

**United States Department of Transportation  
Annual Modal Research Plans**

***Federal Transit Administration***

***7-18-2018***

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**Federal Transit Administration Modal Research Plan Executive Summary**

The Federal Transit Administration (FTA) is pleased to provide the Fiscal Year (FY) 2019 Annual Modal Research Plan (FTA-AMRP). The FTA AMRP describes FTA's mission and vision, and how FTA's research furthers Departmental, statutory, and modal goals. All funding levels noted are in alignment with the FY 2019 budget submission, and the U.S. Department of Transportation (DOT) requirement to utilize 3.2 % of discretionary research dollars for the small business innovation (SBIR) program. The FTA-AMRP discusses critical research programs, performance measures, cross-cutting issues, and the essential role of collaboration with both external and internal partners. As our Acting Administrator K. Jane Williams noted at a recent industry conference, "public transportation is a lifeline for many people." FTA's research programs and portfolio provide public transit agencies essential information to help them ensure efficiencies today and prepare for tomorrow.

***Mission, Vision, and Statutory Authority***

FTA's mission is to improve public transportation for America's communities, and FTA's vision is that the United States has a world-class public transportation system with access and mobility for all. This FTA-AMRP supports the innovation goals of Federal Public Transportation legislation; the strategic plan of DOT; and the strategic plan of FTA. Demographic, economic, and technological trends are converging to create both exciting possibilities and difficult challenges for the future of public transportation. Thus, FTA's research vision is that innovative technologies, projects, partnerships, and world-class infrastructure promote economic growth, productivity, safety, and improve quality of life in communities. FTA's research mission is to advance public transportation innovation by leading research, development, demonstration, deployment, evaluation, and implementation practices and technologies that enhance effectiveness, increase efficiency, expand quality, promote safety, and ultimately improve the transit rider's experience. The primary customers for FTA's research are transit agencies and their customers. FTA's research activities are designed to respond to issues facing public transit systems today while also laying a foundation for their transitions to the future. DOT's strategic goals of improving safety across the transportation system; investing in infrastructure; preparing for the future through innovation, and accountability to reduce regulatory burden are the bedrock for the FTA-AMRP.

FTA's research activities are authorized by Federal Public Transportation Law, Title 49 U.S.C. § 5312, which states that the Secretary of Transportation shall provide assistance for projects and activities to advance innovative public transportation research and development. The law specifies research focus areas, including providing more effective and efficient public transportation service; mobility management; system capacity; advanced vehicle design; asset maintenance; construction and project management; environment and energy efficiency; and safety improvements. 49 U.S.C. § 5312 further stipulates a series of research phases that form a pipeline process moving from early research of promising ideas to evaluation and implementation.

The four-phases of the research pipeline process are:

1. **Research** – developing and deploying new and innovative ideas, practices, and approaches.
2. **Innovation and Development** – improving public transportation systems nationwide to provide more efficient and effective delivery of public transportation services including through technology and technological capacity improvements.
3. **Demonstration and Deployment** – enabling early deployment and demonstration of innovation in public transportation that has broad applicability, including low or no emission vehicle deployment.
4. **Evaluation and Implementation** – analyzing project results and plans for broad-based implementation of research findings.

FTA's adherence to this four-phased research pipeline process helps to optimize the success of FTA's research program. Research is a discovery-based process where inquiry builds upon findings, thus it is essential to follow an iterative process that enables a 'fail fast' approach, and an ability to pivot research activities based upon real-world results. Therefore, FTA prioritizes research spending on demonstration and deployment activities – usually approximately 70% of available research funds – as this enables FTA to test promising research findings with public transit agencies. Finally, the evaluation of demonstration programs provides information on the results in support of dissemination activities to assist agencies to implement proven solutions.

### ***FTA Research Programs***

Based upon industry feedback and the DOT strategic plan, FTA will continue to focus on three broad research program areas: safety, infrastructure, and mobility innovation. Safety research seeks new processes and technology to improve public transportation safety for workers, riders, and the public. Infrastructure research activities conduct studies and demonstrations of new low and zero emission transit buses, facilities, and related charging and maintenance technologies developed and tested by the private sector (fuel cells, lithium ion batteries), but not yet been widely applied or adopted in the public transportation industry. Mobility innovation research is studying and assessing new public transportation service models that improve riders' access and experience of public transportation while also delivering operational efficiencies by leveraging both public and private assets and technology. Projects and activities associated with these program areas take into consideration research to practice; and cross-cutting issues. Key cross-cutting issues are: institutional governance and culture; policy; workforce; automation; data; and standards. Additionally, partnerships play a central role in determining the success of FTA's research activities. Three of FTA's research programs directly support DOT's Strategic Plan goals in the following ways:

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

Additionally, an important, statutorily required extramural research program is the Transit Cooperative Research Program (TCRP). TCRP was established through Federal public transportation law (49 U.S.C. § 5312(i)). It is administered through the Transportation Research Board (TRB) of the National Academy of Sciences. TCRP oversees the selection, development, and dissemination of research projects across a broad set of research topics based on the real needs of the public transportation industry. TCRP provides applied research with near-term, practical results addressing key challenges identified by the public transportation industry. Much of TCRP's research falls under the infrastructure goal. However, its research can span other areas – thus TCRP activities touch almost all DOT goals and objectives. FTA's overall research program yields positive impacts across multiple DOT goals, as reflected in Table 1:

Table 1. FTA Research Program Alignment to DOT Strategic Plan Goals

DOT Goals	Safety	Infrastructure	Innovation	Accountability*
<b>FTA Research Programs</b>				
Safety	✓			✓
Infrastructure		✓		✓
Mobility Innovation			✓	✓
TCRP		✓		✓

*\* FTA sees accountability as a cross-cutting goal. All projects in the three FTA Research Program areas explore issues of regulatory reform and mission efficiency.*

FTA's research programs also align with specific objectives within the DOT goals as shown in Table 2. Often, a program with a major focus in one strategic goal may directly and significantly contribute to an objective in another strategic goal. In addition, all FTA research programs support the strategic goal of accountability and its two objectives: regulatory reform and mission efficiency. Mission efficiency is furthered through strategies to improve program performance and create small business development opportunities. As an illustration of this, over the last year, FTA's research office held a series of trainings for staff and grant recipients to educate them on Federal processes. In FY 2018, FTA rolled out the new DOT public data access requirement. FTA's Small Business Innovation Program (SBIR), part of the larger DOT SBIR program, actively supports small business growth through the award of innovation grants. These grants assist small businesses to bring ideas to market that enhance their business and FTA's mission. Additional examples of DOT objectives relating to specific FTA research programs are discussed in each program section in this document.

Table 2. FTA Alignment with DOT Strategic Objectives

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

### Collaboration Efforts

FTA seeks input on its research activities with many stakeholders within the public transit industry, the private sector, and the public to help inform how the research program carries out its statutory direction. Broad public, private, and nonprofit partnerships leverage innovation. Thus, a significant component of FTA's research initiatives are internal and external collaborative partnerships. These partnerships are the major drivers for testing and implementing research findings. FTA internal partnerships include other

DOT modal administrations such as the Federal Highway Administration (FHWA), the Joint Program Office (JPO), the National Highway Traffic Safety Administration (NHTSA), and the Federal Motor Carrier Safety Administration (FMCSA).

Key external partnerships that assist FTA with research-to-practice include research institutions, training partners, private firms, non-profit partners, national transportation associations, university transportation centers, transit agencies, state agencies, technical assistance partners, and international partners. Public transit agencies may test innovative approaches to public transportation capital investments, operations, passenger mobility, and safety practices. Private sector partners are partnering with public transit agencies to field new models for integrated, seamless mobility. Bus manufacturers continue to innovate with new and improved propulsion technologies. Small businesses in the small business innovation research (SBIR) program are developing new safety methods to protect transit workers, and reduce bike/pedestrian injuries and fatalities. Non-profit, academic institutions, and quasi-governmental agencies lead independent evaluations and early research development projects.

Major public transportation associations like the American Public Transportation Association (APTA) partner with FTA's Research Program through their research committees. Conferences hosted by APTA, the Transportation Research Board (TRB), and the Community Transportation Association of America (CTAA) provide invaluable opportunities for the exchange of pertinent and recent developments in research projects. FTA works with the National Academies' TRB, the Volpe National Transportation Systems Center, and APTA to support various standards discussions. The National Academies aid with strategic planning and research prioritization by hosting the Transit Research Analysis Committee (TRAC). TRAC meets twice a year to provide feedback on FTA's research program through both informal exchanges during the meetings, and a formal letter report detailing the highlights of each of these meetings. TRAC meetings are public, and the letter reports are posted on the TRB website. FTA also engages subject matter and evaluation experts to assist with innovative deployment and demonstration program evaluation. Booz Allen Hamilton are evaluation partners with FTA's mobility on demand project. The National Renewable Energy Laboratory (NREL) provides evaluation and deployment research for FTA bus projects. The above noted partners are illustrative examples of the broad reach and stakeholder engagement of FTA's research programs.

### ***Economic Impacts, Regulatory Reform, Asset Recycling and Value Capture***

FTA's research programs (mobility innovation, safety and infrastructure) have significant potential to yield economic impacts, identify areas for regulatory reform, and provide opportunities for public/private shared investment through value capture. Mobility innovation is developing and deploying new public transit models with private industry. Infrastructure development research with low and no emission vehicles is enabling bus manufacturers to move into new markets. New safety innovations reduce injuries and fatalities for riders and workers while also helping small businesses grow. Demonstration grants in all three of these areas are assessing opportunities for regulatory reform and reducing barriers to economic growth. On the other hand, when there is a surplus of infrastructure resources, government and transit providers have the option of asset recycling as a mean to reduce costs. Asset recycling allows for the use of existing, publicly-owned infrastructure to be leased or sold to a private partner with the lease or sale revenues used to fund new projects. Private entities pay governments an up-front payment to lease existing public infrastructure or fixed assets. During this leasing period, the government retains ownership of the asset while the private entity maintains and operates the asset in exchange for the asset's revenues from user fees and taxes. The government then uses the lump-sum payment to fund infrastructure projects that could include critical public transit projects. Proceeds from these assets are typically invested in non-revenue generating assets which have difficulty obtaining funding such as public transit systems.

Additional detailed discussion regarding asset recycling is in the section on FTA's Infrastructure research program.

Value Capture fosters new ways of doing business to enhance communities and spur private sector growth. New public transit projects typically result in significant housing and retail development. Asset management may provide opportunities for partnerships with the private sector. Public transportation investment often raises real estate values and financial resources for reinvestment in corridors and entire regions.

FTA's research does not encompass improving the mobility of freight – public transportation moves people.

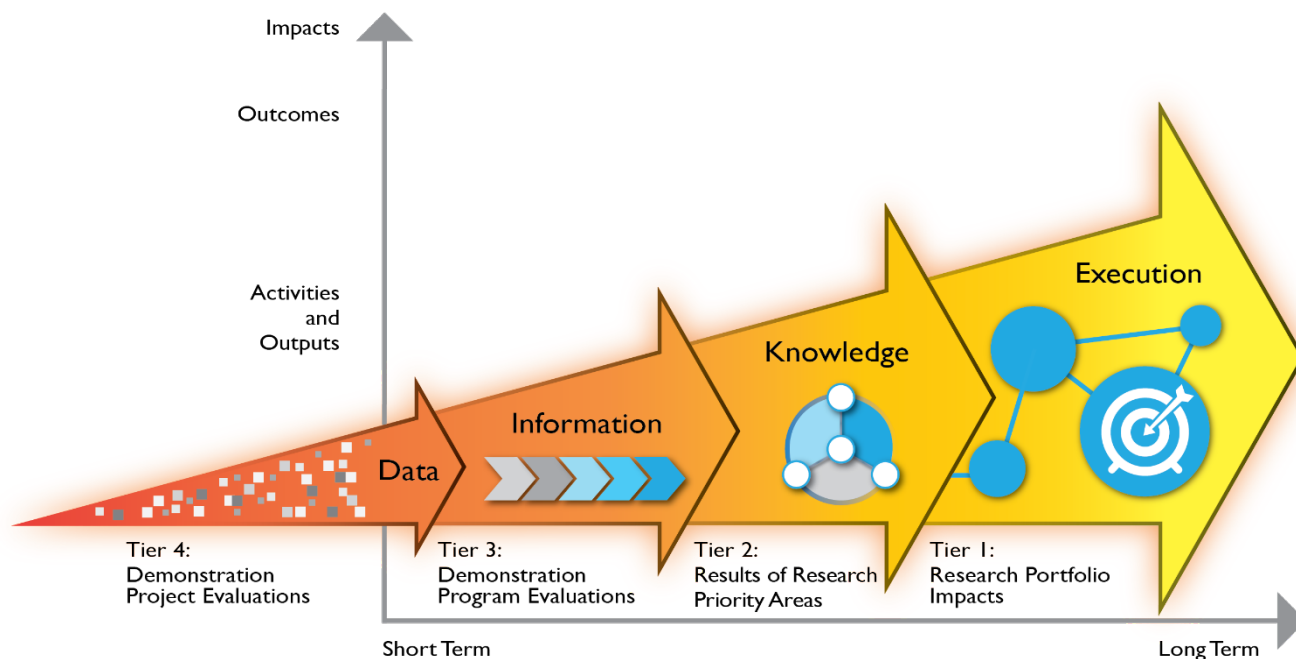
### ***Anticipated Outcomes and Assessing Results of FTA Research***

FTA intends to assess its research portfolio through a multi-tiered, nested research evaluation framework that builds upon the data of each of the three tiers of the framework (see **Figure 1. Nested Research Framework**). This framework is designed to comply with federal requirements for the evaluation of demonstration programs, and to evaluate FTA's entire research portfolio. At the highest level, FTA's research should advance public transportation innovation to solve issues facing the public transit industry. Examples of some of these issues are declining bus ridership; rail safety; worker safety; workforce shortages; challenges with accessible mobility; lack of public transportation infrastructure to meet the demand for services both geographically and hours of service; addressing the first and last mile access to transit services; reducing the lifecycle costs of buses; taking advantage of new bus technologies; fulfilling rider expectations of real-time information for rides; public and private sector data integration; and finding ways to leverage private sector resources to reduce costs and expand public transportation. FTA finalized this framework in March 2018 with the intention of applying it to FY 2018 research results. FTA is using FY 2017 research results to set key benchmarks for project performance measures. Anticipated outcomes for FTA's research programs revolve around the levels of efficiency, effectiveness, and quality achieved from research investments.

There are three major tiers of research evaluation in this framework: Tier 3, demonstration programs that must be evaluated under Federal public transportation law (49 U.S.C. § 5312); Tier 2, the three research programs which are FTA's research priority areas; and Tier 1, FTA's overall research portfolio. Under the Nested Research Evaluation Framework, the different tiers of research activity build upon the results of the previous tier in a step-wise process leading from demonstration outcomes to overall industry impacts. The Tier 3 demonstration program evaluations use data provided by individual demonstration project grantees to perform summative evaluations of overall program results. Evaluations assess demonstration program outcomes based upon demonstration project grantees' pre-determined performance measures; document new questions or research needs generated by the discovery process; and provide information for the statutorily required annual report to Congress. Tier 2 builds upon the results of the Tier 3 demonstration program evaluations to compare year over year results of FTA's research programs (Mobility Innovation, Infrastructure, and Safety) in terms of efficiency, effectiveness, and quality.

Finally, Tier 1 – the assessment of the overall FTA research portfolio - builds upon the Tier 2 evaluations to articulate the impact of FTA's research portfolio to find solutions to public transportation needs through public transit innovation. Because Tier 2 applies to FTA's entire research program, there is a strong focus on the importance of federal leadership to address issues and develop real-world solutions to public transit industry opportunities and problems. Additionally, a review of FTA's overall research portfolio also looks at the what is learned in this discovery-based research world where both expected and unexpected outcomes inform future decisions. Figure 1 provides a visual representation of FTA's multi-tiered, nested research evaluation framework.

**Figure 1. Nested Research Framework**



## Research to Practice

### *Communicating Research Outcomes through Research to Practice*

FTA develops and deploys new practices and technologies to support national transportation goals. An essential part of FTA's national leadership role through research to practice is to ensure that promising research findings and technologies benefit public transportation. Research to practice and technology transfer activities employ eight key models: Knowledge transfer through training; Industry diffusion; Operational testing and demonstration; Partnerships; Standards development; Formal dissemination; Communities of practice; and Social network marketing. Research reviews identify which research findings rise to the level of adoption. FTA's research team is beginning a new, quarterly deliberative process to target specific projects for lab to market campaigns.

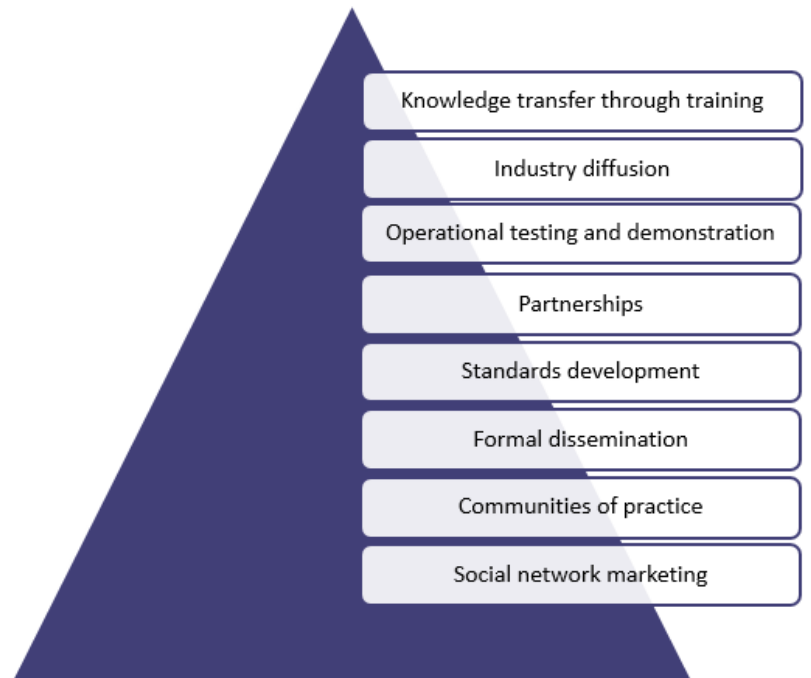
Currently, FTA has a number of research to practice partners supporting project level activities: The National Transit Institute (NTI), APTA, TRB, the Center for Urban Transportation Research (CUTR), U.S. Department of Energy NREL, and the Shared Use Mobility Center (SUMC).



FTA uses a variety of mechanisms to disseminate research results. Information about research findings are shared through speaking engagements at key industry events. FTA publishes research reports and posts them on FTA’s website. Social media venues such as the U.S. DOT Connections blog and posts on FTA’s Facebook and Twitter accounts announce new reports and resources. FTA conducts webinars both in-house and through partner organizations. FTA also introduced a new video in FY 2018 to communicate how its research program is “[Harnessing Innovation for Public Transportation](#)”.

The FTA Office of Congressional and Public Affairs maintains roughly 60 Gov Delivery subscriber lists with nearly 35,000 unique subscribers. The distribution list for “Research, Development, Demonstration, and Deployment,” has 12,164 subscribers - more than one-third of FTA’s overall subscribers. FTA is increasing the uniformity of its activities to conduct and monitor research to practice activities across various programs. This includes the standardization of ‘research to practice’ language for Notices of Funding Opportunity; metrics for inclusion in Statements of Work; and in regular reporting on research results.

**Figure 2. Eight Research to Practice Models**



### ***Cross-cutting Factors Affecting Research Outcomes***

Sometimes the biggest research challenges affecting outcomes are not the technical solutions, but cross-cutting factors. Just as important as the “what” of each project, is also the “how” a solution is implemented. Cross-cutting factors such as institutional governance and culture; policy; workforce/training; automation/technology; data, and standards exert a strong influence on the outcomes of FTA’s research. Below are short descriptions of each of these cross-cutting factors:

- **Institutional governance and culture** relates to elements both internal and external associated with successful adoption or implementation of research findings. Key questions could be, are there regulatory barriers or needs associated with a public transit area of inquiry? How should organizations institutionally prepare to utilize a promising research result? Are there human, societal, community, or other dynamics that affect the successful adoption of a new technology or solution? Human behavior elements must be studied for research into areas like transit automation. Issues such as rider readiness to adapt to using driverless vehicles are critical to assess. Additionally, transit worker willingness to adopt and accommodate new technologies and ways of doing business will affect the success or failure of new systems.
- **Workforce/Training** is needed to ensure a ready workforce with the skills to support new solutions and technologies. As business models change, public transit workforce requirements may need also need to change. However, the transformations in the industry, such as transit automation, is occurring at a time when many agencies continue to experience shortages in front-line workforce roles such as bus operators, call center specialists, and maintenance workers.



Additionally, transit systems integrating public and private assets require data integration and software application programming expertise. Skills with social media and web-based applications are also in high demand.

- **Policy** will continue to evolve as automation and other new service models are implemented. Thus, an important area of exploration is whether current policies are barriers or new policies are needed to address anticipated and unanticipated consequences.
- **Data** –Both transportation providers and travelers are embracing cloud-based software solutions, and public transit agencies are seeking ways to integrate both public and private data. Real-time data provided via smartphones help travelers make ride choices. System usage trend data can increase efficient service planning, and measure performance. Data from sensors are supporting transportation demand planning, scheduling, routing, and management. Private sector data can be integrated with public sector data to improve mobility, and systems efficiency. Additionally, data security issues abound. These changes in how public transit does business require a sound data/information management enterprise strategy and capability.
- **Automation and Technology** are bringing advances in service for public transit and transit customers, but with these emerging technologies are many complex, multi-faceted issues. One critical issue facing transit stakeholders, and the broader transportation planning community, is the impact of emerging technologies and new travel options on long-range planning and capital investment decision-making. As an example, communities across the country are planning for or evaluating major capital fixed-guideway public transit investments where future success in terms of ridership may be affected by the presence of alternative mobility options. Fixed-guideway commitments may have extensive economic life remaining when new travel options compete with them. Another area of transformation that carries many new challenges is technology that is enabling lower-cost travel options. More and more transit agencies are partnering with private transportation network companies like Uber and Lyft, and assessing options such as bikesharing, carsharing, and dynamic ridesharing to create a host of choices for riders. This mobility shift is altering traditional travel patterns, expectations, and preferences. Peoples' smartphones are ubiquitous tools - becoming their 24/7 window into mobility and accessibility irrespective of owning a car. Human factors may play a significant role in rolling out automation solutions both for riders and providers' workers. These and many other aspects of technology adoption must be assessed as new products and services ready their entry to the public transit marketplace.
- **Standards** review and development are often an integrated aspect of research programs, especially in the safety area. FTA's research portfolio includes significant investments to find whether new standards are needed – both voluntary and mandatory.

Some of these cross-cutting factors apply to all three research programs, and others are specific to only a few. Many people predict that we are in one of the most transformative times in the public transit industry, perhaps akin to the move from horse and buggies to cars. Cross-cutting factors play a major role in the success or failure of public transit to harness the benefits of these new ways of providing service in the new mobility paradigm.

### **Importance of Rural Public Transportation and the Importance of Increasing Research In this Area**

Rural public transportation systems serve communities outside of urban areas. Types of rural public transportation include demand-response public transportation (dial-a-ride), traditional and deviated fixed route services (e.g., shuttles, circulators), or vanpool. The need for rural public transportation has historically been linked with providing mobility and accessibility to essential employment, goods, and services for older adults, persons with disabilities, low-income persons, and others. In reviewing data

from 2000 to 2005, APTA found that nearly 9% of public transportation trips were for medical purposes in areas with populations less than 200,000. AARP emphasizes that “access to health care is a key purpose of local public transportation services and rural public transportation programs.” Rural public transportation services more broadly support well-being for rural residents by also providing transportation to employment, schools, places of worship, and social and recreational destinations. Access to public transportation in rural areas is limited by travel times and distances, frequency of service, cost, and limitations in funding to address these challenges. FTA’s rural transportation formula grant program (49 U.S.C. § 5311) enables states to fund a number of activities, including research; and it funds a national technical assistance center – the National Rural Transportation Center. States may use rural public transportation funds to support nonurbanized transit activities in four categories: training, technical assistance, research, and related support services. Typically, rural research tends to be locally funded and managed.

FTA’s current research priorities of mobility innovation, safety, and infrastructure support both urban and rural systems. Some public transit agency demonstration grantees are from rural areas. For FY 2019, FTA will increase focus on the unique aspects of rural communities in applicable projects. There may be many instances where implementation of promising findings should to be tailored for rural community use.

### **Five High Priority Research Projects for FY 2019**

FTA has five active, high-priority research projects planned for FY 2019 that illustrates how FTA’s research portfolio to further DOT strategic goals, meets statutory requirements, and provides value to the public transit industry. Some of the projects are new, while others are a continuation of areas that are reflective of the new DOT strategic goals. These five projects are:

1. Accessible Transportation Technologies Research Initiative (ATTRI)
2. Mobility on Demand (MOD)
3. Strategic Transit Automation Research (STAR new in FY 2018)
4. Safety Research Demonstrations (SRD)
5. Low and No Emission Component Assessment Program (LONO-CAP) – a new, statutorily required project.

Each project has a description of why FTA invests in the program; what other entities are researching the issues addressed by the project; what FTA has learned to date; objectives, activities, performance measures, and the problem being addressed by each project; how the projects align with DOT Strategic goals; the expected total project cost; anticipated funding for FY 2019; and any expected non-Federal financial contribution.

#### ***Accessible Transportation Technologies Research Initiative (ATTRI)***

The ATTRI project was developed to address the many accessibility challenges that still exist for people living with disabilities –an underserved community. Many positive changes have made public transit systems more accessible. However, even when public transit systems have all the required accessibility functionality, it is still difficult for people with disabilities to independently plan, and navigate a trip. People with disabilities face disproportionate barriers to mobility that results in unemployment, seclusion, and a lack of independence. The unemployment rate for people with disabilities is twice the rate for people who do not have a disability. Per the Bureau of Labor Statistics, in 2015, the unemployment rate for people disabilities was 11%, while the rate for those without a disability was 5%. Unemployment rates were higher for workers with disabilities than those without across all education levels. 29% of people with disabilities

indicate that transportation is a barrier to their employment. ATTRI research focuses on removing barriers to transportation for people with visual, hearing, cognitive, and mobility disabilities. Emerging technologies and creative service models funded by ATTRI will offer all Americans enhanced travel choices and accessibility. ATTRI is a partnership between government, the private sector, and academia to research, develop, and implement transformative technologies and solutions to allow people of all abilities to independently plan and accomplish travel. ATTRI also seeks to identify and advance policies and guidance that further accessibility.

ATTRI is a joint DOT initiative, co-led by FTA, FHWA, and the Intelligent Transportation Systems Joint Program Office (JPO). The program is supported by a range of interagency Federal partners including the Departments of Health and Human Services (DHHS), Labor (DOL), Defense, and others. As an example, one DHHS division, the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) is a key partner providing funding for the development of a robotics application. ATTRI also leverages innovators in the private and academic sectors, partnering to develop technologies that can fill technology gaps and become commercially viable.

In FY 2018, FTA supported an ATTRI-focused small business innovation notice of funding availability (NOFO) through a competitive solicitation that closed on March 20, 2018. FTA will select and fund up to three small business innovation projects at \$150,000/each to explore the use of virtual and augmented reality as way to help travelers with disabilities plan, and use transit options. Additionally, in previous years, FTA provided funding to support the ATTRI program. ATTRI conducted extensive research and outreach into the needs of the disability community to develop its focus areas. Findings in these outreach activities showed a need for tools to help people with disabilities overcome current barriers for a “Complete Trip.” A complete trip is defined as all aspects of planning, purchasing, navigating, and taking a multi-modal trip. Currently, prototypes are under development to assist people with disabilities in four areas - visual, hearing, cognitive, and mobility disabilities.

The potential economic benefit for reducing barriers and improving community inclusion for people with disabilities could be significant. U.S. Census data shows that approximately 12% of the US population lives with a disability, and of that 12%, 51% are of working age – between 18 and 64 which equates to about 20 million people. Even just a 1% improvement in the employment rate for people with disabilities of a working age, could yield an additional \$7 million in yearly aggregate wages using a low average wage of \$35,000/year. To date, FTA invested over \$2 million of the total \$9 million in ATTRI program expenses. Commitments from federal partners include over \$1 million from NIDILRR to advance robotics research. This shows that even such a modest investment has the potential to provide significant return on investment - a payback of less than one year for the FTA research investments.

ATTRI funded recipients are working on various solutions to support the concept of a ‘complete trip’ that encompasses:

- Wayfinding and Navigation applications that guide wheelchair users and people with visual impairments along routes using smart phone applications and other assistive technologies. Four different projects were awarded.
- A Pre-trip and Concierge application suite that supports pre-trip planning for individuals with cognitive disabilities.
- The Safe Intersection Crossing application that uses connected vehicle technology to connect pedestrians with the traffic signal system to improve the safety of intersection crossings and increase independent mobility.

Products in these areas are still primarily in academic laboratories. Some companies are complementing their traditional mobility devices with navigation aids. However, to date, there are few commercially available products that have had enough testing and validation – this is one of the major reasons for Federal investment in this area. In the future, FTA expects some manufacturers to take the findings of the research and build commercially viable and available products. Activities/Deliverables:

- Phase I: User Needs Assessment
- Phase II: Prototype and Testing of Candidate Technologies
- Phase III: Demonstration of Candidate Technologies in Transit Environment

Outputs (Performance Indicators)	Outcomes (Performance Goal)	Impact (Project Goal)
Number of technologies developed through ATTRI programs.	Increase mobility of ATTRI (and consequently all) populations by identifying at least 1 technology per functional area of focus that is ready for commercial development every 2 years.	Increase accessibility to transportation for people with different functional abilities (people with disabilities) through technological advances and new operational practices.

ATTRI supports the DOT’s strategic goal of innovation to “Lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation’s Transportation System” by ensuring the usability of the transportation system by Americans with disabilities. The specific objective areas are the development of innovation through research, coordination, and partnerships. It also supports the DOT strategic infrastructure goal of ensuring mobility and accessibility – the products developed because of ATTRI will help people with disabilities independently plan and navigate a complete trip. For FY 2019, FTA proposes to leverage ATTRI to advance its multimodal payment integration and mobility on demand research efforts. The exact amount of funding has not been determined. Depending upon what projects are selected for funding, there may be up to a 20% match of non-federal funds.

### ***Mobility on Demand (MOD)***

FTA’s mobility on demand (MOD) research seeks to help the public transportation industry address and benefit from emerging mobility models and technologies. New mobility concepts, technologies, and solutions - from traveler planning and payment applications to demand-responsive bus services and ride sharing service start-ups - are providing travelers with new transportation options. These new models may increase access to transportation for underserved communities in rural or suburban areas through first and last mile, and circulator services. Private sector feeder services are often critical for these communities to utilize public transportation resources. As an example, outside of many urban enclaves, reverse commute issues keep lower income workers from accessing good jobs in thriving corridors. With the rise of private sector transportation network companies like Uber and Lyft, there are greater transportation resources across a community –increasing mobility for everyone, including those who traditionally could not access public transportation resources. Many industry leaders feel that traditional public transportation services are changing to mobility services. These new service approaches are beginning to transform current business, funding and regulatory models. There is enormous potential for new forms of shared mobility, and real-time information on traveler choices derived from smartphones, to expand rider travel options and improve services by leveraging both public and private transportation investments. FTA’s MOD project explores the emergence of these models; how they are being implemented; and how communities

can take advantage of these new technologies and service models to expand travelers' mobility and reduce operational costs.

FTA coordinates the MOD project activities with other DOT research offices including FHWA, the JPO, and the Department of Energy (DOE). FTA also leverages significant private sector and local funding through the MOD project-level demonstration effort, the MOD Sandbox. Additionally, the transportation industry is driving other MOD related research through the Transportation Cooperative Research Program (TCRP) – a statutory program in 49 U.S.C. § 5312(i). Many academic institutions have active projects associated with MOD concepts, and there is significant collaboration with European countries like Sweden are implementing new public transportation mobility models. Recently, a delegation from Sweden presented a webinar on mobility as a service (MAAS). National nonprofits such as the Shared Use Mobility Center (SUMC), TransitCenter, ITS America, and Mobility Lab, among others, have active research activities associated with new public transportation mobility models. SUMC and Transit Center are cooperative agreement partners with FTA supporting various aspects of FTA MOD projects.

FTA funded MOD research is relatively new – it began with FY 2017 competitively selected demonstration projects. Many of these 'sandbox' projects are moving from the planning stage into execution. Funding to date for MOD is approximately \$9 million. Many MOD solutions build upon DOT's previous work in intelligent transportation systems (ITS); the mobility services for all Americans project; connected vehicle technologies; and some of the earlier breakthroughs in fare payment technologies.

The current sandbox projects are educating FTA and the public transportation industry on how to approach MOD-related policies. These innovative projects are uncovering promising technologies, and business models through both formal and informal means. Formally, independent evaluations provide invaluable information on results, and informally, a growing community of practice promotes peer to peer information exchange. Specific impacts to date in MOD include:

- Expanding options for communities and transit agencies to provide MOD-based transportation solutions.
- Enhancing transit capacity and readiness to adopt MOD solutions.
- Greater understanding of innovative business models that deliver high-quality, seamless and equitable mobility.
- Enabling FTA to adopt FTA policies on shared mobility that improve transit agencies' and communities' ability to implement these new service models.
- Supporting the deployment of traveler-centric, effective transportation systems that share the MOD guiding principles of system integration, and partnership-driven solutions that are innovative and equitable.

MOD project activities advance mobility by 1) exploring emerging technology solutions and new business approaches with the potential to transform mobility services; 2) at a systems level, enabling the transportation industry to deliver innovative mobility solutions that enhance transportation efficiency and effectiveness; and 3) at the user level, improving customer service, fostering personal mobility, and increasing access to goods and services. The overarching objective of MOD is to develop and facilitate the fast adoption of innovative technologies, partnerships, and practices to advance mobility for all. Major activities/deliverables/performance measures for MOD include:

- Conducting demonstration efforts through the Sandbox and evaluate the MOD deployments.



- Developing new performance metrics for MOD models to measure and understand the effectiveness of new mobility options as well as their impacts on both the transportation system and respective communities.
- Examining current policies and practices for MOD models to minimize barriers to innovation implementation.
- Engaging in Stakeholder Engagement, Knowledge Transfer, and Outreach activities to ensure research results are transferred to practice.
- Planning and providing technical assistance to transit agencies to incorporate new mobility options within the uniqueness of their communities.

<b>Outputs (Performance Indicators)</b>	<b>Outcomes (Performance Goal)</b>	<b>Impact (Project Goal)</b>
Number of public transit agencies collaborating with alternative shared mobility solutions through public/private partnerships to increase service coverage and hours.	Achieve greater personal mobility choices through 10% annual increase in number of public transit agencies that expand service coverage (geographic or temporal) by collaborating with alternative shared mobility solutions and public/private partnerships.	Enable transit agencies and communities to benefit from innovative business models, partnerships, and emerging technologies to implement integrated mobility solutions that are more efficient, equitable, accessible and effective to enhance the personal mobility of all travelers.
Operating expense per revenue mile for public transit agencies that expand service portfolios with new mobility solutions.	Each year, public transit agencies that adopt alternative mobility solutions into their portfolio of service provisions (e.g., fixed-route bus, light rail, demand response, etc.) achieve more efficient operations while supporting more traveler-centric mobility choices.	

The MOD program closely aligns with the DOT strategic goal to lead in the Development and Deployment of Innovative Practices and Technologies that Improve Safety and Performance of the Nation's Transportation System. Specifically, MOD projects are developing innovations by providing seed funding so communities can experiment with new approaches then report back to FTA so that the findings can inform other public transit agencies' activities. Development of innovation is also supporting the objectives of expanding partnerships and coordination between the public and private sector. Deployment of innovation is furthered by the growth of communities of practice; widespread stakeholder collaboration activities; and broad outreach to support technology integration and technology transfer.

MOD funding allocations for FY 2019 is expected to be in the range of \$8 million, and depending upon the type of MOD project, the non-Federal share of costs will typically be 20%.

### ***Strategic Transit Automation Research***

Vehicle automation is advancing rapidly in the light-duty vehicle market (i.e., personal passenger vehicles), and to some extent in the heavy-duty commercial vehicle market (i.e., trucks). Whereas automation is relatively mature in rail transit operations, this is not the case in bus transit. Transit agencies have expressed interest in automating some aspects of transit bus operations to improve mobility and



safety. The potential benefits of transit bus automation include avoiding collisions, lowering operational costs, improving service frequency and flexibility, and enabling new service models. However, transit agencies are 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. FTA's Strategic Transit Automation Research (STAR) program will investigate and address these factors. STAR is beginning with the formulation of a strategic plan. Initial research will explore specific needs then move toward field operational testing and, finally, evaluation. The intent is to identify promising products, processes, practices, and approaches to help transit agencies successfully implement transit bus automation.

The DOT Secretary's Office is leading the Department in developing and issuing multimodal policy vehicle automation guidance to the transportation industry. It is also coordinating research activities across DOT modes, especially: NHTSA, FHWA, FMCSA and the Intelligent Transportation Systems Joint Program Office (ITS JPO). Other modes such as FRA and MARAD are just commencing research programs or are in the process of increasing their research efforts. Also, TRB is fielding several automation research projects relating directly to transit. In the past, some universities have conducted transit bus automation research, such as the University of California Partners for Advanced Transportation Technology (PATH), Carnegie Mellon University, and CUTR.

FY 2018 is the first year for significant investment in transit automation with approximately \$950,000 allocated to date for projects. Funding for STAR projects in FY 2019 is expected to be a significant part of the \$12 million budget for mobility innovation research.

To date, the major product for FTA's automation research is the completion of a comprehensive Strategic Transit Automation Research (STAR) plan. The reason FTA decided to begin with the development of a stakeholder-driven, five-year Strategic Transit Automation Research Plan was to address the concerns of the public transit industry associated with adopting automated systems. As an example, in 2015, FTA and the ITS JPO sponsored a Vehicle Assist and Automation (VAA) successful proof-of-concept demonstration of bus lane lateral control and bus stop precision docking. However, even with this leading-edge work, the transit industry was reticent to fully adopt this technology. The STAR plan maps out a process of research to practice with automation commercialization in public transportation.

Realizing that automation technology is rapidly advancing in light-duty and heavy-duty commercial vehicles, the plan outlines a FTA's research agenda to advance transit readiness for automation. The STAR presents a framework for transit industry automation technology adoption. The STAR plan was built upon extensive stakeholder consultation, and the analysis of specific transit use cases. STAR components include: a review of existing policies and administrative requirements that might influence automation adoption; focused user acceptance research; an assessment of potential labor impacts; light and heavy duty commercial vehicle automation transferability analysis; industry research, development, and testing of level 4 and 5 transit automation capabilities; at least seven demonstrations and evaluations with transit agency partners; and strategic partnerships to leverage activities in other transportation sectors. In addition to these activities, FTA released two requests for comment (RFC) notices in January 2018. The RFC's requested input on the current and future status of automated transit buses and related technologies; and current or potential regulatory and policy barriers to the development, demonstration, deployment, and evaluation of automated transit buses and related technologies. In FY 2019, FTA intends to fund many the STAR plan components informed by the results of the RFC's. The primary objective of FTA's STAR research is to develop and facilitate the fast adoption of proven automation technologies.

Key activities/deliverables and performance measures for STAR include:

- Demonstration projects, autonomous systems research.
- Analyses and/ or assessments of demonstrations and deployments.

Outputs (Performance Indicators)	Outcomes (Performance Goal)	Impact (Project Goal)
Number of transit agencies that plan automation projects, as noted in state transportation improvement plans and/or FTA grant recipient program of projects.	Every year, 3% of urban transit agencies begin the planning process to automate some aspect of their transit service/ operations by 2022.	Establish and execute an FTA research program to expedite deployment of transit automation for various areas of transit operations.

The Strategic Transit Automation Research Plan and FY 2019 selected projects align with the DOT strategic goal to lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the nation's public transportation system. Specific associated objectives include the development of innovation through private sector collaboration; research partnerships; and coordination with public transit agencies to identify issues and needs associated with transit automation. Key deployment objectives include technology integration with existing transit assets; technology transfer to enhance commercialization of transit automation resources; and updating regulations to facilitate adoption of proven transit automation technologies. The expected total FTA investments in STAR for FY 2019 is \$5.8 million. Cooperative agreements in support of STAR will not require a match, however, demonstration programs such as the planned bus yard automated operations demonstration project will require a 20% match. There is also the possibility of private sector investments, so a rough estimate of the combined total matching funds and other contributions could be as high as \$1 million in FY 2019.

### ***Safety Research Demonstration Program***

FTA's research supports safety and enhances FTA's regulatory responsibilities by implementing projects that further the DOT safety goal to reduce crashes, fatalities, and injuries. Innovative technologies hold great promise to reduce injuries and fatalities for riders and transit workers. However, transit agencies require assistance to identify new technologies, and acquire information on the potential benefits of new technologies, before they invest in new safety solutions. Often transit agencies request support for operational strategies; potential risks; cost of implementation; and other factors related to the adoption of new technologies and practices. The FTA Safety Research Demonstration (SRD) Program is built upon the findings the Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Program. 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.

To improve transportation safety, FTA works extensively with State, local, and, private partners. Several DOT modes (FHWA, FRA, NHTSA) have safety research agendas. FTA collaborates with FRA to address passenger rail safety. In addition, TRB, the small business innovation program, and academia are all leading safety-related transit research. CUTR is the independent evaluator for SRD. CUTR will evaluate the six SRD grantees' projects per the criteria of safety improvements, system effectiveness, and return on investment. The grantees have established performance metrics for each of these criteria in their

statements of work. Below is the list of current SRD grantees and the total amount of funding inclusive of the evaluation:

**Table 1. SRD Projects that Received Assistance from FTA, FY 2017**

Safety Research and Demonstration Program (SRD)			
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>

The \$9 million investment in the SRD projects builds upon the investment of \$24 million in the SRER program. The SRER Program pursued innovative approaches to eliminate or mitigate safety hazards, improve infrastructure resiliency, and improve all hazards emergency response and recovery.

FTA funded twelve projects in SRER in nine states. Many safety-related technologies are now being assessed and tested at transit agencies because of these investments. Examples of outputs of three select SRER projects with significant results include:

- **Track Worker Safety** –This demonstration project is deploying secondary track worker safety system along six miles of a heavy rail system to be tested and validated. This innovative wayside system potentially can reduce, if not eliminate, injuries and fatalities due rail vehicles colliding with rail track inspectors and maintenance crews.
- **Rail Track & Wheel Monitoring** –This demonstration project is testing a condition monitoring system to assess rail track and wheel conditions. The system potentially can improve the effectiveness and efficiency of rail vehicle and track maintenance by moving the transit agency from schedule-based maintenance to condition-based maintenance.
- **Rail Vehicle Bumper/Coupler** – This demonstration project is developing and demonstrating a light rail vehicle front end bumper/coupler that potentially can reduce injuries and minimize the impact of collisions between light rail vehicles and automobiles, pedestrians, and bicyclists. The prototype bumper/coupler has the potential to reduce head injury criteria (HIC) up to 85% and thoracic trauma index (TTI) up to 99% with a collision speed of 20 mph.

Another result of the SRD program is that FTA is partnering with transit systems to make design changes to the layout of the operator compartment on buses—in particular, the placement and size of the operator mirrors—to prevent and minimize obscuration and provide drivers with an optimal view of pedestrians,

bicyclists, and customers. Current regulations related to mirror configurations on transit buses are minimal compared to those for other vehicles. With the results of this initiative, 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. Reducing the frequency and severity of crashes with pedestrians is critical to the overall transit safety mission. The design and demonstration of optimized mirror solutions for street-side mirrors on low-floor transit buses could reduce the number of serious crashes and enhance the overall state of transit vehicle driver visibility.

SRD 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. Key activities/deliverables, and performance measures for SRD include:

- Demonstrating sensor-based collision avoidance technologies.
- Validating vehicle automation/operational automation.
- Demonstrating and validating technologies to prevent suicides and/or detect trespassers.

Outputs (Performance Indicators)	Outcomes (Performance Goal)	Impact (Project Goal)
Number of transit agencies that demonstrate and adopt new technologies or practices.	Achieve a 10% increase in the deployment of innovative practices or technologies at transit agencies within 5 years.	Improve safety of transit agencies by reducing suicides and trespasser incidents.
Number of demonstrations that achieve positive Return on Investment.	Achieve break-even within the infrastructure (fixed or rolling) life cycle.	Improve operational efficiency of transit agencies.

The safety research planned for FY 2019 aligns with the DOT strategic goal of Safety to reduce transportation related fatalities and injuries. Key DOT objectives within the safety goal addressed by SRD are the identification of risks; providing leadership to facilitate the development of safety technologies; and evaluating the performance and efficacy to deploy various safety technologies.

The expected total FTA allocation for these projects in FY 2019 is \$6 million. It is anticipated that all transit safety projects will be funded with a 20% match from grantees. Additional investment from research partners, both private and public, above the 20% match is encouraged.

### ***Low and No Emission Component Assessment Program (LoNo-CAP)***

FTA has managed the statutory low and no emission transit bus program. The statutorily required LoNo-CAP is authorized in Federal public transportation law (49 U.S.C. § 5312(h)). The LoNo-CAP program provides unbiased assessments of LoNo components used in transit buses, publishing the assessments online, and summarizing them in a required annual report to Congress. For LoNo-CAP, the term “low or no emission component” means an item that is separately installed in and removable from a low or no emission transit bus. LoNo is a voluntary program for LoNo component manufacturers. When components are tested under LoNo-CAP, it will significantly support low or zero emissions transit bus operation.

LoNo-CAP differs from the Bus Testing Program (49 U.S.C. § 5318) in that LoNo-CAP testing is a voluntary program; it will only test components; and will not assign passing or failing scores. The LoNo component testing performed under LoNo-CAP complements the Bus Testing Program – in this program, FTA oversees the testing of complete buses as a condition of their eligibility for FTA grant funding. FTA competed the new testing centers and awards were made to two universities in the fall of 2018: Ohio State University, and Auburn University. These award recipients are in the process of developing and implementing their centers.

In addition to fulfilling the statutory requirements by developing and implementing voluntary test and certification procedures through the new testing centers, FTA's primary objectives and activities for LoNo-CAP are to provide unbiased assessments of low or no emission vehicle components; document (at a minimum) the maintainability, reliability, performance, structural integrity, efficiency, and noise of the tested components; increase the quality and lower the overall cost of low or no emission vehicle components; expand the supply chain for low or no emission vehicle components; increase the deployment of the cleanest and most energy-efficient transit buses into transit agency fleets; advance the development of materials, technologies, and safer designs; and support the development of applicable standards, protocols, and best practices.

LoNo-CAP activities align with the DOT strategic goals of Innovation and Infrastructure, especially the innovative deployment of infrastructure that improves economic competitiveness. Having a testing resource should allow component manufacturers to lower their product development costs, build their businesses, and provide viable new products for the industry. FTA is authorized to fund LoNo-CAP at \$3 million annually for a total of \$15 million starting in FY 2016 through FY 2020. FTA pays 50% of the established testing fees with the remaining 50% paid by low and no emission component manufacturers. Funds awarded under the LoNo-CAP program are used only to reimburse the cost of assessing components eligible under the program.

## **Two Completed High Priority Projects**

### ***Low and No Emission Vehicle Deployment Research Program***

The objective of the Low and No Emission Vehicle Research Deployment Program (LoNo) was to fund demonstration grants to public transit agencies to deploy clean and energy efficient U.S. manufactured transit buses largely proven in testing and demonstrations, but not yet widely deployed in transit fleets. LoNo provided a significant market signal to investors, and US vehicle manufacturers, that Federal law strongly supported the American electric bus industry. \$76 million was awarded to seventeen public transit agencies for this project. Though many of these projects are ongoing, FTA considers this an important project to highlight because in 2015, the program was codified as a formula grant in Federal transit law (49 U.S.C. § 5339) as the Low or No Emission Competitive Vehicle Program. This program provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses as well as acquisition, construction, and leasing of required supporting facilities. Under Federal transit law as amended by the FAST Act, \$55 million per year is available until fiscal year 2020.

Under LoNo research, eligible expenses included the acquisition, construction, and leasing of facilities needed to support new technology buses such as recharging, refueling, and changes or enhancement to maintenance facilities. LoNo increased private investment in cutting-edge U.S. transit bus development and the number of job opportunities in bus design, manufacturing, and operations. The low emission bus industry grew significantly from its beginning in 2007 to 2013. It is estimated that by 2013, almost two hundred zero emission buses were purchased for an aggregate market value of approximately \$160



million. It is expected that the market will grow 400% by the end of 2018 to \$640 million. This shows that LoNo program research enabled transit agencies to incorporate lessons learned from the initial deployment of low or no emission buses into broader plans for bus procurements. It is also beginning to result in lower cost, improved quality, and increased availability of more efficient buses.

The LoNo program aligns with the DOT strategic goals of Innovation and Infrastructure. The program improved key objectives associated with these goals: it drove the deployment of new technologies; improved system operations and maintenance; and increased economic competitiveness.

Through the LoNo Program, FTA learned that there are clear benefits but continuing challenges in the deployment of low and zero emission transit buses into transit revenue service. In addition, while per-unit cost for electric vehicles still exceeds that of combustion-engine vehicles, the lifecycle costs of electric buses will likely be lower because of reduced overall operating and maintenance costs as well as structural integrity (fewer moving parts).

LoNo buses are ready for introduction in the right environments, but factors such as the composition of fleets, type of climate, maintenance systems, and charging systems need to be considered. What LoNo research has demonstrated is that while electric buses have the potential to perform on par with conventionally-powered vehicles in many operational environments, critical information about fleet operations and infrastructure requirements is still needed.

As an example, research showed that for battery electric buses, the cost of electrical power is variable, and many transit agencies face electricity pricing structures that make charging electric buses more expensive than expected. While it is relatively simple for an agency to acquire and operate a small number of battery electric buses (5 or so), it may become unexpectedly costly as the size of the electric fleet increases, and

the need for electricity grows. This raises the possibility that while fuel cell electric buses (charged on board with hydrogen fuel cells) have been in the minority of deployments up to now, as fleet sizes increase, the cost-effectiveness of investing in hydrogen fueling stations instead of electric charging infrastructure may be more and more attractive. But, battery costs are also falling and other means of charging (such as in-route inductive charging) are being perfected which may make battery-electric a better option. Additionally, FTA is aware of some battery issues associated with very hot and very cold climates. So, there is still uncertainty and a need for continued research so that FTA can provide data and analyses to transit agencies about the nature of the technology and optimal deployment strategies.

To date, research outputs are the procurement of 111 zero emission transit buses at transit properties nationwide. Many of these vehicles are now operational and in service. Data collection and analysis of their performance is being planned. The market for new technology buses is expanding because of the LoNo Program. The program outcome is the continued viability of American electric bus manufacturing. In a market dominated by public procurements, the impact of the support of the Federal government for demonstrations of this new vehicle technology cannot be understated. The LoNo program has ensured the employment of thousands of Americans in quality jobs in the American electric bus industry, while making America one of the leading designers and manufacturers of the best electric buses in the world.

As noted earlier, further research is needed. The market is new, growing, and the technology is still developing. The primary purpose of further research is to determine the requirements and costs of electric bus infrastructure as fleets become larger; and to analyze as well as model fleet composition. Currently, the largest LoNo project supports only a 25-bus fleet; the program needs to include at least 2-3 fleets of 50-200 buses to determine how well the needed infrastructure scales. Studies are needed for how transit agencies can optimally negotiate electricity pricing structures for battery electric fleets.



The LoNo Program made available about \$77 million and required a minimum 20% non-federal match. Non-Federal stakeholders are not part of any current Federal research efforts. If further research were proposed, a 20% to 50% local share could be expected depending on the location.

### ***Bus Efficiency Enhancements Research and Demonstration (BEERD)***

The Bus Efficiency Enhancements Research and Demonstration (BEERD) project advances DOT's strategic infrastructure and innovation goals. The program supports the goals of developing and deploying new and innovative ideas, practices, and approaches for transit buses. It promotes the development and demonstration of energy efficiency technologies to enhance electrification of accessories and improvements in thermal management of bus bodies utilized in public transportation. In addition to reducing systems operations costs from energy use by transit buses, projects funded under this program can have favorable impacts for the riding public and public transportation operators, and can lead to enhanced competitiveness for the American bus industry and its supplier base.

Under the BEERD Program four technologies were selected for research and demonstration: thermoelectric power generators; reducing idling during paratransit passenger loading operations; reducing engine idle load systems; and hybrid beltless alternators. Researching these technologies helped American transit bus manufacturers and component suppliers achieve greater competitiveness by offering highly-desirable advanced technologies with substantial improvements in operating costs and energy efficiency, while supporting a pathway to greater electrification of transit and paratransit bus powertrains. FTA partnered with the Center for Transportation and the Environment (CTE), Hi-Z, Energy Florida, and Central Florida Regional Transportation Authority to develop and demonstrate a thermoelectric generator that will be used to provide supplemental power and reduce the amount of power required from the alternator during operation. 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.

To lower operating costs, reduce energy usage, and improve air quality, FTA partnered with CTE and Utah Transit Authority (UTA) to develop and demonstrate a system to eliminate or reduce idling during paratransit passenger loading operations. The first prototype paratransit bus incorporating a high-power alternator and electrical energy storage enabled paratransit buses to provide comfortable cabin air, lights, and wheelchair ramp/lift operation during engine-off stops. The prototype was delivered in July 2017 after completing a 1400-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 December 2017.

FTA has also partnered with CTE, Metropolitan Atlanta Rapid Transit Authority (MARTA), and BAE Systems to develop and demonstrate a BAE Systems prototype reduced engine idle load system. This first-of-its-kind effort will bring a multimode electric accessory 'power plant' to market. 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.

For the fourth project, FTA partnered with the Maryland Transit Administration (MTA) to develop and demonstrate a retrofit of 41 hybrid buses with a hybrid beltless alternator and support equipment to monitor fuel savings and impact on house batteries. So far, beltless alternators were retrofitted to at least 37 of the planned 41 existing diesel hybrid-electric buses and are being demonstrated in revenue transit service with substantial fuel economy improvements (up to 20%) and more than \$6,000/year per bus in combined fuel and maintenance savings.

The BEERD Program provided \$3 million in Federal funding with a 20% match requirement totaling about \$920,000 in non-Federal funds. The total cost of BEERD Program including both Federal and non-Federal funding was approximately \$4 million.

## Section 1 – Program Descriptions, FY 2019

### FY 2019 RD&T Program Funding Details

RD&T Program Name	FY 2019 Pres. Budget (\$000)	FY 2019 Basic (\$000)	FY 2019 Applied (\$000)	FY 2019 Development (\$000)	FY 2019 Technology (\$000)
Mobility Innovation	11,616		1,216	7,400	3,000
Infrastructure	4,936		936	4,000	
Safety	5,808		308	4,500	1,000
Transit Cooperative Research Project (TCRP)	5,000		5,000		
Small Business Innovation Research (SBIR) Program *	640		640		
<b>Totals</b>	<b>\$28,000</b>		<b>\$8,100</b>	<b>\$15,900</b>	<b>4,000</b>

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

RD&T Program Name	FY 2019 Pres. Budget (\$000)	Safety (\$000)	Infra-structure (\$000)	Innovation (\$000)	Account-ability (\$000)
Mobility Innovation	11,616			11,616	
Infrastructure	4,936		4,936		
Safety	5,808	5,808			
TCRP	5,000		5,000		
SBIR*	640			640	
<b>Totals</b>	<b>28,000</b>	<b>5,808</b>	<b>9,936</b>	<b>12,256</b>	

*\*The SBIR program is authorized by the Small Business Act, 15 U.S.C. § 638. FTA participates in the SBIR program by providing 3.2% of its funding from its discretionary Research and Development appropriations for SBIR programs.*

## **Mobility Innovation**

### **Funding Request \$11,616,000**

#### **Program Description**

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

#### **Program Activities**

1. *Mobility on Demand (MOD)* – this series of projects are exploring ways to provide travelers with enhanced mobility options; improving travel decision tools; and increasing convenient and seamless travel. MOD projects are testing innovative new operational models in transit agencies such as solutions for the first/last mile; more effective leveraging of existing investments; and improving service quality. FTA is working with MOD stakeholders to promote the transit industry's awareness and support preparedness for MOD, and to understand impediments to implementation. The research will also increase awareness and buy-in from local stakeholders and transportation companies/vendors needed for successful deployments of integrated MOD solutions in communities. MOD research is also exploring how under-served communities, such as rural and suburban residents, can benefit from these new service models. Many demonstration grantees are working on new smartphone apps. to share ride information, building on the widespread availability of smart phones in many parts of the country.
2. *Transit Automation Research* – these projects in automation are developing use case scenario analyses to assess and prioritize vehicle automation technologies for public transit applicability; developing a plan for future transit automation development; and paving the way for demonstration projects.
3. *Accessible Transportation Technologies Research Initiative (ATTRI)* – these innovative projects are developing tools that enhance mobility for travelers with disabilities and improves mobility for underserved communities. Innovative tools in development are using Intelligent Transportation Systems (ITS), and other advanced technologies. This program leverages recent advances in vehicle, infrastructure, and pedestrian-based technologies, as well as accessible data, mobile computing, robotics, artificial intelligence, object detection, and navigation.
4. *Multi-modal Integrated Universal Payment Systems* – this research area is promoting the quick adoption of integrated payment options for transit agencies and other mobility providers at the regional and interregional levels. Such payment systems facilitate and increase seamless traveler experiences and data availability, thus improving overall system wide mobility efficiency and performance. FTA is working with a broad group of public and private stakeholders in this area.

## Statutory Requirements

FTA's Mobility Innovation Program is not mandated by statute but are discretionary activities eligible under Public Transportation Law at 49 U.S.C. § 5312.

## Program Alignment with Strategic Goals

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Mobility Innovation	Improving Mobility

The MOD program closely aligns with the DOT strategic goal to lead in the Development and Deployment of Innovative Practices and Technologies that Improve Safety and Performance of the Nation's Transportation System. Specifically, MOD projects are developing innovations by providing seed funding so communities can experiment with new approaches then report back to FTA so those findings can inform other public transit agencies' activities. Development of innovation is also supporting the objectives of expanding partnerships and coordination between the public and private sector. Deployment of innovation is furthered by the growth of communities of practice; widespread stakeholder collaboration activities; and broad outreach to support technology integration and technology transfer.

Mobility Innovation further supports the DOT strategic goal of innovation by funding projects that explore automation in the public transportation industry. As an example, the FTA STAR plan will be a useful tool for planning and executing DOT-sponsored transit automation development and demonstration projects and integrated, multi-modal service solutions. Thus, transit agencies will be able to significantly accelerate deployment of automation or partial automation in their operations.

FTA's Mobility Innovation program takes into consideration both urban and rural areas. FTA's Mobility Innovation Program provides a venue through which integrated concepts and solutions – supported through local partnerships – are demonstrated in real-world settings. One example of a rural setting is in the Vermont Mobility on Demand (MOD) Sandbox Project - Flexible Trip Planner. In this project, FTA is partnering with the Vermont Agency of Transportation to create a statewide transit trip planner that enables flex-route, hail-a-ride, and other non-fixed-route services to be incorporated in mobility apps. The online trip planner for both fixed and flexible transit services particularly benefits non-traditional rural transit system users, allowing universal access to transit information, including for people with disabilities. The project advances an innovative business model and fosters a marketplace for future business opportunities. For future demonstration grants, there will be an increase on research that specifically addresses the unique aspects of rural environments – perhaps a percentage of available funds in upcoming notices of funding availability will be targeted for rural applicants.

## Program Objectives

The primary objectives of FTA's Mobility Research are to:

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

Overall, Mobility Innovation research projects improve the efficiency, effectiveness, and quality of public transportation services through adaptation to new mobility options by public transportation providers. Transformative and, at times, disruptive, technologies are driving massive changes in the way customers access and use public transportation and transportation information.

FTA's Mobility Innovation research is identifying promising practices in shared services that not only increase access but also address operational efficiencies and effectiveness. The research is doing this by examining important operational details such as data collection, data access, and data management issues rising from the need to share and integrate public, private and personal information in the new mobility paradigm. The research looks at advanced payment systems, communications and system navigation techniques that form the basis of a future integrated mobility environment. There are some extremely challenging technology issues that must be overcome but with potentially high payoff for travelers.

FTA recognizes microtransit as a service model that sits between traditional fixed-route transit and the new tech-enabled TNC models. It is a demand-responsive service using ad-hoc pickup and drop-off points within a few minutes' walk of multiple customers, generally within limited service zones. In general, microtransit uses vehicles smaller than traditional 30-ft or 40-ft transit buses but larger than the passenger vehicles commonly used by TNCs. Prices are higher than for standard transit service, but lower than a TNC ride over the same route. The hallmark of microtransit is the ability to flexibly create routes and stops in response to customer demand. In practice, the services tend to converge on a limited number of routes between dense areas of high demand, and most operate only at weekday peak hours.

FTA's Mobility Innovation research investigates the technical and institutional feasibility of various business models and partnerships, such as microtransit. Transit agencies may collaborate with microtransit providers to address service gaps in their mobility networks. In addition, FTA also incorporates microtransit as a tool in the Mobility on Demand toolbox. Microtransit contributes to an integrated and connected multi-modal network of safe, affordable, and reliable transportation options available to all. FTA is examining specific challenges facing public transportation agencies as they seek to leverage microtransit opportunities:

- **Need for Capital Investment and Subsidy:** to date, "microtransit" relies on a business model that involves leasing (generally larger, wheelchair accessible) vehicles and paying drivers as employees – a different business model than the TNC model.
- **Equity of Service:** there are challenges around the usability of microtransit services by all travelers for travelers without smart phones or credit cards.
- **Marketing:** The design of a service, and how it is promoted are key to its success.
- **Workforce:** impacts to the existing transit workforce may vary with the nature of the employment model and contractual arrangement.

Facing rapidly evolving technologies and innovations, FTA mobility research is also gathering data to understand the economic opportunities supported by the new mobility paradigm. In FY 2019 and FY 2020, FTA is also evaluating existing public transportation policies and regulations to see how they affect the adoption of new service models and economic growth.

FTA is developing a set of performance indicators that reflect the dynamic and multimodal nature of mobility to facilitate innovation and modernize regulation. In FY 2019, FTA will define performance indicators and units of measurement to reflect the economic impact of regulatory reform at three geographic scales: by the local jurisdictions, at the regional level, and at the national level. It is primarily at the second (regional) and the third (national) levels where economic impacts such as productivity and



jobs are found. In FY 2020, FTA plans to test the validity and usefulness of these performance indicators in various settings, such as the MOD Sandbox projects. As an integral part of FTA's Mobility Innovation research, regulatory relief requires FTA to work with partners and stakeholders in government, industry, and the general public for input. It is also essential to examine the potential impact and possible unintended consequences of regulatory changes on safety, efficiency, innovation and economy.

FTA's Mobility Innovation research is also considering cybersecurity issues in the areas of automation and fare payment. Safety issues are critical for public transit providers, and automation systems introduce new types of risks, ranging from technology limitations, hardware failures, and cybersecurity breaches. The security of personally identifiable information and personal banking/credit access must be addressed and assured. Research will be required across multiple areas to demonstrate the safety of automated vehicles. Cyber-security threats of remote access and hijacking a vehicle must be safeguarded against. FTA is considering the potential for assaults and criminal activity to become more prevalent in driverless vehicles. Currently, the presence of a driver or other public transit employee such as law enforcement can act as a deterrent to criminal behavior. Cybersecurity with fare integration is another area considered by FTA. For example, FTA's MOD Program is addressing challenges with integrating payments when using multiple modes of transportation into one method. The personal information and other potential risks must be addressed to ensure the security of the systems.

When conducting mobility innovation research, development and demonstration in Fiscal Years 2019 and 2020, FTA will continue to emphasize the requirement for sufficient cybersecurity and fail-safe measures. In the meantime, FTA will continue to actively participate in all Departmental cybersecurity initiatives where transit representation and subject matter expertise are needed.

### **Research Collaboration Partners**

Mobility innovation is highly participative with both internal and external partners. The DOT program partners include the various offices within the Office of the Secretary (OST-P, -R -X), the Federal Highway Administration (FHWA), the National Highway Traffic Safety Administration (NHTSA), the Federal Motor Carrier Safety Administration (FMCSA), the Federal Railroad Administration (FRA), and the Intelligent Transportation System (ITS) Joint Program Office (JPO). The FTA Mobility Innovation research program specifically also regularly interacts with other Federal partners outside of DOT on common research interests, knowledge exchanges, and the active sharing of resources. These partners include the Department of Energy Vehicle Technology Office and the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR).

Technical assistance partners like the Shared Use Mobility Center provide critical information on how new mobility models are being used and are increasing across the United States – FTA is using this map to track the some of the results of the program – the adoption rates for new mobility models. The model can be found at: <http://maps.sharedusemobilitycenter.org/sumc/>. Other partners are supporting dissemination activities and convening peer to peer communities of practice. As the STAR work develops, FTA expects to engage external partners in supporting the expansion of automated public transit systems and disseminate promising results.

FTA engages in strategic partnerships that leverage research initiatives and investments led by other entities, both public and private. In many instances, FTA funding and technical assistance supplements the work of partners in the development, deployment and evaluation of specific innovative activities. Current external partners include APTA, TransitCenter, CTAA, Booz Allen Hamilton, the Shared Use Mobility Center, as well as Valley Metro in Phoenix, AZ.

## **Acquisition/Assistance**

It is the intent of the FTA Mobility Innovation research program to utilize competitive procurement processes to allocate program funding, including all opportunities for demonstration and deployment through Notice of Funding Opportunity (NOFO). FTA may enter cooperative agreements with the qualified recipients for specific types of assistance through a sole source. When this is needed and advisable, FTA will document the justification and obtain leadership approval as appropriate. All statements of work for agreements are reviewed and approved by FTA's legal, including sole sources. All demonstration grants are done through competitive notices of funding (NOFO) availability – so most the investment planned for mobility innovation will use this process. The selection of NOFO awardees is achieved through a combination of a thorough internal review process which is then vetted with FTA leadership for final decisions. Most projects in the Mobility Innovation program are single-year acquisitions. Additionally, all demonstration grants require a minimum of 20% non-Federal match.

## **Technology Transfer (T2)**

To support the vision of on-demand mobility, the FTA Mobility Innovation program primarily employs three technology transfer strategies:

- Structured Stakeholder Engagement and Outreach activities,
- An Innovation and Knowledge Accelerator (IKA), and
- Focused Strategic Partnerships.

The Mobility Innovation program is committed to practice, and established an ongoing stakeholder engagement and outreach mechanism through a cooperative agreement with the Intelligent Transportation Society of America (ITSA). ITSA provides Mobility Innovation research and outreach support to the transit industry with: Special Studies, Communications, Outreach, and Stakeholder Engagement. As an example, ITSA produces a biweekly publication, called Mobility Rush, that highlights the latest Mobility on Demand (MOD) activities and partnerships.

In addition, FTA funds the Shared Use Mobility Center (SUMC) for a project called the Innovation and Knowledge Accelerator (IKA). This is a structured, supported learning and information exchange system. The SUMC IKA also includes a communities of practice initiative for FTA that enables colleagues to share ideas; lessons learned; problems and solutions; research findings; and share mutual support in a trusted setting of experimentation and open communication. The IKA combines aspects of traditional project-based technical assistance with those of a staffed, Community of Practice (CoP) environment.

Another major technology transfer and research to practice model FTA currently uses for its Mobility Innovation program, and will continue to use for FY 2019, is Strategic Partnerships. FTA will fund additional strategic partnerships with transit industry sponsors, private sector stakeholders, and others - such as academia. The goal for strategic partnerships is to leverage research projects and investments from other agencies, and facilitate knowledge transfer to accelerate the adoption of innovative technologies and business models. Mobility Innovation research results are also presented in the annual research report to Congress that is posted on FTA's website; the National Transportation Library including its Digital Repository; and are incorporated into the DOT Research Hub.

## Evaluation / Performance Measurement

FTA conducts independent evaluations for all demonstration programs. At present, the firm Booz Allen Hamilton is the evaluator for the Mobility on Demand Sandbox. As FTA awards demonstration programs in the other mobility innovation areas, FTA will contract with additional outside evaluation organizations. To evaluate the overall program area of mobility innovation, FTA is in the process of applying the new FTA research evaluation framework that uses public transportation efficiency and effectiveness as measures to track Mobility Innovation program performance.

FTA enhances transit operational efficiency and reduce costs by leveraging public and private assets as well as the development and deployment of innovative technologies. FTA tracks the percent change in the type of service options used by transit agencies that expand service using alternative shared mobility solutions and public private partnerships. The measure is being baselined in FY 2018 through data in the National Transit Database (NTD) and will be tracked annually with a goal to have a longitudinal trend assessed over 5 years. FTA also advances personal mobility by identifying and facilitating faster adoption of proven mobility solutions, partnerships, and business models from both the private and public sectors for enhanced mobility for all travelers. FTA records the percent change in the number of public transit agencies that expand service coverage (geographic or temporal) through alternative shared mobility solutions and public private partnerships. The measure will be tracked annually with a baseline established from FY 2017 data from the SUMC map with a goal to have a longitudinal trend tracked over 5 years.

FTA is funding the development of additional performance metrics which will be applied to the MOD Sandbox program and grantees through the independent evaluator. Once the Sandbox Evaluation is completed, FTA will leverage the information to test the validity and feasibility of these new performance metrics.

FTA's Mobility Innovation program complements DOT's strategic goal of Innovation and addresses the strategic objectives of development and deployment of innovation. Transit Automation, Multi-Modal Payment Systems, and ATTRI provide significant opportunities for technology developments in data and communications. FTA is meeting the strategic objective to further the development of innovation through demonstration grants. Innovative development is also achieved by encouraging and strengthening coordination across DOT modal administrations, stakeholders, jurisdictions, institutions, and sectors. The coordination efforts meeting this strategic objective are exemplified in FTA's Transit Automation strategy. FTA coordinates with other DOT modal administrations by participating in DOT's automation working group to reduce duplicative efforts, ensure a coherent strategy, and optimize the use of limited research resources across the Department. FTA research is providing seed funding to stimulate new technologies such as smartphone apps. FTA is using the planning process to engage with a broad array of stakeholders in support of innovative development. The recently published Strategic Transit Automation Research (STAR) Plan (<https://www.transit.dot.gov/research-innovation/strategic-transit-automation-research-plan>) provides a framework for the transit industry to pursue advanced technologies for transit bus automation in a safe, efficient, and economically sound manner. It also builds on a foundation of stakeholder engagement.

FTA's Mobility Innovation program furthers the strategic objective of deployment of innovation by encouraging the safe introduction of innovative practices and technologies. Under this strategic objective, FTA is encouraging technology deployment through collaboration by advancing the integration of new

transportation technologies and practices into existing transportation systems to improve safety, accessibility, mobility, and performance. For example, the GoVermont Flexible Trip Planner Project demonstrates how the integration of technologies occurs through successful collaborations. The State of Vermont State DOT (Vermont Transportation Agency), local providers of public transportation, and private industry collaborated to ensure the integration of information within a new trip planner that benefits rural communities in Vermont. The planner, accessible at <https://plan.vermont.org/>, was launched in February, 2018.

Finally, the Mobility Innovation area also addresses the strategic objective of economic competitiveness and workforce that falls under the infrastructure strategic goal. Transit automation research activities will examine the needs of the public transit workforce for retraining and job reclassification. Automation may lead to new, perhaps better, jobs such as in the information technology field that will provide greater career growth for public transit workers.

**Safety**  
**Funding Request \$5,808,000**

**Program Description**

As the steward of the nation's public transportation system, FTA is obligated to provide the resources necessary for safe, efficient, and effective operations for transit customers, employees, and others through safety research, innovation, and/or regulation. The nation's economy depends on a secure public transit system for millions of Americans to get to work every day. FTA supports research on new safety technologies that can reduce fatalities, injuries, and expand American economic and technological leadership.

**Program Activities**

1. *Safety Research and Demonstration Program* – The Safety Demonstration Program builds a portfolio of demonstration projects that assist transit agencies to 1) improve operational safety, 2) strengthen infrastructure resiliency, and 3) improve the state of good repair for transit assets. This program will add to the current portfolio of innovative safety demonstration projects started under Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Program.
2. *FTA Standards Development Program* – This program covers a variety of public transportation topics with current focus on safety standards development. This safety standards work is a product of the FTA Safety Standards Strategic Plan project. FTA is working with public transportation industry organization(s) in the development of voluntary safety standards. FTA Standards Development Program tasks include a) modification and enhancement of existing standards, b) development of new voluntary standards, and c) expansion and re-establishment of partnerships with Standard Development Organizations (SDOs).

The type of research methods used in FTA's Safety Research program and the corresponding outcomes help agencies develop appropriate safety policies and procedures. These research activities identify effective safety practices and principles; determine whether transit agencies are implementing recommended practices; and evaluate the impact of those practices on transit safety. For safety risk management, FTA is researching emerging hazards and evaluating their associated risks to help agencies formulate controls to reduce or eliminate high risk hazards. The surface transportation network includes all modes of public transportation that links workers to jobs, goods to markets, and people to essential services. Keeping America's surface transportation infrastructure in a state of good repair contributes to traveler safety, a robust economy, and improved quality of life for all Americans. Whether access to economic opportunity or to health care, safe, high quality public transit infrastructure has immense impact to travelers. As part of FTA's safety research, FTA is assessing permitting reform issues to identify where they may negatively impact safety.

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. For example, the Safety Research and Demonstration (SRD) Program provides technical and financial support for transit agencies to pursue innovative approaches to eliminate or mitigate safety hazards. 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 is working 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, as 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 and the proximity of the bus operator's eyes to the pillar structure and mirror. The design and demonstration of an optimized mirror solution set for street-side mirrors on low-floor transit buses could reduce the number of serious crashes and enhance the effectiveness of transit vehicle visibility systems. The SRD Program intendeds to help transit agencies by exploring these and other advanced technologies to prevent transit vehicle collisions; enhancing safety of transit services by incorporating safer design elements; and evaluate cost-effectiveness and practicability of potential solutions.

## Statutory Requirements

Safety Program is not mandated by statute but is discretionary and all activities are eligible under 49 U.S.C. § 5312.

## Program Alignment with Strategic Goals

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting Safety

DOT's Safety goal seeks to reduce transportation-related fatalities and serious injuries across the transportation system, and FTA's research addresses this goal in public transit systems. FTA is developing a systemic safety approach that mitigates risks and encourages the adoption of useful infrastructure and behavior changes that improve safety. FTA is using a data-driven systemic safety approach to identify these risks, enhance standards and programs, and evaluate effectiveness. FTA's Safety research and demonstration program can potentially transform how urban and rural public transit systems monitor, assess, and manage their systems to address safety. The mission of FTA's safety research program is to provide leadership and vision in the development and management of initiatives that improve the safety of passengers, employees, emergency responders, and all others who encounter the public transportation system.

FTA's Safety research program will continue to focus on demonstrating and deploying transformative technologies and operational procedures through partnership with transit agencies, technology suppliers, and other private sector entities. In FY 2019, FTA's investment in safety research will pursue both development as well as deployments of innovative public private partnerships; data-driven demonstrations and deployment tests; and the research and development of cutting-edge technology demonstrations.

Rural areas face many unique safety challenges. Rural crashes are more likely at higher speeds than urban crashes; victims of fatal crashes in rural areas are more likely to be unbelted than their urban counterparts; and it often takes first responders longer to arrive at the scene of a rural crash, leaving victims waiting longer for medical attention. Outdated roadway design and roadside hazards such as no sidewalks or bike



lanes, utility poles, sharp-edged pavement drop-offs, and trees close to the roadway are major contributors to the severity of rural crashes.

FTA seeks to address these and other challenges facing rural transit providers such as higher speeds and sharp pavement drop off that cause vehicle rollovers. This challenge is particularly evident with rolling stock (smaller buses) and technologies and vehicle structural integrity to make vehicle and operations safer. FTA funds both urban and rural grantees in safety research. For example, a project under the Safety Research and Demonstration (SRD) Program with the Pierce County Public Transportation Benefit Area Corporation (Pierce Transit) is deploying buses equipped with collision avoidance warning systems or automatic braking features. The objective of this project is to deploy and demonstrate collision avoidance technology in partnership with the Washington State Transit Insurance Pool (WSTIP), a collaborative organization of 25 Washington public transit agencies that combine their resources to provide and purchase insurance coverage, manage claims and litigation, and receive risk management and training. Pierce Transit will work with WSTIP to accurately determine the business case for investing in these technologies that can be replicable in rural areas. Any new FY 2019 projects will expand specific focus on rural public transportation safety, and FTA will engage in dialogue with the National Rural Transportation Program to help identify critical rural public transportation safety areas.

## **Program Objectives**

The goals of FTA's Safety research program are to improve public transportation safety, support the Agency's regulatory role, and, finally to develop a comprehensive safety oversight framework. The program is focused on improving public safety by reducing transit-related injuries, fatalities, safety events, and enhancing system reliability. Though public transportation is a very safe system overall – independent research by the Victoria Policy Institute in 2016 notes that:

“Public transportation is overall a very safe form of travel. Its passengers have less than a tenth the per-mile crash rates as automobile occupants, and transit-oriented communities have less than a fifth the total (pedestrian, cyclist, automobile and transit passenger) per capita traffic fatality rates as in automobile-dependent communities. Traffic casualty rates tend to decline in a community as transit ridership increases. In fact, cities where residents average more than 50 annual transit trips have about *half* the average traffic fatality rates as cities where residents average fewer than 20 annual transit trips. (from <http://www.vtpi.org/safer.pdf>, retrieved 4-1-2018).

However, when accidents happen, FTA must learn from these events and develop safety improvements as needed as well proactive safety measures. FTA safety responsibilities have increased over the last ten years, and there are new requirements for rail safety. FTA's responsibility with the State Safety Oversight (SSO) program is to oversee safety at rail transit systems. The SSO program is administered by eligible states with rail transit systems in their jurisdiction. FTA provides federal funds through the SSO Formula Grant Program for eligible states to develop or carry out their SSO programs. Under 49 U.S.C. § 5329(e), FTA is required to certify each state's program to ensure compliance with Federal regulations. With these and other safety initiatives, it is important that FTA's safety research supports and complements these programs. Thus, the main goal for FTA's safety research improve public safety by reducing transit-related injuries, fatalities, safety events, and system reliability by testing promising new safety technologies; and assessing ways to promote better public transit safety cultures through the adoption of promising voluntary safety standards.

In the future, FTA will begin to look at Cybersecurity issues in coordination with other modes. Though this has not been an area of FTA responsibility for many years, there is increased industry interest in having FTA assume an active role.

### **Specific Safety Objectives**

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

From a marketplace perspective, transit agencies must assess risk very carefully, and their ability to adopt, fund, and deploy proven new safety technologies can be difficult. Without FTA assistance to fund innovations and identify the most promising technologies with real-world assessment of implementation processes, new technologies might not be available or useable. The limited application of these types of safety technologies to a unique public sector system makes private sector investment in these areas lag other transportation safety initiatives such as with cars, so that public sector investment is critical to seeding private sector investments. One example is how the FTA-funded SRER program addressed both operator and passenger safety. The Sacramento Regional Transit District (RT) is adding a secondary warning system for track worker protection. RT is developing, implementing, and testing a system providing three-way communication between workers on the track, train operators, and dispatchers in the central office. This project will deploy the technology across RT's entire light rail fleet, which will fully demonstrate its functionality, reliability, and utility on an operating light rail system.

The FTA Safety research program uses a methodical and data driven approach to research. The program uses the statutory pipeline phased approach (Foundational research, innovation/development, demonstration/deployment and evaluation) with the aim of improving the safety of the nation's public transportation system. The use of performance-based regulations to promote safety and reduce risk in high-hazard industries is at the core of FTA's Safety program research. The broad definition of "performance-based" refers to: (a) standards that mandate outcomes and provide flexibility in meeting them; or (b) requirements for using management systems consisting of internal plans and practices to promote safety and reduce risk. FTA's Office of Safety leads the adoption of a Safety Management Systems (SMS). SMS is a comprehensive, collaborative approach that brings management and labor together to build on the transit industry's existing safety foundation to control risk, detect and correct safety problems, share and analyze safety data, and measure safety performance outcomes. SMS applies resources to specific risks and ensures that a transit agency has the organizational infrastructure to support safety related decision-making at all levels.

The Safety research program is designed to provide: a) financial and technical support for transit agencies to pursue innovative solutions to mitigate safety hazards; b) demonstration and evaluation of cutting-edge safety technologies, data driven approaches to safety and safer designs on existing safety issues identified and c) consensus based, voluntary safety standards to improve the overall safety of transit industry. Program activities collect relevant, unbiased, data driven safety information to the industry and to the agencies regulators. This approach allows FTA the flexibility to promote safety practices and seek consensus and partnerships when appropriate. It also allows for the implementation of performance-based

regulations, guidelines, or voluntary standards when the data suggest the need or there is in a positive return on investment based on the data collected from the safety research programs.

## **Research Collaboration Partners**

At every step, FTA utilizes input from a variety of working groups and sources such as TRAC, the safety standards working group, webinars, Transportation Research Board publications, academic research, collaboration with FTA's safety office, and direct transit industry engagement to inform research topic decisions. For example, the safety standards working group has provided FTA with a top ten list of safety standard priorities to include track worker safety and bus operator assaults that have driven the focus FTA's safety research program.

Given its focus on technology neutral and multi-modal approach, safety research relies on extensive partnerships with both public and private sector stakeholders. Frequent and constant collaboration is expected with internal and external stakeholders. Some partners include the Office of the Secretary, Federal Highway Administration (FHWA), National Highway Traffic Safety Administration (NHTSA), Federal Motor Carrier Safety Administration (FMCSA), Federal Railroad Administration (FRA), and to a lesser extent the Intelligent Transportation System (ITS) Joint Program Office (JPO). FTA's safety research program also regularly communicates with others outside of the DOT for common research interests and knowledge exchange and sharing of resources such as transit agencies, APTA and other trade associations, academia, and consulting firms.

## **Acquisition/Assistance**

FTA's safety research program utilizes both sole source and competitive solicitations for selecting organizations to conduct research. All demonstration grantees are selected by competitively by NOFO's and are required to have a 20% match with Federal funding allocations. For example, the Safety Research and Demonstration program was solicited using a competitive Notice of Funding Opportunity through the *Federal Register* and *Grants.gov*. Evaluation and initial inquiry projects are usually done through sole source multi-year Cooperative Agreements with nonprofit organizations with specialized subject matter expertise.

## **Technology Transfer (T2)**

Safety research to practice is achieved through broad partnerships with key stakeholders. Partners test and demonstrate the efficacy of technologies deployed, disseminate research, and help develop standards. FTA recipients tailor individualized dissemination activities to specific research projects to facilitate sharing results with interested stakeholders. FTA is phasing in a more standardized approach for disseminating and evaluating the dissemination of results as part of a larger project evaluation effort. A good illustration of this is reflected in the Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Program. In SRER FTA is conducting uniform evaluations of all projects and their dissemination activities with a consistent approach as opposed to each recipient contracting with an independent evaluator.

Key organizational partners include research institutions, training partners, non-profit partners, national transportation associations, university transportation centers, transit agencies, state agencies, technical assistance partners, and international partners. FTA's safety research activities, to the extent possible, include collaboration with other modes including FHWA, NHTSA, FRA, and FMCSA. Additionally, FTA works with TRB to support safety research; gather input from advisory committees; and provide

access to other pertinent research from TCRP studies. The Transportation Research Advisory Council (TRAC), hosted by the National Academies, helps with strategic planning input. Major research labs and academic institutions, including those running University Transportation Centers, promote research findings and provide input for future safety research and technology deployments. Major areas for safety research include bus operator assault prevention, right-of-way track worker protection, and potential automated vehicle solutions. FTA contracts with the Center for Urban Transportation Research (CUTR) to administer the Transit Safety Standards Working Group. This thirteen-member group represents a cross section of the U.S. public transportation industry and includes transit systems operating in large and small urban environments as well as those providing rail/bus and bus services. The group also includes representatives from industry associations –APTA and the Community Transportation Association of America (CTAA). CUTR and FTA established the Working Group in early 2017. It meets on a quarterly basis.

The broader transit industry, academia, consultants, and policy-makers are the intended audience. An important component for future safety information dissemination is to establish communities of practice and peer-to-peer exchanges. TRI coordinates important safety research study announcements with FTA's Office of Public Affairs. To promote formal dissemination of safety research findings, FTA posts research results on its website and utilizes social media tools like Facebook and Twitter as well as traditional listservs that send out notices of webinars. In FY 2019, FTA will expand the marketing and promotion of findings through greater use of social networking and outreach with the goal of increasing industry awareness of the short- and long-term benefits of implementing the findings of safety-related research. Programmatic research funds support T2 activities including electronic report production, newsletter creation, and use of social media through FTA's congressional affairs office. Safety Program research results are noted in the annual research report to Congress, the National Transit Library, and the DOT Research Hub.

## **Evaluation / Performance Measurement**

FTA is also required by Public Transportation Law at 49 U.S.C. § 5312 to complete an independent evaluation of its Safety program, measuring its objectives and outcome goals. FTA funds independent evaluation of its safety demonstration programs through CUTR. Information from demonstration evaluations inform the assessment for FTA's safety program. FTA uses safety efficiency and effectiveness as overall measures to track the program's performance. FTA safety effectiveness is operating systems in a safer manner through application of advanced technologies and innovative practices in safety culture development and human factors. FTA rates the change in public transportation agency deployment rate of advanced safety technologies and voluntary safety standards to track results. The measure will be assessed annually with a baseline established from FY 2017 data with a goal to have a longitudinal trend tracked over 5 years. Improving transit capital and operational efficiency while supporting improved transit system safety is the efficiency measure which will utilize NTD data. To assess overall industry impact, FTA seeks to reduce injuries and fatalities by using innovative technologies that improve worker and rider safety.

There is a major lag time between fielding research and having results in the field through the implementation of evidence-based safety technologies. However, it is important to monitor this important overall measure longitudinally to see if public transit agencies can make substantive impact to reduce injuries and fatalities. FTA counts the percent change in public transit related injuries and fatalities using NTD data. The measure is tracked annually with a baseline established from FY 2017 data with a goal to have a longitudinal trend tracked over 5 years. Key safety outcomes that will serve as proxies to the longer term result of lower injuries and fatalities, are an annual increase in the demonstration and

deployment of innovative practices or technologies at transit agencies; an increase in the adoption of a safety management systems approach by ensuring State Safety Oversight (SSO) Certification federal goals are met each year; the adoption of employee safety reporting systems across the US; and the use of data to improve transit agency safety policies and practices. The program is starting to establish data baselines. FTA will analyze emergent trends and evaluate the benefits from the above noted measures and the commensurate overall impact on fatalities and injuries. For example, FTA is working with the Volpe Center to complete a research project on a close-call reporting system.

FTA's Safety program aligns with DOT's Strategic goal of Safety and meets the strategic objective to support a systemic safety approach. FTA's Safety program conducts safety demonstration projects and explore safety standards, and improves the collection, management, and integration of data on public transportation related fatalities and serious injuries. FTA is implementing evidence-based risk elimination and mitigation strategies. The Safety Research and Demonstration (SRD) Program is an example of a systemic safety approach. An SRD grantee, the Maryland Department of Transportation, installed secondary track worker warning systems on the entire Maryland Transit Administration yellow line and completed a radio-mesh network for the system. This groundbreaking demonstration project will document safety improvements for track workers, evaluate the system effectiveness, and document the return on investment of the system.

FTA's Safety program is further examining the safety systems approach by conducting efforts to identify risk and through collaboration with relevant stakeholders. FTA is developing a Safety Standards Strategic Plan and safety data collection strategy. Once completed, the plan will provide information FTA on existing transit safety standards and propose new standards for use by the transit industry where gaps may exist. This strategic plan, as well as other efforts under the Safety program, will promote the use of performance-based safety standards and measures.

**Infrastructure  
Funding Request \$4,936,000**

**Program Description/Activities**

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

**Program Activities**

1. *Asset Management and Asset Innovation* – FTA will demonstrate “health” monitoring techniques of transit assets using advanced technologies to include sensors and the use of innovative construction techniques and new materials to include nano-particles, recycled polymers, and composites. There are major advances in sensor technology - including: strain gauges and unmanned vehicles (drones); and increased processing power and data analytic tools. As an example, hand-held field devices may now enable real-time health monitoring of fixed and moving infrastructure/assets as a viable alternative or to complement existing visual inspection.
2. *Advanced Propulsion Research* – With the goal of furthering the commercialization of zero emission vehicles, FTA will evaluate its previously funded low and no emission demonstration programs to better assist both grantees and the industry with technology transfer and capital equipment selection. In addition, FTA will begin a comprehensive program of testing and certifying a range of components specifically for use on low and no emission transit buses.

**Statutory Requirements**

FTA’s Infrastructure Program is not mandated by statute but are discretionary projects within the eligibilities authorized by 49 U.S.C. § 5312.

**Program Alignment with Strategic Goals**

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

DOT’s Strategic goal of Infrastructure looks to invest in infrastructure to ensure mobility and accessibility and to stimulate economic growth, productivity, and competitiveness for American workers and businesses. DOT seeks to facilitate expanded infrastructure development, modernization, and construction in both rural and urban communities by fostering more efficient and collaborative planning and construction techniques, accelerating project approval, leveraging all sources of funding, and promoting innovative financing while maintaining environmental stewardship.



FTA's FY19 Infrastructure research program supports DOT's strategic goals as follows:

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

This program will have a direct impact on rural communities in the form of improved public transit infrastructure, and the overall condition of assets. For example, the infrastructure program will improve transit-related infrastructure to include the use of nano-technology to reinforce concrete to extend its useful life for elevated rails transit structures, bridges, and transit bus stop pads. Developing promising practices for lifecycle maintenance and asset management can help all sizes of transit systems with proven processes to improve operations. New technology buses can help reduce energy costs which, again, supports all sizes of systems. Specific research associated with rural communities' infrastructure issues is an area for expansion in FY 2019.

### **Program Objectives**

Public transit assets need significant investments to maintain state of good repair, and funding constraints for maintaining and improving infrastructure typically require Federal assistance – NTD data suggests that 41% of capital is federally funded. Additionally, pressures on operational costs require public transit agencies to find ways to reduce the lifecycle costs of capital such as energy and maintenance. Thus, the main goal of infrastructure research is to improve deteriorating public transit infrastructure, bring assets up to a state of good repair, and improve lifecycle maintenance by evaluating methods, products, approaches, and practices to develop products or service more efficiently, deploy cutting edge "infrastructure health monitoring" technologies, and create American jobs.

The market challenge is funding and supporting public transportation infrastructure needs. Fare box revenue covers less than 50% of public transit costs. When capital is not maintained or there are not enough infrastructure resources, many issues arise – safety risks occur, levels of service suffer, and riders' satisfaction plummet. It is essential that public transit agencies have a trusted resource and research to provide answers to these critical issues. Federal research provides the venue for addressing these issues without bias – it is the inherent Federal role to provide leadership and information to help public transit agencies succeed. As an example, FTA oversees bus testing and new low and no emission testing centers will provide a way for manufacturers to voluntarily have their products tested. Buses must pass testing at the Altoona Center for Federal funds to be used to purchase them. FTA's infrastructure research team manages these efforts, and can apply lessons learned as well as economies of scale resulting from these Federal programs and investments in infrastructure.

The potential impacts of asset recycling, coupled with the use of Federal government infrastructure incentive payments (up to 15%) to states or local governments, could expand and improve public transit infrastructure and operations/maintenance over both the long and short-term. Current publicly-owned infrastructure and assets includes existing leasable and sellable (privatization) assets that could fund new or expand existing public transit systems. For example, these publicly-owned assets could be waste and water treatment plants, highways/roads (tolling), vacant land or buildings underutilized parking lots and parks, and other similar resources. The recycling of these assets could be applied to new light, heavy, or

commuter rail systems, expanded transit bus operations such as Bus Rapid Transit Systems, or to repair aging public infrastructure such as bridges, tunnels, or rail tracks. Asset recycling provides a reliable and steady revenue stream to expand build new public transit infrastructure.

Another potential impact is the lengthy delays in the permitting process. The delays in the permitting process costs billions, or perhaps trillions, of dollars for both the public and private sectors. Direct costs increase for materials, supplies, and labor during permitting delays. There is also a real public cost to delaying needed infrastructure improvements with older facilities and systems such as aging heavy rail systems and bridges in rural areas. This also greatly reduces the safety of these facilities and systems. Other economic issues with permitting delays include the adverse effects of prolonging inefficiencies and unnecessary pollution from existing and outdated infrastructure. Any effort to rebuild America's public transit systems, roads, bridges, tunnels, energy and manufacturing sectors without substantive permitting reform may increase long-term costs to taxpayers.

## **Research Collaboration Partners**

Given its focus on technology, infrastructure research relies on extensive partnerships with both public and private sector stakeholders. Frequent and constant collaboration is conducted with internal and external stakeholders. Some partners include the Office of the Secretary, Federal Highway Administration (FHWA), National Highway Traffic Safety Administration (NHTSA), Federal Motor Carrier Safety Administration (FMCSA), Federal Railroad Administration (FRA), and to a lesser extent the Intelligent Transportation System (ITS) Joint Program Office (JPO). Other federal partners include the Department of Energy. FTA's infrastructure research program also regularly communicates with others outside of the DOT for common research interests, knowledge exchange, and sharing of resources. In certain instances, private industry has partnered with FTA and transit agencies to provide technical expertise in the form of in-kind labor as well as hardware/software products used in the program-level technology, testing, and/or demonstrations. Important partners also include the testing centers and organizations like CALSTART and the Center for Transportation and the Environment are a key part of external collaboration activities in infrastructure.

## **Technology Transfer (T2)**

As discussed earlier for other FTA research programs, broad partnerships with key stakeholders assist in testing and demonstrating the efficacy of technologies; and deploying and disseminating research. Key organizational partners include research institutions, training partners, non-profit partners, national transportation associations, university transportation centers, transit agencies, state agencies, technical assistance partners, and international partners. FTA's infrastructure research activities, to the extent possible, include collaboration with other modes including FHWA, NHTSA, FRA, FMCSA, and other Federal partners to include the Department of Energy. FTA utilizes strategic planning input from advisory committees such as the Transportation Research Advisory Council (TRAC), and outcomes from TCRP studies and NREL. Major areas for infrastructure research include fuel cell validation, operational plans to integrate electric buses into existing transit fleets, solar rights-of-way, and automation. Findings from infrastructure research is often shared at industry conferences. The annual research report to Congress is another major way that FTA's shares infrastructure results.

As FTA implements a standardized approach for research to practice as part of an FTA-wide, project and program evaluation effort, a prime example of this is reflected in the Fuel Cell Bus and Low and No Emission Vehicle Deployment Programs. The DOE's NREL is conducting uniform evaluations of vehicle deployment projects and their dissemination activities as opposed to each recipient contracting with an

independent evaluator. Programmatic research funds support T2 activities including electronic report production, newsletter creation, and use of social media through FTA's Office of Public Affairs. Infrastructure research results are noted in the annual research report to Congress, the National Transit Library, and the DOT Research Hub.

An important component for future infrastructure research information dissemination is to establish communities of practice and peer-to-peer exchanges. Like other research areas, TRI coordinates important infrastructure research study announcements with FTA's Office of Public Affairs. To promote formal dissemination of infrastructure research findings, FTA posts research results on its website and utilizes social media tools like Facebook and Twitter as well as traditional listservs that send out notices of webinars. In FY 2019, FTA will expand the marketing and promotion of findings through greater use of social networking and outreach with the goal of increasing industry awareness of the short- and long-term benefits of implementing the findings of infrastructure research.

## **Evaluation / Performance Measurement**

The Infrastructure program conducts a comprehensive evaluation on all demonstration projects to measure and assess benefits and outcomes as required by Public Transportation Law at 49 U.S.C. § 5312. An example of an independent evaluator partnering with FTA to track and evaluate a project under the infrastructure program is the National Renewable Energy Lab's (NREL). NREL has a technology validation team that evaluates fuel cell electric buses (FCEBs) to provide comprehensive, unbiased evaluation results of fuel cell bus development and performance compared to conventional baseline vehicles. Transit buses are one of the best early transportation applications for fuel cell technology. Buses operate in congested areas where pollution is already a problem. These buses are centrally located and fueled; highly visible, and subsidized by government. By evaluating the experiences of these early adopters, NREL can determine the status of bus fuel cell systems, and establish lessons learned to aid other fleets in implementing the next generation of these systems. Both the Dept. of Energy and FTA fund NREL's hydrogen and fuel cell evaluations. A joint plan was put in place to manage these evaluations. The program is performing as expected given it is still in early stages of conducting the research and demonstration projects and data collection.

FTA uses infrastructure efficiency and economic competitiveness as measures to evaluate this program. For infrastructure efficiency, FTA seeks to improve the lifecycle maintenance practices by evaluating methods, products, and approaches that promote more efficient asset management, and preservation of federally procured capital. FTA tracks the percent change in lifecycle maintenance costs for maintaining rolling stock. The measure will be tracked annually with a baseline established from FY 2017 data with a goal to have a longitudinal trend tracked over 5 years. To track infrastructure economic competitiveness, FTA will continue to monitor the growth of the low and no emissions bus industry. FTA also counts the increase in US bus manufacturers' product offerings to reflect service expansion and vehicle diversity. The measure is tracked annually with a baseline established from FY 2017 data with a goal to have a longitudinal trend tracked over 5 years.

FTA's Infrastructure program aligns with DOT's Strategic goal of Infrastructure. It addresses the strategic objective of project delivery, planning, environment, funding and finance by prioritizing and targeting Federal investments toward public transportation projects that address high-priority infrastructure and safety needs. The FTA Infrastructure program also furthers the objective of life cycle, preventive maintenance. The program supports restoring public transportation infrastructure and assets to a state of good repair through asset management planning and innovative maintenance strategies. It addresses risk management through research, technical assistance, and targeted funding to ensure that transportation

infrastructure is planned, constructed, and maintained using proven operational and risk management practices. FTA recently completed a Transit Asset Management Guidebook, accessible at <https://www.transit.dot.gov/research-innovation/transit-asset-management-guide-fta-report-no-0098>, that explains what transit asset management is and the business benefits to an agency. The guidebook also supports DOT's strategic objective of system operations and performance. It provides an enterprise asset management framework and business model that agencies can refer to as a best practice. It describes the elements of a transit asset management plan and system reliability. It details, for each major asset class, the major enabling components of asset management—inventory, condition assessment, performance analysis and modeling, risk management, and lifecycle cost management. It guides organizations through the migration from their current baseline to high-performance asset management.

FTA's workforce initiative complements the DOT objective on workforce. Over the last six years, FTA invested almost \$20 million dollars in training, technical assistance, and human resources funding for workforce grants. Many of the projects addressed frontline workforce issues – especially shortages of bus operators and maintenance workers. Once all projects are completed, FTA will disseminate promising findings from that important body of work.

## **Transit Cooperative Research Program (TCRP) Funding Request \$5,000,000**

### **Program Description**

The Transit Cooperative Research Program (TCRP) is established in Federal public transportation law (49 U.S.C. § 5312(i)) and operated through the Transportation Research Board of the National Academy of Sciences. TCRP provides applied research with near-term, practical results addressing key challenges facing the public transportation industry. Recently published research reports addressed critical issues such as public private partnerships, value-capture financing, shared use mobility, rail transit safety, emergency response, and multiagency electronic fare payment systems. TCRP is a critical partner in shaping and sharing information about FTA's public transportation innovation projects, and is a key driver for moving research to practice. TCRP plays a unique role as a national resource for the public transportation industry, where such pooled research can be delivered more cost-effectively. TOPS-selected projects are monitored and supported through a panel of expert practitioners from the industry. The engagement inherent in TCRP studies brings together the transit industry, interested stakeholders, and the public. TCRP's mission is to promote, select, and conduct research and disseminate research findings to improve the practice and performance of public transportation.

### **Program Activities**

1. *Research Project Selection:* Twice yearly, TCRP issues requests for research problem and synthesis statements. The TOPS Committee then meets twice annually to discuss, identify, prioritize research needs, and select approximately 15 problem statements for funding.
2. *Research Project Panel and Solicitation:* Selected statements and project panels are developed by TRB staff, the TCRP project panel reviews solicitation and bids, and FTA liaisons participate in the process to assist TCRP with the release to solicit bids to carry out the research.
3. *Conduct Research:* Proposal submissions are evaluated, a winning proposal is selected, and the TCRP project team oversees the applied research product to offer insights, guidance, and feedback.
4. *Dissemination:* Results are published on the TRCP website, and the American Public Transportation Association, through their J-1 program for TCRP, leads the outreach to promote the results of TCRP project findings.

### **Statutory Requirements**

This program is statutorily mandated in Federal public transportation law (49 U.S.C. § 5312(i)) for FTA to make grants to the National Academy of Sciences carry out activities for public transportation research, development, and technology transfer activities.

TCRP concentrates on applied research projects. The program is directed at problems of an immediate, near-term nature that can be undertaken with moderate research funds. TCRP project-funding levels are typically around \$250,000 per project.

## Program Alignment with Strategic Goals

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

TCRP supports DOT's Strategic Goal of infrastructure, though the program is cross-cutting and often addresses all of DOT's strategic goals. However, because of the strong focus of TCRP to field practical research that aids public transit agencies' operations, this relates to the infrastructure strategic goal and helps to drive economic vitality for America's communities.

TCRP develops research products across several sub-programs: Research Reports, Ideas Deserving Exploratory Analysis, Legal Studies, and Syntheses. Research Reports are further categorized to address emerging practice in: Operations, Service Configuration, Engineering of Vehicles and Equipment, Engineering of Fixed Facilities, Maintenance, Human Resources, Administration, Policy and Planning, and Special Projects.

TCRP has a positive impact on rural communities. TCRP is a unique resource that pools expertise from many providers to create useful tools and materials. Rural transit providers tend to be more limited in resources and technical capacity to conduct their own independent research, though rural formula grants do allow states to allocate funding to research projects. With the TOPS selection process, issues of significant importance to rural communities can be selected, though there is not a provision for a specific amount of funding for research focused on the unique aspects of rural communities. Membership of TCRP's governing board reflects the diversity of the public transportation community, and includes members from rural and rural-serving organizations to inform the project selection process. While many general research reports are applicable to rural contexts (asset management, safety, human resources, etc.) TCRP has published reports with a specific focus on rural operators, some examples include: Methods for Forecasting Demand and Quantifying Need for Rural Passenger Transportation and Toolkit for Estimating Demand for Rural Intercity Bus Services.

## Program Objectives

The stated objectives of the Transit Cooperative Research Program are as follows:

- To identify transit problems in need of research and development (R&D) investigation; and to establish a priority ranking for them.
- To provide an opportunity for transit operators, local government officials, and many other constituents - including construction organizations, financiers, real estate developers, and community representatives - to identify problems and participate in developing appropriate solutions.
- To improve communications, technical information transfer, and dissemination.
- To provide a means of addressing a variety of near-term transit problems in cooperation and in coordination with Federal public transportation research.

The existence of TCRP is related to a market need. There are more than 3,000 organizations across the country that receive FTA funds to provide public transportation. Often, these organizations are lean, and cannot afford to put their limited funding into research unlike private sector transportation organizations who have a profit-based structure.



Despite differences in geography, markets, and organizational capacity, transit providers share many areas of common interest and concern. Building on the National Academies' commitment to objectivity and independence, TCRP meets an important market niche for public transportation research that is directly driven by the public transportation industry.

## **Research Collaboration Partners**

The Transit Cooperative Research Program is a cooperative undertaking characterized by continuous opportunities for public and stakeholder partnership. It is a research program for the public transportation community, guided by the public transportation community, and produces reports of maximum benefit to the public transportation community. The processes described earlier demonstrate the broad reach of the program's partnerships. Each project is managed by industry subject matter experts; projects are selected by a diverse industry committee.

Yearly, TCRP issues a series of public solicitations requesting proposals for research ideas, vets the ideas, then uses full and open competitively to source contractors for selected research projects. Contractor selection is based on: (1) understanding of the problem, (2) research approach, (3) experience of the research team, (4) application of results and implementation plan, (5) plan for participation by disadvantaged business enterprises, and (6) facilities and equipment. Staff and panel members evaluate all proposals based on these criteria. Each research product is guided by a panel of expert practitioners who represent public transportation and related organizations. Solicitations to (self-)nominate to serve on a research panel are public. Determinations are made through TRB to ensure adequate diversity of perspectives. The TCRP governing board publicly conducts an annual process to solicit and select new members. TCRP tracks the number and types of proposals received as well as qualitative panel input throughout the development of the research product. TCRP periodically surveys those serving on panels to gauge levels of satisfaction with the experience.

Key Internal DOT partners include:

- FTA Research Office (lead), FTA Program offices, FTA Regional offices, FTA Office of the Administrator and FTA Office of Communications.
- FTA's Research office informally shares information about TCRP with other modes as appropriate, particularly with peer program managers working with the other cooperative research programs.

Key External non-DOT partners include:

- National Academy of Sciences / Transportation Research Board (NAS / TRB) – serves as the formal host of TCRP to conduct solicitations for research, build expert practitioner panels, manage the production of research deliverables and overall dissemination. As the premier platform for transportation research globally, TRB brings extensive resources to the TCRP.
- American Public Transportation Association (APTA) – Formal partner, signatory of an MOA with TRB and FTA on carrying out the program. APTA administers the Transit Development Corporation, which manages the governance board, the TCRP Oversight and Project Selection (TOPS) Committee. APTA also holds the contract to carry out dissemination activities for TCRP. Given that APTA's membership represents most transit providers, APTA plays a key role in connecting TCRP deliverables with the primary intended audience.

- Conference of Minority Transportation Officials (COMTO) – COMTO has a formal agreement with APTA to carry out a TCRP Ambassadors program, whereby industry professionals are competitively selected to represent TCRP at conferences and meetings to educate the community about TCRP results.
- National Transit Institute (NTI) – NTI supports TCRP dissemination primarily through webinars. There are also instances where NTI course curricula is updated to reflected new ideas and the latest thinking on a given issue, as reflected in TCRP publications.

## **Acquisition/Assistance**

Consistent with Federal transit law, FTA maintains a cooperative agreement with the National Academies Transportation Research Board to host and manage the TCRP program. The TCRP program uses a full and open process to solicit research ideas, and full and open competition to select contractors for research. TCRP research ideas are generated through a public solicitation process. Deliberations take place with the statutorily-mandated governing board. Once the board selects research ideas, TCRP program managers work with research panels (developed through a public solicitation) to draft requests for proposals for the research products, which are publicly competed. The research panels review and select researchers to carry out the work.

Current federal public transportation law authorizes the program at \$5 million each year for FY 2016-2020; and that amount has been appropriated each year through FY 2018. FTA issues yearly cooperative agreements to the National Academy for the TCRP program.

## **Technology Transfer (T2)**

TCRP develops contractor-led research and publishes reports and tracks the downloads of those reports and many other indicators. The transfer of research into practice is primarily through TCRP's through the APTA led J-1 project. Dissemination activities are coordinated through a high-level Strategic Plan for Dissemination and Implementation for the Transit Cooperative Research Program 2017 - 2019.

Key stakeholders for moving TCRP research to practice include:

- Principal Investigators and Research Panelists, TRB and TCRP staff, APTA, FTA, the National Transit Institute, and COMTO are the primary collaborators for dissemination activities.
- TCRP staff administer the overall program,
- TCRP J-1 Panel for Dissemination made up of expert practitioners from the field provides industry feedback and guidance to TCRP and APTA about dissemination practices. The J-1 panel is responsible for drafting TCRP's Strategic Plan for Dissemination.
- APTA holds the TCRP subcontract to deliver most dissemination activities,
- COMTO operates the TCRP Ambassadors program, which competitively selects and trains high-performing transit professionals to represent TCRP at conferences across the country.
- FTA is a major partner on dissemination in concert with the FTA Office of Communications for the promotion of TCRP products and solicitations.

The primary audience for TCRP products is professionals working in the public transportation industry. The recently updated Dissemination Strategic Plan also includes explicit recommendations to broaden stakeholders to better represent the multi-modal nature of public transportation. The Plan also identifies the need to develop better pathways to communicate with individuals who do not attend conferences and

with young professionals. The importance of a strong social media dissemination strategy is a large part of the revamping of J-1 through the new strategic plan.

In addition to J-1 activities, TCRP encourages dissemination planning at the proposal stage. Proposers are encouraged to include a section in their proposals on the applicability of results to transit practice. This section should clearly describe how the anticipated research results can be used to improve transit practices and indicate the expected audience for research results. This process ensures that final research reports are presented appropriately for their intended audience. Research recipients of TCRP are required to report their results in a form that succinctly summarizes the findings for both a busy administrator and transit practitioner. The program has style and organization guides for all research reports.

To ensure maximum and timely distribution of findings, after publication, products are distributed through TRB's distribution system. Announcements of their availability are included in TRB's weekly electronic newsletter, which is sent to more than 65,000 individuals. All TCRP publications are available on the Internet in PDF (portable document format) for immediate, accessible, and free electronic access.

APTA reports on dissemination activities to the J-1 Dissemination Panel on a quarterly basis. The format generally follows that of the Strategic Plan for Dissemination and provides information on any activities undertaken. There is not currently a systematic format for tracking numbers quarter over quarter, however, a format is being developed. Reporting on webinars, which are hosted by TRB and NTI, requires APTA to consolidate registrant / attendee information from multiple sources.

## **Evaluation / Performance Measurement**

TCRP and FTA collaborated extensively over the last year to develop a new set of performance measures. The draft plan was just issued in March and will be reviewed for final approval with the TOPS committee in its June meeting. Currently, TCRP is utilizing the following measures to track performance:

### *Measure: Program Span and Outreach Effectiveness*

- Description: Through conferences, webinars, and project panels, maintain industry and stakeholder engagement. Maintain a high level of public transportation industry and stakeholder participation and involvement in the TCRP Program.
- Calculation methodology: Total number of stakeholders engaged in various TCRP activities involving formulation of research topics to improve the state of public transportation.

### *Measure: TCRP Project Selection Effectiveness*

- Description: Select timely and high priority research projects through the TOPS Committee process to ensure that the most immediate needs of the public transportation industry are selected for research.
- Calculation methodology: Total number of specific projects selected and funding allocation to support those projects through TOPS committee meetings.

### *Measure: TCRP Program Innovation*

- Description: Identify the most significant public transportation needs and determine appropriate applied research through the generation of submitted research problem statements from the public transportation industry and stakeholders.
- Calculation methodology: The annual total number of problem statements submitted to TCRP due to outreach activities and generation of interest.

TCRP track many variables, but it does not conduct a systematic year over year tracking of performance across a series of formalized indicators. TCRP does issue periodic surveys to capture information about the program's longer-term impacts and benefits. The new set of measures, once approved, will set baselines and have a clear set of longitudinal measures.

In addition to the scorecard under development, the program has taken steps to improve over time. TCRP uses feedback from each year to improve on the deliverables for the following years. FTA and TCRP draft a cooperative agreement, which serves as a roadmap for that year. At the end of a quarter, principles meet to discuss what worked well and where to seek improvement. An example of recent progress, is the TCRP Strategic Plan for Dissemination, which required all partners to work cooperatively to overhaul TCRP's outreach strategy for greater efficiency and effectiveness. As an instance, in previous years, final TCRP reports could be downloaded on two different sites – a special site maintained by APTA as well as the TCRP site. Now, all links for downloading reports are on a new, single National Academies Press platform. This makes accessing information much more intuitive; aggregates usage data for easier monitoring; and improves the staff's ability to analyze and report results.

As noted earlier, TCRP research is broad and can align with each DOT goal. However, since TCRP is primarily an applied research program designed to address near-term issues facing the public transportation industry – the program is most closely aligned with DOT's strategic goal of Infrastructure. Many TCRP reports provide invaluable information on asset delivery, planning, funding and finance as well as ways to improve lifecycle/preventive maintenance, and systems operations and performance. TCRP research has even examined workforce issues in the past as well. The TCRP governance committee meets twice annually to discuss, identify, prioritize research needs relevant to the transit industry. TCRP selects research projects as recommended by an independent governing board of public transportation stakeholders. TCRP measures the performance of public transportation systems and identifies targeted investments that have the potential to improve the experience of the traveling public. TCRP 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 also communicates FTA's strategic research goals to its audiences, helping to further extend FTA's reach.

## Section 2 - Program Descriptions, FY 2020

### Mobility Innovation

#### Program Description

The FY 2020 mobility innovation program will build upon the findings of prior years. By FY 2020, MOD sandbox projects should be complete, and the first set of transit automation grants should be obligated and in process. FTA will have several years of data on the new performance measures using the FY 2017 baseline. The program will remain tightly aligned with DOT's Strategic Goal of Innovation. FTA's Mobility Innovation research will continue to strengthen the capacity of transit agencies and communities to navigate the dynamic, evolving landscape of personal mobility. Data should be available on how well the new innovative business models, partnerships, and private-sector solutions have seamlessly improved mobility options for all travelers. FTA will also be able to assess if there were commensurate reductions in costs for public transit agency operations – though the lag time for significant changes would suggest that one year would not be expected to yield significant results.

#### Program Activities – goals for these activities remain consistent with FY 2019

1. *Mobility on Demand (MOD)* – this series of projects are exploring ways to provide travelers with enhanced mobility options; improving travel decision tools; and increasing convenient and seamless travel. MOD projects are testing innovative new operational models in transit agencies such as solutions for the first/last mile; more effective leveraging of existing investments; and improving service quality. FTA is working with MOD stakeholders to promote the transit industry's awareness and support preparedness for MOD, and to understand impediments to implementation. The research will also increase awareness and buy-in from local stakeholders and transportation companies/vendors needed for successful deployments of integrated MOD solutions in communities.
2. *Transit Automation Research* – demonstration programs should be underway, and FTA will be working with grantees to develop detailed statements of work and automation plans. Research may have begun to gather data on use cases. FTA hopes to have a good understanding as well regarding any regulatory or programmatic barriers that need to be addressed.
3. *Accessible Transportation Technologies Research Initiative (ATTRI)* – data should begin to be available for how well new technologies such as accessible data, mobile computing, robotics, artificial intelligence, and object detection, are enhancing independent trip planning and navigation for people with disabilities.
4. *Multi-modal Integrated Universal Payment Systems* – expected level of progress for this area is uncertain for FY 2020. It will be essential that MOD and transit automation research can leverage research into integrated payment options for transit agencies and other mobility providers at the regional and interregional levels.

#### Program Alignment with Strategic Goals

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Mobility Innovation	Improving Mobility

The MOD program will continue to closely align with the DOT strategic goal to lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation's Transportation System. Specifically, MOD projects are developing innovations by providing seed funding so communities can experiment with new approaches then report back to FTA so those findings can inform other public transit agencies' activities. Development of innovation is also supporting the objectives of expanding partnerships and coordination between the public and private sector. Deployment of innovation is furthered by the growth of communities of practice; widespread stakeholder collaboration activities; and broad outreach to support technology integration and technology transfer.

## **Program Objectives**

The primary objectives of FTA's Mobility Research for FY 2020 will remain to:

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

In FY 2020, FTA will be able to assess how well Mobility Innovation research projects improved the efficiency, effectiveness, and quality of public transportation services through adaptation to new mobility options by public transportation providers. FTA will apply the new FTA research evaluation framework that uses public transportation efficiency and effectiveness as measures to track Mobility Innovation program performance. FTA will see if mobility projects improved transit operational efficiency and reduced costs by leveraging public and private assets as well as the development and deployment of innovative technologies. FTA will measure the percent change in the type of service options used by transit agencies that expand service using alternative shared mobility solutions and public private partnerships. The measure is being baselined in FY 2018 through data in the National Transit Database (NTD), and will be tracked annually with a goal to have a longitudinal trend assessed over 5 years. FTA will also record the percent change in the number of public transit agencies that expand service coverage (geographic or temporal) through alternative shared mobility solutions and public private partnerships. The measure will be tracked annually with a baseline established from FY 2017 data from the SUMC map with a goal to have a longitudinal trend tracked over 5 years.

FTA's Mobility Innovation research will continue to identify promising practices in shared services and help transit agencies make the shift to being providers of mobility. New public data access plans should be in place for all grantees which would give FTA access to new data sources. There are some extremely challenging technology issues that must be overcome but with potentially high payoff for travelers – FTA should have a greater understanding of the return on investment and cost benefit for some of these new mobility paradigms. FTA will continue to partner across DOT and with key industry partners such as APTA, CTAA, SUMC, TCRP, ITS America and TransitCenter – many of whom will field their own areas of inquiry into new mobility paradigms in public transportation.



## Safety

### Program Description

In FY 2020, FTA will continue the two major activities in safety research to test the efficacy of new safety technologies to reduce fatalities, injuries, and expand American economic and technological leadership. Some of the major demonstration programs will have findings, so that FTA may be able to make recommendations of the most promising new technologies for enhancing safety. Additionally, research into safety standards should result in a set of new voluntary standards that can improve the safety culture in transit agencies. FTA should be able to build upon SRD results and suggest ways to improve the state of good repair for transit assets. These research activities will illustrate effective safety practices and principles; determine whether transit agencies are implementing recommended practices; and evaluate the impact of those practices on transit safety.

### Program Activities – these areas of focus will remain the same in FY 2020

1. *Safety Research and Demonstration Program* – The Safety Demonstration Program builds a portfolio of demonstration projects that assist transit agencies to 1) improve operational safety, 2) strengthen infrastructure resiliency, and 3) improve the state of good repair for transit assets. This program will add to the current portfolio of innovative safety demonstration projects started under Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery (SRER) Program.
2. *FTA Standards Development Program* – This program covers a variety of public transportation topics with current focus on safety standards development. This safety standards work is a product of the FTA Safety Standards Strategic Plan project. FTA is working with public transportation industry organization(s) in the development of voluntary safety standards. FTA Standards Development Program tasks include a) modification and enhancement of existing standards, b) development of new voluntary standards, and c) expansion and re-establishment of partnerships with Standard Development Organizations (SDOs).

### Program Alignment with Strategic Goals

DOT Strategic Goal	DOT RD&T Critical Transportation Topic
Safety	Promoting Safety

FTA's research will continue to align with DOT's Safety goal to reduce transportation-related fatalities and serious injuries in public transit systems. FTA's systemic safety approach will mitigate risks and encourage the adoption of useful infrastructure and behavior changes that improve safety. FTA will leverage safety data to improve the safety of passengers, employees, emergency responders, and all others who encounter the public transportation system. FTA's Safety research program will continue to focus on demonstrating and deploying transformative technologies and operational procedures through partnership with transit agencies, technology suppliers, and other private sector entities.

### Program Objectives will remain the same in FY 2020

The goals of FTA's Safety research program are to improve public transportation safety, support the Agency's regulatory role, and, finally to develop a comprehensive safety oversight framework. The

program is focused on improving public safety by reducing transit-related injuries, fatalities, safety events, and enhancing system reliability.

## Safety Objectives

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

Without FTA assistance to continue to fund innovations and identify the most promising technologies with real-world assessment of implementation processes, new technologies might not be available or useable. The limited application of these types of safety technologies to a unique public sector system makes private sector investment in these areas lag other transportation safety initiatives such as with cars, so that public sector investment is critical to seeding private sector investments. Partnerships will continue to be critical to maintain technology and multi-modal approaches. FY 2020 projects will build upon continued collaboration with internal and external stakeholders. External safety committees run by the industry will play invaluable roles to educate FTA on important perspectives. CUTR will remain a significant partner as the evaluator and with staff who support FTA as safety subject matter experts.

In FY 2020, FTA will have data to assess the safety efficiency and effectiveness measures to track the program's performance. FTA safety effectiveness is operating systems in a safer manner through application of advanced technologies and innovative practices in safety culture development and human factors. FTA rates the change in public transportation agency deployment rate of advanced safety technologies and voluntary safety standards to track results. The measure will be assessed annually with a baseline established from FY 2017 data with a goal to have a longitudinal trend tracked over 5 years. Improving transit capital and operational efficiency while supporting improved transit system safety is the efficiency measure which will utilize NTD data. To assess overall industry impact, FTA seeks to reduce injuries and fatalities by using innovative technologies that improve worker and rider safety. There is a major lag time between fielding research and having results in the field through the implementation of evidence-based safety technologies. Key safety outcomes serving as proxies to the longer-term result of lower injuries and fatalities, such as the annual increase in the demonstration and deployment of innovative practices or technologies at transit agencies; increases in the adoption of a safety management systems plans; the adoption rate of employee safety reporting systems across the US; and the use of data to improve transit agency safety policies and practices.

## Infrastructure

### Program Description/Activities

In FY 2020, FTA should have significant findings relating to the development and deployment of zero emission transit buses, facilities, and related charging and maintenance technologies. New low and no component bus testing centers could yield important information from which FTA can build additional infrastructure resources for public transit providers to assist them with low and no bus acquisition and maintenance strategies. Asset management projects by FY 2020 should be showcasing new techniques to monitor the health of capital assets.

FTA will have data from advances in technology and new information on the market growth of new buses which will provide important information on the economic impact of FTA's infrastructure research. New projects will build upon FY 2018 and FY 2019 results, and FY 2020 may be a year when FTA should reassess research infrastructure investment areas – perhaps embarking on new research based upon what was learned as the almost \$75 million in grants invested in low and no research concludes.

### Program Activities – current plan is to stay with these areas

1. *Asset Management and Asset Innovation* – FTA will demonstrate “health” monitoring techniques of transit assets using advanced technologies to include sensors and the use of innovative construction techniques and new materials to include nano-particles, recycled polymers, and composites. There are major advances in sensor technology - including: strain gauges and unmanned vehicles (drones); and increased processing power and data analytic tools. As an example, hand-held field devices may now enable real-time health monitoring of fixed and moving infrastructure/assets as a viable alternative or to complement existing visual inspection.
2. *Advanced Propulsion Research* – With the goal of furthering the commercialization of zero emission vehicles, FTA will evaluate its previously funded low and no emission demonstration programs to better assist both grantees and the industry with technology transfer and capital equipment selection. In addition, FTA will begin a comprehensive program of testing and certifying a range of components specifically for use on low and no emission transit buses.

### Program Alignment with Strategic Goals

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

FTA's FY 2020 Infrastructure research program will continue to support DOT's strategic infrastructure goals by:

1. Improving lifecycle maintenance by evaluating methods, products, approaches, and practice to develop products or service more efficiently.
2. Enhancing the environment by providing mechanisms for mainstreaming and determining performance specifications for low and no emission transit bus components through university-based laboratory testing.
3. Improving the build and project approval process.
4. Stimulating economic growth.

## **Program Objectives - will remain the same in FY 2020**

Thus, the main goal of infrastructure research will remain to improve deteriorating public transit infrastructure, bring assets up to a state of good repair, and improve lifecycle maintenance by evaluating methods, products, approaches, and practices to develop products or service more efficiently, deploy cutting edge “infrastructure health monitoring” technologies, and create American jobs.

In FY 2020, FTA will leverage the extensive partnerships and collaboration with both public and private sector stakeholders. It is expected that transit vehicle manufacturers and important partners like CALSTART and the Center for Transportation and the Environment will expand in their roles working with FTA. By FY 2020, FTA expects to overhaul the bus testing program and create a national network of centers of excellence in advanced propulsion – this set of centers will add significant value to the public transit industry and to FTA.

FTA’s infrastructure research activities with FHWA, NHTSA, FRA, FMCSA, and other Federal partners including the Department of Energy, as well as outcomes from TCRP studies and the National Renewable Energy Labs will help refine infrastructure research findings. With so many significant investments in infrastructure research ending by FY 2020, a major area of focus for FTA will be research to practice and technology transfer to ensure that the public transit industry benefits from these investments.

Results from NREL evaluations and technology validations team of fuel cell electric buses (FCEBs) will provide comprehensive, unbiased results of fuel cell bus development and performance compared to conventional baseline vehicles to aid public transit agency acquisition decisions. The new FTA research evaluation framework will be applied to assess infrastructure research efficiency and economic competitiveness. For infrastructure efficiency, FTA will report on whether there was an improvement in lifecycle maintenance practice approaches that promote more efficient asset management, and preservation of federally procured capital. FTA will verify whether there was a percent change in lifecycle maintenance costs for maintaining rolling stock and FTA will continue to monitor the growth of the low and no emissions bus industry.

## Transit Cooperative Research Program (TCRP)

**Program Description – this statutory program will remain unchanged in FY 2020 except there will be new problem statements and research agreements finalized**

The Transit Cooperative Research Program (TCRP), operated through the Transportation Research Board of the National Academy of Sciences, is an applied contract research program manages near-term, practical research that addresses key challenges facing transit agencies. An independent board comprised of key public transit industry stakeholders selects projects to ensure that research projects responds to the most pressing needs of the industry – the TCRP Oversight and Project Selection (TOPS) committee. Recently published research reports addressed critical issues such as public private partnerships, value-capture financing, shared use mobility, rail transit safety, emergency response, and multiagency electronic fare payment systems. TCRP is a critical partner in shaping and sharing information about FTA’s public transportation innovation projects, and is a key driver for moving research to practice. TCRP plays a unique role as a national resource for public transportation agencies whose operations are usually so lean as to make individualized research activities cost prohibitive. TOPS selected projects are monitored and supported through a panel of expert practitioners from the industry. The engagement inherent in TCRP studies brings together the transit industry, interested stakeholders, and the public. TCRP is a trusted and enduring forum for the transit community to share ideas and best practices to improve public transportation in communities across the country. TCRP’s mission is to promote, select, and conduct research and disseminate research findings to improve the practice and performance of public transportation. TCRP disseminates research findings in cooperation with its TCRP J-1, Dissemination and Implementation of TCRP Research Findings, panel. J-1 uses various dissemination means including the National Academies Press database for publications; Transportation Research Board platforms; and through formal partnerships with the APTA, the Conference of Minority Transportation Officials (COMPTO), and the National Transit Institute (NTI). As an example, APTA’s main website has links for TCRP projects, and NTI regularly does webinars on TCRP research findings.

### Program Activities

1. *Research Project Selection:* Twice yearly, TCRP issues requests for research problem and synthesis statements. The TOPS Committee then meets twice annually to discuss, identify, prioritize research needs, and select approximately 15 problem statements for funding.
2. *Research Project Panel and Solicitation:* Selected statements and project panels are developed by TRB staff, the TCRP project panel reviews solicitation and bids, and FTA liaisons participate in the process to assist TCRP with the release to solicit bids to carry out the research.
3. *Conduct Research:* Proposal submissions are evaluated, a winning proposal is selected, and the TCRP project team oversees the applied research product to offer insights, guidance, and feedback.
4. *Dissemination:* Results are published on the TRCP website, and the American Public Transportation Association, through their J-1 program for TCRP, leads the outreach to promote the results of TCRP project findings.

## Program Alignment with Strategic Goals

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

TCRP supports DOT's Strategic Goal of infrastructure, though the program is cross-cutting and often addresses all of DOT's strategic goals. However, because of the strong focus of TCRP to field practical research that aids public transit agencies' operations, this relates to the infrastructure strategic goal and helps to drive economic vitality for America's communities.

TCRP develops research products across several sub-programs: Research Reports, Ideas Deserving Exploratory Analysis, Legal Studies, and Syntheses. Research Reports are further categorized to address emerging practice in: Operations, Service Configuration, Engineering of Vehicles and Equipment, Engineering of Fixed Facilities, Maintenance, Human Resources, Administration, Policy and Planning, and Special Projects.

## Program Objectives

The objectives of the Transit Cooperative Research Program are:

1. To identify transit problems in need of research and development (R&D) investigation; and to establish a priority ranking for them.
2. To provide an opportunity for transit operators, local government officials, and many other constituents - including construction organizations, financiers, real estate developers, and community representatives - to identify problems and participate in developing appropriate solutions.
3. To improve communications, technical information transfer, and dissemination.
4. To provide a means of addressing a variety of near-term transit problems in cooperation and in coordination with Federal public transportation research.

The Transit Cooperative Research Program is a cooperative undertaking characterized by continuous opportunities for public and stakeholder partnership. It is a research program for the public transportation community, guided by the public transportation community, and produces reports of maximum benefit to the public transportation community. The processes described earlier demonstrate the broad reach of the program's partnerships. Each project is managed by industry subject matter experts; projects are selected by a diverse industry committee; and research to practice is driven by a cooperative agreement with an industry association – APTA.

Key Internal DOT partners include:

- FTA Research Office (lead), FTA Program offices, FTA Regional offices, FTA Office of the Administrator and FTA Office of Communications.
- FTA's Research office informally shares information about TCRP with other modes as appropriate, particularly with peer program managers working with the other cooperative research programs.



Key External non-DOT partners include:

- National Academy of Sciences / Transportation Research Board (NAS / TRB) – serves as the formal host of TCRP to conduct solicitations for research, build expert practitioner panels, manage the production of research deliverables and overall dissemination. As the premier platform for transportation research globally, TRB brings extensive resources to the TCRP.
- American Public Transportation Association (APTA) – Formal partner, signatory of an MOA with TRB and FTA on carrying out the program. APTA administers the Transit Development Corporation, which manages the governance board, the TCRP Oversight and Project Selection (TOPS) Committee. APTA also holds the contract to carry out dissemination activities for TCRP. Given that APTA's membership represents most transit providers, APTA plays a key role in connecting TCRP deliverables with the primary intended audience.
- Conference of Minority Transportation Officials (COMTO) – COMTO has a formal agreement with APTA to carry out a TCRP Ambassadors program, whereby industry professionals are competitively selected to represent TCRP at conferences and meetings to educate the community about TCRP results.
- National Transit Institute (NTI) – NTI supports TCRP dissemination primarily through webinars. There are also instances where NTI course curricula is updated to reflected new ideas and the latest thinking on a given issue, as reflected in TCRP publications.

In FY 2020, TCRP will have one year utilizing a new performance scorecard verified by the TOPS committee in June of 2018. This scorecard expects to track the below measures; however, slight modifications may occur between the time this FTA AMRP is completed and the final measures are adopted.

*Measure: Program Span and Outreach Effectiveness*

- Description: Through conferences, webinars, and project panels, maintain industry and stakeholder engagement. Maintain a high level of public transportation industry and stakeholder participation and involvement in the TCRP Program.
- Calculation methodology: Total number of stakeholders engaged in various TCRP activities involving formulation of research topics to improve the state of public transportation.

*Measure: TCRP Project Selection Effectiveness*

- Description: Select timely and high priority research projects through the TOPS Committee process to ensure that the most immediate needs of the public transportation industry are selected for research.
- Calculation methodology: Total number of specific projects selected and funding allocation to support those projects through TOPS committee meetings.

*Measure: TCRP Program Innovation*

- Description: Identify the most significant public transportation needs and determine appropriate applied research through the generation of submitted research problem statements from the public transportation industry and stakeholders.
- Calculation methodology: The annual total number of problem statements submitted to TCRP due to outreach activities and generation of interest.