and transportation sectors and the final report was posted on the following webpage: <https://outreach-partners.org/2017/06/23/rides-wellness-community-scan-project/>.



The Rides to Wellness Community Scan Project sought to determine the impact of transportation barriers on healthcare costs while highlighting existing, patient-centered transportation solutions. Key results of the project included:

- Health Resources and Services Administration (HRSA)-funded health centers were recruited via email to participate in a national survey. The goal of the survey was to identify the impact a lack of transportation has on missed medical appointments and consisted of 25 questions using a cross-sectional design with a mixed-methods approach. A total of 188 responses were received, representing a sample size of 15% of health centers. Based on the survey findings, health centers have no-show rates ranging from 11% to 30%, but 92% of health centers reported tracking their missed appointments. When asked whether health centers track the reason why patients miss appointments, 40% responded yes, 50% no, and 10% unsure. The key takeaways from the survey indicate that:
  - Missed appointments are a problem for health centers and impact key clinical outcomes. Transportation is a top reason why patients miss their appointments, and certain patient subgroups are disproportionately affected. Even though Community Health Centers are not required by the Health Resources Services Administration to report missed appointments or the reason, most understand it is an issue for their center: When asked how significant transportation barriers are for their patients, 86% indicated that it is a “moderate” or “serious” problem.
  - Health centers are engaged in quality improvement efforts to decrease missed appointments. For those health centers that responded that they are doing so, a follow-up question was asked about specific strategies used, with over half (51%) indicating using patient reminders such as phone calls, emails, or texts. Several health centers (17%) mentioned using transportation strategies such as asking about and providing transportation, providing rides through grants funds, helping patients find transportation options, and referrals to transportation services.
  - Health centers are not tracking reasons for missed appointments or the cost of missed appointments consistently, making it difficult to pinpoint the percentage of missed appointments due to transportation issues. With limited data, it is difficult to definitively estimate the costs of missed appointments due to transportation barriers.
- The following six locations adopted patient-centered transportation solutions that show promising opportunities for return on investment: Buffalo, NY; King County, WA; Portland, OR; South-Central, MO; Worcester, MA; and Southern IL.

Rides to Wellness Demonstration Grants are 18-month projects that began implementation in the second half of 2017. Each will submit a detailed final report

on results within 90 days of project completion. In addition, there will be a comprehensive evaluation of outcomes and impacts of each grant project.

**Outcomes/Impacts:**

These demonstration grants are part of a series of activities supporting the Rides to Wellness initiative and will result in ways to overcome barriers to essential services by leveraging diverse partnerships. For historically disadvantaged populations, there are many challenges to maintaining optimal health. Through community partnerships that break down industry silos, these projects are providing a framework to improve the health of transportation disadvantaged Americans. The impact of this program is the development of replicable, sustainable solutions to healthcare access challenges that bring about fundamental change. The program fosters local partnerships among health, transportation, and other sectors to collaboratively develop and support solutions that increase healthcare access.

**Project/Program Evaluation:**

For all federally-funded Rides to Wellness grants, FTA is providing evaluation support through a cooperative agreement with CUTR, which began the evaluations in May 2017. The final evaluation report is due to FTA in the Summer 2018.

**FTA Funding: \$3,355,541**

**Table 6**  
Rides to Wellness  
Projects Receiving  
Assistance from FTA,  
FY 2017

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	St. 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
Transportation Research Board and Health and Medicine Division Project	National Academies of Sciences, Engineering, and Medicine	Washington, DC	\$267,097
Rides to Wellness Community Scan Project	Health Outreach Partners	Oakland, CA	\$223,211
<b>Total</b>			<b>\$3,355,541</b>

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

**Grantee:** State departments of transportation and transit authorities as direct recipients (see Table 7)

**Project Description:**

MSAA increases mobility and transportation accessibility and engage in the deployment planning and preparation of coordinated Human Service Transportation (HST) systems that use ITS capabilities. Persons with disabilities comprise nearly 20% of the U.S. 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 is targeted for communities of any size or definition and includes public entities currently establishing, operating, coordinating, or brokering general public transportation and HST, including public transit agencies, state and local government departments of transportation, health and human service agencies, federally recognized Indian tribes, and metropolitan planning organizations. MSAA provides the opportunity to design a replicable, scalable, and interoperable Travel Management Coordination Center (TMCC) and allows agencies to use a coordinated system to share trip requests and schedules to easily book rides and transfers for customers across service areas, 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.

MSAA has national significance because the research enhances accessibility and mobility for persons who are transportation disadvantaged. The MSAA initiative focuses on applying ITS solutions to advance HST delivery and has significance to the transit industry and community because of its ability to showcase promising technologies and practices that improve travel planning and coordination for people who need specialized transportation 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.

**Outputs:**

Performance indicators will be a direct product of the project or program. Examples include reports, webpages, new technology, and new processes. Additional performance indicators and products include:

- Technical assistance to MSAA planning and development grantees in Atlanta, Denver, San Louis Obispo (CA), and Madison (WI) by holding periodic project progress meetings and participating in stakeholder conference calls, providing systems engineering support, assisting in development of deployment planning documents such as user needs and system requirements documents, providing input in developing phased implementation plans, and providing assistance in identifying resources for sustainable funding strategies for deployment, operation, and maintenance of the planned systems.
- A TMCC reference manual, to be published in Spring 2018, to guide agencies through the systematic process of system planning, documentation, procurement, and integration of TMCC systems.
- An updated and dedicated website developed in phases since 2016 and updated periodically to include current information and web links about the initiative, as well as a library of documents developed by FTA and MSAA grantees, reference materials, and resources for assistance to agencies considering MSAA and TMCC deployments.
- A comprehensive “lessons learned” document developed by one of the MSAA demonstration sites documenting their experience throughout the process, which will be ready for distribution by May 2018.
- Four final project reports will be submitted to FTA by May 2018.

### **Outcomes/Impacts:**

Results and specific changes to the project or program that are expressed as a tangible, measurable, or quantitative standard, value, or rate in the short term include:

- Concept development for TMCCs.
- Stakeholder needs, requirements, and architecture models shared and used as baselines for TMCC systems nationwide.
- Documentation of TMCC evaluations and lessons learned.
- Knowledge and technology transfer tools and guidance for future TMCC systems across the U.S.
- Improving service and expanding travel opportunities for all Americans, including those with mobility challenges to provide a better quality of life.
- Optimizing paratransit operations by modernizing their scheduling systems to provide efficiencies and effectiveness in operations, reducing costs for transit agencies and providers, and identifying the most efficient fee for traveler rides considering the time of the ride and across different providers.
- Facilitating improved methods for TMCC acquisitions and transferring that knowledge to improve stakeholder understanding and capabilities with general ITS deployments.

The MSAA program works to improve the travel experience for all Americans, with an emphasis on those who are transportation disadvantaged. The impact of the MSAA program is that it will improve 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 are in the process of planning and developing their systems. Some locations have already improved their systems enough to enhance the traveler experience.

**FTA Funding: \$795,545**

**Table 7** MSAA Projects Receiving Assistance from FTA, FY 2017

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
<b>Total</b>			<b>\$795,545</b>

## Infrastructure

### Description:

FTA continues to leverage findings in infrastructure and asset innovation, specifically related to vehicle technologies; enhancing economic opportunities for U.S. bus manufacturers; and supporting more energy efficient technology. FTA has a successful history of supporting transformative public transportation infrastructure research and demonstration projects to include those capital assets that are used to directly support and provide public transportation service. FTA’s research focus has been to ensure that transformative innovations meet the public demand for safe and speedy adoption. For example, FTA has applied this thinking to all research activities within the Infrastructure research program to include next generation vehicles and related facilities. At present, FTA conducts transformative research on and demonstrations of low and no emission and next generation transit buses, facilities, and related charging and maintenance technologies developed and tested by the private sector, such as fuel cells and lithium ion batteries, but that have not yet been widely applied or adopted in the public transportation industry.

### Objectives:

The Infrastructure research priority promotes the development and deployment of technologies to reduce the energy consumption of transit systems. The focus on infrastructure to improve asset management and drive asset innovation are to:

- Improve lifecycle maintenance by evaluating methods, products, approaches, and practices to develop products or services more efficiently.
- Enhance energy efficiency and effectiveness 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.

### Outcomes/Impacts:

The outcomes of FTA’s Infrastructure research will be the ability of transit agencies to:

- Determine performance specifications and lifecycle metrics for components.
- Ensure that transit buses can withstand the rigors of daily revenue public transportation service.
- Increase US manufacturing and economic competitiveness in the development and production of next generation transportation.

### List of Projects:

FTA had 11 active Infrastructure areas in FY 2017, as shown in Table 8.

**Table 8** *Infrastructure Programs Receiving Assistance from FTA, FY 2017*

Type of Project	Project Title	FTA Funding
Demonstration & Deployment	Low or No Emission Vehicle Deployment Program (LoNo) Program	\$76,969,249
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
Innovation & Development	Next Generation Transit Vehicle (Zero Emission Bus) Research	\$2,750,000
Research	Next Generation Bus Evaluation and Support	\$1,400,000
Demonstration & Deployment	Bus Efficiency Enhancements Research and Demonstrations (BEERD) Program	\$3,000,000
Research	U.S. State Department –China Low and No Emission Bus Collaboration	\$500,000
Innovation & Development	Transit Economic Requirements Model	\$2,000,000
<b>Total</b>		<b>\$94,244,249</b>

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

**Grantee:** Transit agencies; project teams comprising transit agencies, systems experts, and bus manufacturers (see Table 9)

**Project Description:**

FTA's LoNo Program deploys the latest new technology in U.S.-made transit buses. The program targets bus models largely proven in testing and demonstrations but not yet widely deployed in transit fleets. The program lowers costs and improves the performance and availability of new-technology buses. It also increases private investment in cutting-edge U.S. transit bus development and increases the number of job opportunities in bus design, manufacturing, and operations. The LoNo Program provides funding for transit agencies for capital acquisitions and leases of next generation transit buses, including acquisition, construction, and leasing of required supporting facilities such as recharging, refueling, and maintenance facilities. This program is resulting in lower cost and increased availability of more energy efficient buses, more private investment in transit bus development, and new jobs in U.S. transit bus design and manufacturing. 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. It also results in lower cost, improved quality, and increased availability of more efficient buses.

**Outputs:**

Currently, all 17 projects are active or in development; the following are examples of outputs with significant results:

- The market for new technology buses is expanding because of the LoNo Program. Since program inception in FY 2013, the total number of new technology buses on order or in service has jumped from approximately 100 to more than 800.
- Data collection is underway at sites that are expanding their electric bus fleets using LoNo program funds. Preliminary reports on electric bus operations in King County, WA, and are available at <https://www.nrel.gov/docs/fy17osti/68412.pdf>.
- The LoNo program put 17 series electric hybrid buses in service at the Red Rose Transit Agency in Lancaster, Pennsylvania. The number of vehicles and the amount of local share represent a strong local interest in LoNo technologies by transit operators.

**Outcomes/Impacts:**

FTA has made significant progress in assisting the transit industry in considering new technology buses for transit service. This program is also assisting most

transit bus manufacturers that are offering or considering electric bus models. The impact of the program is a significant change in the market in the availability of lower cost, improved quality, and more efficient buses.

**Project/Program Evaluation:**

This program requires an independent evaluation, which began under a separately funded effort being conducted by National Renewable Energy Laboratory. Individual project evaluation is in process, and the results will be presented to FTA one year after the initial deployment of the vehicles.

**FTA Funding: \$76,969,249**

**Table 9** *LoNo Projects Receiving Assistance from FTA, FY 2017*

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
Five battery electric buses	Transit Authority of River City	Louisville, KY	\$3,321,250
Five battery electric buses	San Joaquin Regional Transit District	Stockton, CA	\$4,702,011
Five battery electric buses	The Duluth Transit Authority	Duluth, MN	\$6,343,890
Seven battery-electric buses	Dallas Area Rapid Transit Authority	Dallas, TX	\$7,637,111
Five 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
Deploy five 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
Deploy five battery-electric buses	Alameda-Contra Costa Transit District Commission	Oakland, CA	\$1,551,611
Deploy three additional buses to SARTA's fleet of fuel cell electric buses	Stark Area Regional Transit Authority	Canton, OH	\$4,015,174
Deploy 25 battery-electric buses	Southeastern Pennsylvania Transportation Authority (SEPTA)	Philadelphia, PA	\$2,585,075
Deploy five battery-electric buses	Utah Transit Authority	Salt Lake City, UT	\$5,427,100
Deploy eight additional buses to King County's fleet of battery-electric buses	King County Metro	Seattle, WA	\$3,336,040
<b>Total</b>			<b>\$76,969,249</b>



**Figure 7**  
Example of Impact of  
LoNo Program

The Transit Authority of River City (TARC) provides public transportation in the Greater Louisville, Kentucky, area with bus routes in Jefferson, Bullitt, and Oldham counties in Kentucky and Clark and Floyd counties in Indiana. As a result of the LoNo Program, over the past year, TARC has received five battery electric buses from Proterra. With the new buses, TARC has a total of 15 all-electric buses on the road, making it one of the largest electric bus operators in the country.



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

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

**Project Description:**

The purpose of the Low or No Emission Component Assessment Program (LoNo-CAP), established by Section 5312 (h) of the [FAST Act](#), is to establish facilities at institutions of higher education for the testing, assessment, and certification of low and no emission components on public transportation buses sold in the U.S. The program provides financial assistance annually to OSU and Auburn to develop component tests, set up facilities, and complete assessment tests by collaborating with member organizations who bring unique knowledge, skills, and capabilities to the program. The major goals of the projects are to conduct assessment test of LoNo components submitted voluntarily for testing by the component manufacturers and to provide data and assessment reports for each test. The benefits, coupled with the industry benchmarking, practice, and reports, will bring increased capabilities and efficiency for manufacturers to build low or no emission transit components. Transit agencies benefit by being able to deploy bus fleets that have competitively priced, advanced energy-efficient components.

**Outputs:**

The LoNo-CAP program will provide detailed results and data after the component tests, including the following outputs:

- Component Assessment Report, due to FTA quarterly in 2018.
- Annual Assessment Report, due in December 2018; will be available on FTA's website once completed.

**Outcomes/Impacts:**

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:**

This project is a demonstration of innovative track asset management practices by using an autonomous track inspection system (ATIS). 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 was introduced and used on passenger and freight railroads for several years. The major goals of this project are to demonstrate the transferability of an ATIS system to transit, demonstrate its effectiveness compared to existing transit track management practices (track inspection, data analysis, data management and maintenance), and evaluate the return on investment of the system at MARTA. The benefits of such inspection technologies, coupled with the asset management practices, will bring significant capabilities for transit agencies to continuously and autonomously monitor, assess, and trend the track conditions to perform condition-based asset management in revenue service. The transit industry benefits by replicating and deploying similar systems to improve safety and maintenance of the track infrastructure.

**Outputs:**

MARTA will select a technology vendor and independent evaluator to assist with the project. The project will provide the following outputs:

- Evaluation and Assessment Report, Phase I, August 2019
- Evaluation and Assessment Final Report, Phases I and II, August 2021; report will be available on FTA's website once completed.

**Outcomes/Impacts:**

Successful development of ATIS will demonstrate a cost-efficient and safe technology that can be easily replicated and adopted by any transit system. This project will be the first deployment of this technology on a transit system in the U.S. and enable track workers to realize track anomalies in a real-time environment, resulting in a timelier response, which will increase the safety of

the overall system. The long-term impact of this project will be the widespread use of this autonomous technology with track inspection, computer vision, and data analytics to enable predictive maintenance practice for improved overall track safety and cost savings with both rail vehicle and track maintenance efforts.

**Project/Program Evaluation:**

The program requires an independent and continuous evaluation during the project performance period. The Transportation Technology Center, Inc., will conduct the independent evaluation and submit an 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:** Price Waterhouse Coopers (PWC)

**Project Description:**

This project assesses transit cost estimates versus bid pricing for the period of 1995–2015. This research seeks to uncover cost factors affecting project budgets. Federal funding for transit capital projects is based on cost estimates provided by project sponsors and is reviewed by FTA. Accurate estimating is required to reliably establish baseline budgets for these Federal grants. Anecdotal evidence shows that overall economic conditions or patterns of project conditions may affect the ability of cost estimators to accurately forecast project costs. The discovery of indicators and recommendations for rational adjustments throughout economic cycles or under certain project conditions will produce more accurate estimates.

**Outputs:**

A key result is the comprehensive review of new and existing literature on managing capital costs through an examination of construction bids and cost estimates.

**Outcomes/Impacts:**

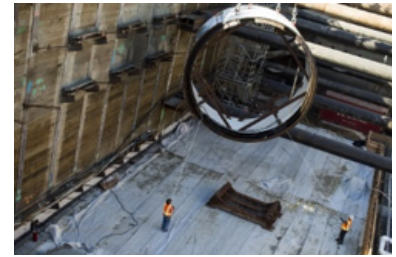
This project is in the beginning phase, and outcomes are in development. The project will improve cost estimating in the transit industry.

**FTA Funding: \$200,000**

**Figure 8**

*Capital Cost  
Forecasting Study and  
Research*

Capital costs need to be considered using overall lifecycle costs, including energy, operations, and maintenance and replacement cycle. Agencies need to conduct lifecycle cost analysis as part of their decision-making process; ideally, this would include review of asset lifecycle data and incorporation of forecast lifecycle costs into transit expansion plans.



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

**Grantee:** Volpe National Transportation Systems Center

**Project Description:**

This project identifies best practices in lifecycle management applicable to public transportation. This project is critical because continued increases in actual capital cost versus budgeted costs are not consistent, which creates sizable 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.

**Outputs:**

Activities under this project include reviewing the literature regarding methods used by public capital institution managers in other industries, especially airline and railroad, to effectively address and resolve reliability, supportability, maintainability, and sustainability challenges throughout capital project development. Additional activities conduct original research and benchmarking in the U.S. and internationally. This research provides industry current best practice processes and procedures regarding lifecycle management throughout all phases of a project. It begins with concept definition and continuing through design, engineering construction, fielding, and sustainment. Expected final products and delivery dates include:

- Final report documenting research data, analysis, findings, and recommendations for next steps, due May 2018.
- Examination of analytical tools and processes that use data-driven benefit cost analysis to prioritize projects and evaluate alternatives for expansion versus maintenance.

- Examination of Transit Asset Management and other FTA policies and initiatives such as the role of the discretionary grant programs on asset management.
- Showcase of effective practices from transit and other industries—for example, how bringing maintenance staff into procurement and project planning impacts long-term effectiveness of transit assets.

Once all deliverables are completed, a final report with recommendations will be provided to FTA.

### **Impacts/Outcomes:**

To date, FTA has determined what analytical tools and processes significantly aid in extending the life of transit assets. FTA discovered effective practices from transit and other industries, specifically in other countries that maintain transit facilities, and determined the impact of specific FTA policies and initiatives. Effective practices relate to maintaining assets, particularly improvements in contracting and procurement, cross-agency teaming, standards and requirements development, management processes, and procedures and tools. The impact of this project is the gradual reduction of transit lifecycle costs for the operations and maintenance of transit systems, which will result in additional long-term savings.

### **FTA Funding: \$200,000**

#### **Title:** *Next Generation Transit Vehicle Research*

**Grantee:** Non-profit organizations leading industry consortia

#### **Project Description:**

This research program supports the research, development, and deployment of electric drive and other next-generation propulsion technology for transit buses. This includes developing integration and fleet deployment tools, modeling electricity requirements, investigating reducing costs and increasing component durability, and supporting the validation of more standardized bus charging systems. FTA currently supports more than \$100 million in existing bus technology demonstration and deployment projects through various programs such as the National Fuel Cell Bus Program and the LoNo Emission Vehicle Deployment Program. The collective outcomes resulting from this effort will enable FTA to make informed decisions concerning future research needs and priorities related to advanced propulsion bus technology and applications. The research will also enable transit agencies to make informed procurement and operational decisions, including whether, when, and how to invest in bus fleet and subsequent deployment strategies, ultimately benefiting the traveling public and communities across the nation.

**Outputs:**

FTA is in the process of selecting the recipients for this program. Research performance indicators include the number of electric drive and advanced propulsion vehicles manufactured in the U.S. and the number of transit agencies considering the benefits and risks of electric drive and other new technology vehicles for transit fleet operations. Expected final products and delivery dates include:

- Documentation of status and forecasted changes in commercially viable next-generation bus technology.
- Research or evaluation reports on advanced bus technology components.
- Studies and analyses of topics relevant to energy efficiency and bus technology.
- Technical and strategic planning-related assignments as requested.

**Outcomes/Impacts:**

Transit agencies make decisions about whether to pursue electric-drive fleets based on data about vehicle and fleet costs and performance. The impact of this research is that transit agencies can make well-informed decisions about the costs and benefits of acquiring electric-drive transit vehicle fleets.

**FTA Funding: \$2,750,000****Title: *Bus Propulsion Evaluation and Support***

**Grantee:** National Renewable Energy Laboratory (NREL)

**Project Description:**

This project supports FTA's energy efficiency research by providing expert technical analysis and assessment of demonstration projects. It continues the work begun under the Fuel Cell Bus Evaluation and Support Project and expands it to include evaluations of advanced technology propulsion projects awarded under prior FTA and U.S. DOT programs. Through an interagency agreement with the U.S. Department of Energy's (DOE) NREL to support evaluation of new technology buses, the project developed lessons learned to aid other transit agencies in using this technology in their operations. The evaluation also provides input to help with commercialization of advanced technology buses.

**Outputs:**

Significant results under this project include:

- A preliminary document about King County Metro (KCM) Battery Electric Bus Demonstration project, available in May 2017; data are being collected 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. Findings of the evaluation can be accessed at <https://www.nrel.gov/docs/fy17osti/68412.pdf>.
- An American Fuel Cell Project evaluation report that summarizes the demonstration of American built fuel cell electric buses operating in the Coachella Valley (CA) area, available at <https://www.nrel.gov/docs/fy17osti/67209.pdf>.

### Outcomes/Impacts:

FTA has made a significant effort toward sharing information about the performance of new-technology buses. Transit agencies, vendors, and other industry stakeholders are using the data developed under this effort to make decisions about the suitability of new bus technology. FTA and NREL are collaborating to evaluate the buses in revenue service and comparing advanced propulsion bus technology performance to that of conventional technology tracking progress over time toward meeting the technical targets set by DOE and FTA.

**FTA Funding: \$1,400,000**

### Figure 9

*Example of  
NREL Study*

FTA is collaborating with NREL in evaluating buses in revenue service and comparing zero-emission bus technology performance to that of conventional technology and tracking progress over time toward meeting the technical targets

set by DOE and FTA. Recently-published preliminary results of the evaluation were conducted in King County (WA), for which data were collected on a sample of three buses from the standard diesel fleet for baseline comparison to the three-bus battery electric bus (BEB) fleet. The findings of the evaluation can be accessed at <https://www.nrel.gov/docs/fy17osti/68412.pdf>.



**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:**

BEERD promotes the development and demonstration of targeted energy efficiency-enhancing technologies—specifically, enhanced electrification of accessories and improvements in thermal management of bus bodies—for buses used in public transportation. In addition to reducing costs from energy use by transit buses, projects funded can have favorable impacts for the riding public and public transportation operators. These results lead to enhanced competitiveness for the American bus industry and its supplier base. Table 10 shows the BEERD projects funded by FTA.

**Outputs:**

This project led to the development of a thermoelectric generator (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 Reduced Engine Idle Load (REIL) system that enables 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. Outputs of the BEERD Program include:

- In October 2017, the system operated on a composite duty cycle based on more than 2,600 miles of real-world driving data collected earlier in the project.
- By the end of 2018, the results of these tests will be summarized and reported, and a REIL market evaluation and trade study will be delivered.
- 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.
- Beltless alternators were retrofitted to at least 27 of the planned 41 existing diesel hybrid-electric buses and are being demonstrated in revenue transit service.



Testing and delivery of the prototype system to the transit partner were completed in December 2017 and will be followed by installation on a transit bus and demonstration in FY 2018.

**Outcomes/Impacts:**

The BEERD program supports 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 such as 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 under BEERD includes a built-in fully-funded independent evaluation activity by a contractor or university.

**FTA Funding: \$3,000,000**

**Table 10**  
*BEERD Projects  
Receiving Assistance  
from FTA during  
FY 2017*

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	Center for Transportation and the Environment (CTE)	Atlanta, GA	\$1,274,936
UTA Paratransit Accessory Electrification	Center for Transportation and the Environment (CTE)	Atlanta, GA	\$697,185
Hybrid Beltless Alternator Retrofit	Maryland Transit Administration (MTA)	Baltimore, MD	\$495,621
<b>Total</b>			<b>\$3,000,000</b>

**Figure 10**

*Impact on Paratransit Services by BEERD Program*

Paratransit buses spend as much as 25% of their time idling, much of which occurs while dropping off, waiting for, and picking up passengers, often in areas that are sensitive to pollution and noise, such as hospitals and senior centers. The Center for Transportation and the Environment is teaming with the Utah Transit Authority, the University of Texas at Austin Center for Electromechanics, Mobile Climate Control, and Trans World Associates to develop and demonstrate technologies to electrify the heating, ventilation, and air conditioning (HVAC), lights, ADA ramp, and other accessories on two paratransit buses. This system will let the bus operator shut down the engine when the bus is loading, waiting for, or unloading passengers while keeping the cabin comfortable and operating the lights and ramp for up to 30 minutes. The system significantly reduces operating costs, fuel consumption, exhaust, and noise impacts. The goal is to develop a “kit” for both installations on new paratransit buses and retrofits on existing buses.

**Title:** *U.S.–China Race to Zero*

**Grantee:** CALSTART, Inc.

**Project Description:**

This project supports U.S.-China Race to Zero Emissions (R2ZE) project. The R2ZE encourages the incorporation of advanced zero emission buses into fleets and onto streets in the U.S. and China.

**Outputs:**

During FY 2017, the project accomplished the following:

- Potential categories for participating fleets and non-fleets were identified, analyzed, created, and announced on the website at <https://www.transportation.gov/r2ze>.
- Preliminary work on additional outreach imagery for the website was initiated.
- An outreach campaign to organizations and communities that participated in a webinar.
- An outline and draft language for a Wikipedia page was developed.

**Outcomes/Impacts:**

The R2ZE initiative provides a framework for cooperation between the U.S. and China. R2ZE has accelerated commercialization of zero emission buses and

related technologies and focused national attention on advanced technology in transit.

**FTA Funding: \$500,000**

**Title:** *Transit Economic Requirements Model*

**Grantee:** Booz Allen Hamilton, Inc.

**Project Description:**

This project is to maintain, enhance, and run the Transit Economic Requirements Model (TERM) tool, which forecasts transit capital needs over a 20-year period under various distinct investment scenarios and produces the transit portion of the statutorily required Conditions and Performance (C&P) Report to Congress based on its data output. 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 public transportation capital investment needs over the next 20 years. This project also provides support to TERM users by conducting training, providing a help desk, and other related needs. The information provided by FTA is combined with information from FHWA for the final biannual report that includes future capital investment needs of U.S. 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)). A compiled final report, including highways, freight, and transit, will be completed by FHWA once the information from this project is received. The C&P report is intended to provide decision-makers with an objective appraisal of the physical conditions, operational performances, and financing mechanisms of highways, bridges, and transit systems based both on the current state of these systems and their projected future state under a set of alternative future investment scenarios. The report will offer 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.

**Outputs:**

This project:

- Conducted asset decay curve analysis through the TERM model, which is used to calculate the state of good repair for national transit assets.
- Held regular phone calls and in-person meetings with FTA staff and responded to questions and comments based on FTA review, resulting in updates of text and exhibits for the next C&P Report to Congress.
- Provided help desk and technical assistance to TERM-Lite users.

These outputs assist with the maintenance, data management, and enhancements of the modeling capabilities of TERM.

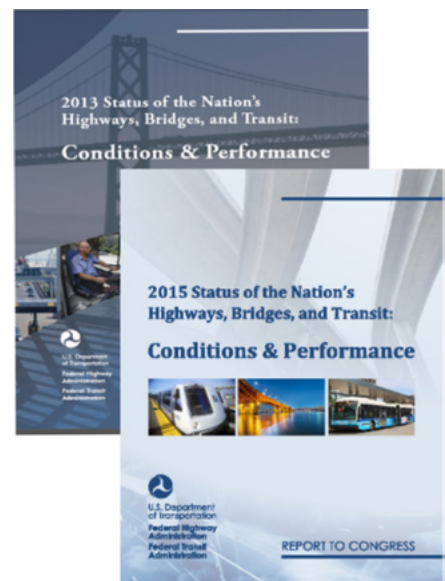
**Outcomes/Impacts:**

The C&P report is produced biannually through a joint effort of FTA and FHWA. The 2017 report is expected to be sent to Congress in 2018 and will be available on the U.S. DOT website.

**FTA Funding: \$2,000,000**

**Figure 11**  
*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. The next report, currently under development and expected to be sent to Congress in 2018, will be available on the U.S. DOT website.



## Supporting Programs and Other Initiatives

**Description:**

FTA has programs and projects to address cross-cutting issues associated with the three research priorities—Safety, Infrastructure, and Mobility Innovation—and 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.

**Outcome/Impact:**

These projects evaluate the effectiveness of research programs and support research to enable the public transit industry to improve operations, safety, asset management, leverage asset innovation, and enhance mobility. Overall, they ensure that research advances public transportation innovation.

**List of Projects:**

FTA had four supporting programs and initiatives active in FY 2017, as shown in Table II.

**Table 11** *Supporting Programs and Initiatives Receiving Assistance from FTA, FY 2017*

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 Research (SBIR) Program	\$3,439,460
<b>Total</b>		<b>\$10,129,152</b>

**Title:** *Information Dissemination and Evaluation Program*

**Grantee:** University of South Florida 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, Section 508-compliant, downloadable versions of FTA final reports that are available to the public through FTA's website. This results in the prompt dissemination of FTA research information in clear, concise, and consistent formats.

The evaluation component of the project helps FTA in the development of a new Five-Year Research Strategic Plan, conducts a comprehensive evaluation of the U.S. DOT–FTA-funded Rides to Wellness (R2W) Demonstration Grants Program, and is creating a multi-tiered evaluation framework to assess results and outcomes of FTA's research program at the project, portfolio, and program levels. The development of the evaluation framework draws upon the research priorities, goals, and objectives defined during the strategic planning process and from lessons learned during the R2W pilot evaluation.

### **Outputs**

Examples of outputs for the dissemination component of the project over FY 2017 include:

- Edited, designed, and made 508-compliant 21 FTA reports, research reports, and reports to Congress, with an additional 10 reports in progress; specially designed three reports for printing. All FTA reports completed under this program can be accessed at <https://www.transit.dot.gov/research-innovation/fta-reports-and-publications>.
- Designed custom graphics and signature imagery to create consistent branding across FTA's various offices, website, products, and materials.

Outputs over the past fiscal year included:

- Conducted webinars and evaluation interviews with the 19 R2W grantees from May to July 2017, 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 R2W program through the duration of the project, until September 30, 2018.
- Began development of a tiered evaluation framework to assess research results and outcomes at the project, portfolio, and program levels; expected to be complete by September 2018.

### **Outcomes/Impacts:**

The materials produced under this program ensure that all web-based materials are 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. In addition, by creating an evaluation framework, FTA meets its statutory

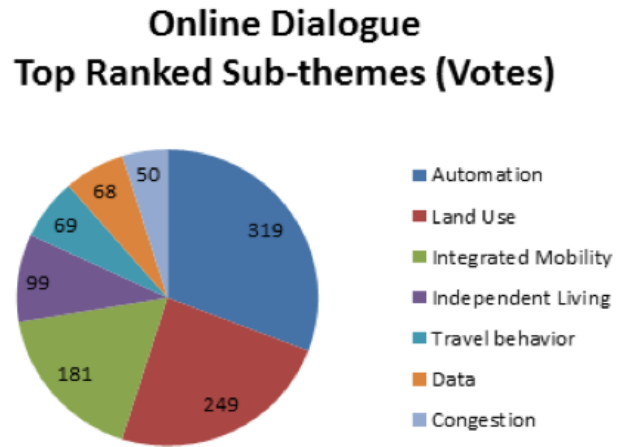
requirement, ensuring that its investment priorities and funding decisions are made strategically, i.e., guided by the research strategic plan.

**FTA Funding: \$1,439,692**

**Figure 12**

*Example of Data Analyzed Under Information Dissemination Program*

FTA conducted a five-year Research Strategic Plan national online dialogue, a social networking application that allows 24/7 online input, and used it to engage the public in a transparent manner to ensure that FTA’s research program is relevant, useful, and accountable to its stakeholders. The online dialogue was a dynamic conversation that resulted in extensive feedback on several questions that FTA posed as well as fresh ideas from participants. Over the course of five weeks, 462 participants suggested 131 research ideas, which they ranked through votes and refined with more than 1,000 comments. CUTR then analyzed the information from the online dialogue and provided a summary on the results and recommendations that were used in the FTA Research Strategic Plan 2017–2020.



**Title: Workforce Development Program Evaluation and Dissemination**

Grantee: Axiom Corporation

**Project Description:**

FTA awarded about \$20 million for the development of successful Workforce Development models and programs. This project conducts evaluations for FTA’s Workforce Development projects and assists with developing materials for the dissemination of successful workforce models. The evaluations are determining if the individual projects met the deliverables and goals set for each activity as well as the grantee’s ability to level investments of strategic partners. The project will showcase innovative methods of youth outreach and will determine 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.

**Outputs:**

This project enables FTA to showcase through one mechanism replicable models and lessons learned from the three unique Workforce Development competitions. Outputs for this project include the following:

- Completed evaluation of workforce projects submitted to FTA.
- Conducted meetings with industry partners in June 2017 to gain input into the Workforce Strategic Plan's goals and objectives.
- Developed a dissemination mechanism for providing outreach to industry partners in June 2017.

Axiom finished the evaluation of the 2012 workforce projects and provided a report to FTA in December 2017. FTA is reviewing the report and will post it on FTA's website by July 2018.

**Outcomes/Impacts:**

This project enables FTA to gain a return on its \$20 million investment in more than 40 Workforce Development projects. Such an evaluation will enable FTA to showcase and deliver models to stakeholders and industry partners.

**FTA Funding: \$250,000**

**Title: *Transit Cooperative Research Program (TCRP)***

**Grantee:** National Academies of Sciences

**Project Description:**

TCRP is a statutory program consisting of a cooperative agreement with the National Academies of Sciences in partnership with the American Public Transportation Association (APTA) and an independent TCRP Oversight and Project Selection (TOPS) committee to carry out research activities in public transportation. TCRP selects research projects recommended by an independent governing board of public transportation stakeholders. Its mission is to promote, select, and conduct research and disseminate research findings to improve the practice and performance of public transportation. Its governing board plays a critical role in suggesting public transportation research, development, and technology transfer activities that further the effectiveness, efficiency, and quality of public transportation. TCRP communicates FTA's strategic research goals to its audiences, helping to further extend FTA's reach.

TCRP's cooperative nature is reflected in the development of research panels comprising practitioner experts that are assigned to each project and help select projects 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. TCRP identifies needs and shares ideas and best practices to improve public transportation in communities across the country and is a vital partner to FTA, its sole sponsor, in fielding practical short-term research that directly benefits public transit practitioners.

### **Outputs:**

Most TCRP studies extend beyond a 12-month period. TCRP staff currently manage a portfolio of approximately 52 active projects that extend across multiple fiscal years. A total of 398 individuals from public, private, and non-profit transit-related organizations serve as expert practitioners on panels that guide these research efforts. Each active project also includes an FTA Liaison to support coordination and information-sharing. Following are significant results of the TCRP program:

- Released an Annual Report of Progress in December 2016, which highlights the year's major accomplishments and activities; it can be accessed at <http://onlinepubs.trb.org/onlinepubs/tcrp/TCRPAAnnual2016.pdf>.
- Completed 14 publications, including 4 research reports, 6 synthesis reports, 1 results digest, and 2 legal digests; all are available at <http://www.trb.org/Publications/PubsTCRPPublications.aspx>.
- Updated its Strategic Plan for Dissemination for 2017–2019, integrated the APTA Resource Library on the APTA website, and consolidated report downloads to the National Academies Press website to enable better collection and analysis of information on downloads.
- 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, an increase from 43 research problem statement submissions in FY 2016.
- In FY 2017, TCRP research reached thousands of practitioners through various dissemination efforts. TCRP enhanced partner coordination, as outlined in the Strategic Plan for Dissemination, with higher webinar attendance. Examples of this high attendance include: (1) 889 people participated in Innovative Financing for Public Transportation: Value Capture and Small- and Medium-size PPPs (hosted by TRB on June 7, 2017); and (2) 516 people registered for the Decision-Making Toolbox to Plan and Manage Park-and-Ride Facilities for Public Transportation: Guidebook on Planning and Managing Park-and-Ride (hosted by TRB on September 19, 2017).

**Outcomes/Impacts:**

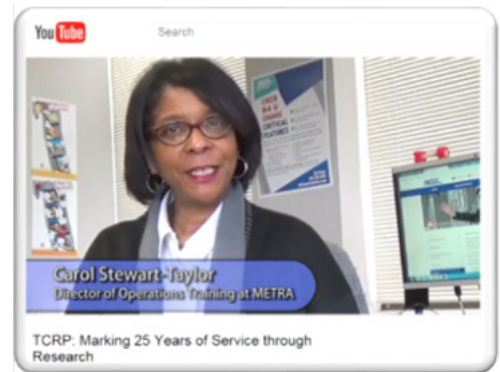
With \$5 million authorized and appropriated annually, TCRP supported the public transportation industry and community through conferences, webinars, and project panels, maintaining a high level of public transportation industry and stakeholder engagement. The program selected high-priority research 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 provide important resources to public transit agencies to improve operations and service.

**FTA Funding: \$5,000,000**

**Figure 13**

*Transit  
Cooperative  
Research Program  
(TCRP) Video*

The statutory TCRP was established more than 25 years ago, through a cooperative agreement between FTA and the Transportation Research Board in partnership with the American Public Transportation Association and an independent project selection committee. TCRP serves the transportation industry and the U.S. by soliciting, selecting, conducting, and disseminating research to improve public transportation. To commemorate the first 25 years, TCRP has a video that highlights the excellent research generated out of the program that the public transportation industry is putting to use. <https://www.youtube.com/watch?v=kyze8swWcIA&feature=youtu.be>

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

**Grantee:** Volpe National Transportation Systems Center

**Project Description:**

Congress established the SBIR Program to stimulate technological innovation through the growth of small businesses to meet federal research and development needs. SBIR increases small business private sector commercialization of innovations derived from federal research and development objectives. U.S. DOT modes contribute at least 2.9% of their overall research budget to SBIR initiatives each year. FTA allocated more than \$1 million to the SBIR program in FY 2017. This funding supported a new SBIR project for \$640,000 and provided funding for Phase II following a successful Phase I for one of FTA's SBIR grantees. During FY 2017, FTA had more than \$3 million in active

SBIR projects. These SBIR projects enhance innovation and help grow small businesses in the U.S. transportation sector. The Volpe Center supports and oversees the overall U.S. DOT SBIR Program.

### **Outputs:**

All projects shown in Table 12 are active. Examples of outputs of selected SBIR projects currently in progress with significant results are:

- In FY 2017, Migma Systems worked on Phase II of its project, which includes developing a commercial product for transit vehicle passenger counting and re-identification under any condition via a small sensor with an embedded microprocessor that can be easily mounted inside a bus or train, aiming at passenger doors. It draws power from bus or train, counts passengers boarding and alighting, and re-identifies the same passenger who may board and alight at different bus stops or train stations. Sensors have built-in WiFi wireless communication capability. To transmit the passenger data to the transit data management center, bus drivers or train conductors can push a button for data transmission. All passenger data will be wirelessly streamed to the server and stored at transit data management center.
- Migma Systems is also working on a multi-pedestrian counting system using the fusion of a stereo camera and laser scanner, a commercial product for pedestrian counting at street intersections. The most recent system was installed in New York City with a counting accuracy of more than 95% at a busy intersection with 1,000 pedestrians during rush hours. When this product is fully developed, it can be installed anywhere and powered by solar energy. It will also have the capability to send messages to bus drivers for pedestrian-bus collision warning. The system can count the level of jaywalking pedestrians to see where further improvement of pedestrian safety is needed, interface with all major traffic controllers, and provide dynamic pedestrian timing for intelligent intersections.
- In 2017, Novateur Research Solutions made progress with Phase II of the Pedestrian and Cyclist Detection Devices for Transit Buses project. Accomplishments of Phase I of this effort include state-of-the-art sensors and collision avoidance technologies and identification of a combination of sensors and software technologies that overcome the limitations of the systems. In Phase II, the project will develop a robust and cost-effective pedestrian and cyclist detection and collision warning system for transit buses. The project will develop and demonstrate a working prototype of the sensor and software system for pedestrian and cyclist detection and a collision warning system for in-service transit buses.
- Mackinac Technology Company is working on Phase II of the Antireflective Coating for Transit Bus Windshields project, assisting transit buses operating at night that are required to maintain interior illumination whenever

passengers are onboard. This interior lighting reflects off the windshield and obscures the driver’s vision, creating a hazardous situation that has not been adequately addressed by industry suppliers. By using newly developed diamond-like materials, the Mackinac team has achieved unprecedented antireflection properties on windshield glass. The new coating reduces windshield reflection from about 8% down to 0.4%, which is a 95% improvement. This improvement will dramatically increase driver visibility and pedestrian safety.

**Outcomes/Impacts:**

Each grantee will submit a final project report upon project completion in Fall 2018 and Fall 2020. The final reports will describe the effectiveness of the proposed technology, method, and/or practice. In addition, successful Phase I grantees have the option to propose a Phase II project for funding. These projects will result in small business growth and technological innovation. The project is expected to drive new business development and growth of small business and solve problems in the transportation industry.

**FTA Funding: \$3,439,460**

**Table 12**

*SBIR Projects  
Receiving  
Assistance from  
FTA, FY 2017*

Project Title	Project Recipient	City and State	FTA Award
Crowding Information Collection and Dissemination System	ARCON Corporation	Waltham, MA	\$149,971
Pedestrian and Cyclist Detection Devices for Buses	Novateur	Sterling, VA,	\$749,994
Transit Safety	Mackinac Technology Co.	Grand Rapids, MI	\$749,496
Multi-pedestrian Counting System using Fusion of Stereo Camera and Laser Scanner	Migma Systems	Walpole, MA	\$749,999
FTA Interagency Agreement with the Volpe Center for New Phase I Project and Phase II Funding for the Migma Project	Volpe Center	Cambridge, MA	\$1,040,00
<b>Total</b>			<b>\$3,439,460</b>

**Figure 14**

*Example of Benefits from SBIR*

Based on statistics reported to the National Transit Database (NTD) for 2008–2010, buses accounted for an annual average of 3,172 collisions resulting in an average of 14,743 injuries and 80 fatalities. In 2010 alone, pedestrians (27) and cyclists (10) had the highest



number of fatalities in bus collisions. The safety of pedestrians and cyclists is an important part of transit vehicle-to-infrastructure (V2I) in which dedicated roadside devices can send pedestrian collision warning signals to bus drivers when pedestrians are in the crosswalk. Under the SBIR program, Migma Systems is developing an advanced pedestrian-bus collision avoidance system that, through wireless communication, continuously broadcasts information of pedestrian presence and the average volume of pedestrians.

## Acronyms and Abbreviations

ATTRI	Accessible Transportation Technology Research Initiative
BEERD	Bus Efficiency Enhancements Research and Demonstrations
CTE	Center for Transportation and the Environment
CUTR	Center for Urban Transportation Research at the University of South Florida
DBE	Disadvantaged Business Enterprise
DOE	Department of Energy
DOT	Department of Transportation
FAST	Fixing America’s Surface Transportation Act (Public Law 114-94)
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FY	Fiscal Year
GHG	Greenhouse Gases
HMD	Health and Medicine Division
HST	Human Service Transportation
ITS	Intelligent Transportation Systems
LoNo	Low or No Emission
MAP-21	Moving Ahead for Progress in the 21st Century Act, (Public Law 112 141)
MARTA	Metropolitan Atlanta Rapid Transit Authority
MOD	Mobility on Demand
MSAA	Mobility Services for All Americans
NAS	National Academies 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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*<https://www.transit.dot.gov/about/research-innovation>*