2021 Program Report

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program

January 2024

U.S. Department of Transportation

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Foreword

The Fixing America's Surface Transportation Act or "FAST Act" established the Advanced Transportation Congestion Management Technologies Deployment (ATCMTD) Program to make competitive grants for the deployment of advanced transportation technologies. The law directs that, beginning 3 years after the first grant award, and annually thereafter, the Secretary of Transportation shall post on the U.S. Department of Transportation (DOT) Website a report about the ATCMTD Program (Section 6004 of the FAST Act (Pub. L. 114-94), codified at 23 U.S.C. 503(c)(4)(G)). This report fulfills that reporting requirement. The report describes the effectiveness of grantees in meeting their projected deployment plans, as well as findings on the safety, mobility, environmental, operational efficiency, and other impacts of the technology deployments. It presents an overview of Fiscal Year (FY) 2016, FY 2017, FY 2018, FY 2019, and FY 2020 ATCMTD projects with information as of March 31, 2021, including key technologies grantees are planning to deploy. It also highlights performance measures grantees are using, and initial grantee insights and lessons learned with respect to their technology deployments.

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LIST OF ACRONYMS

Acronym	Definition
ACTION	Advanced Connected Transportation Infrastructure and Operations Network
AI	artificial intelligence
AIITMS	Artificial Intelligence Enhanced Integrated Transportation Management System
ATCMTD	Advanced Transportation and Congestion Management Technologies Deployment
API	application programming interface
AV	automated vehicle
CAD	computer-aided dispatch
CCTV	closed-circuit television
CV	connected vehicle
C-V2N	cellular vehicle-to-network
C-V2X	cellular vehicle-to-everything
CVPD	Connected Vehicle Pilot Demonstration
DOT	United States Department of Transportation
DSRC	Dedicated Short Range Communication
DSS	decision support systems
FAST Act	Fixing America's Surface Transportation Act
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FMVSS	Federal Motor Vehicle Safety Standards
FRATIS	Freight Advanced Traveler Information System
FY	fiscal year
ICM	integrated corridor management
ITS	intelligent transportation system
IGA	intergovernmental agreement
LED	light-emitting diode
ML	machine learning
MOD	Mobility on Demand
NITTEC	Niagara International Transportation Technology Coalition
NHTSA	National Highway Traffic Safety Administration
NOFO	Notice of Funding Opportunity
OBU	on-board unit
RFID	radio frequency identification
RFP	request for proposal
RSU	roadside unit
RTA	Regional Transit Authority
SCMS	Security Credential Management System
SPaT	signal phase and timing

SOV	single occupancy vehicle
TMC	traffic management center
TSMO	Transportation Systems Management and Operations
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle
VLAN	virtual local area networks

EXECUTIVE SUMMARY

BACKGROUND

This report is the second program report on the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program. The multi-year, comprehensive surface transportation reauthorization Fixing America's Surface Transportation (FAST) Act established, among other programs, the ATCMTD Program, which funds grantees to deploy advanced technologies to improve safety, efficiency, system performance, and infrastructure return on investment.[1] The law sets aside $60 million dollars each fiscal year (FY), from FY 2016 through FY 2020 for the grant awards,[2] and requires the U.S. Department of Transportation (DOT) to award grants each year to at least 5 and no more than 10 eligible entities.[3]

The FAST Act outlines key reporting requirements for the grantees, including annual reports to the Secretary of Transportation.[4] These reporting requirements allow DOT to understand the outcomes of grantees' deployments, providing insight on which technologies and types of projects are most effective at advancing FAST Act goals of improving transportation safety, efficiency, and system performance. In addition, the FAST Act prescribes that the DOT must make publicly available a program report beginning 3 years after the first grant award, and annually thereafter.[5] The purpose of the program report is to provide information on the effectiveness of grantees in meeting their projected deployment plans. As specified in the FAST Act, the program report should include data on impacts related to:

- Traffic-related fatalities and injuries;
- Traffic congestion and improved travel time reliability;
- Transportation-related emissions;
- Multimodal system performance;
- Access to transportation alternatives;
- Public access to real-time integrated traffic, transit, and multimodal transportation information to make informed travel decisions;
- Cost savings to transportation agencies, businesses, and the traveling public; and
- Other benefits to transportation users and the public.[6]

[1] FAST Act § 6004; 23 U.S.C. 503(c)(4).
[2] FAST Act § 6004; 23 U.S.C. 503(c)(4)(I)(i).
[3] FAST Act § 6004; 23 U.S.C. 503(c)(4)(D)(i).
[4] FAST Act § 6004; 23 U.S.C. 503(c)(4)(F).
[5] FAST Act § 6004; 23 U.S.C. 503(c)(4)(G).
[6] FAST Act § 6004; 23 U.S.C. 503(c)(4)(G)(i-viii).

STATUS OF GRANT AWARDS

Unless otherwise specified, information included in this report is as of March 31, 2021. The ATCMTD Program has awarded 48 grants through FY 2020, including 8 in FY 2016, 10 in FY 2017, 10 in FY 2018, 10 in FY 2019, and 10 in FY 2020.[7] Representing a diverse set of metropolitan and rural areas located across the U.S., the grantees are deploying a range of advanced technologies, including connected vehicle (CV) applications, automated vehicles (AV), adaptive signal systems, integrated corridor management (ICM), real-time traveler information systems, green technologies (e.g., electric vehicles), artificial intelligence/machine learning, and infrastructure maintenance and monitoring systems, among other technologies.

All grantees in FYs 2016, 2017, 2018, and 2019 executed their agreements. In addition, all grantees in FYs 2016 and 2017 received funding obligations. As of March 31, 2021, 8 of the 10 FY 2018 grantees have received funding obligations, and 6 of the 10 FY 2019 grantees have received funding obligations. The Federal Highway Administration (FHWA) has conducted kickoff meetings with all FY 2020 grantees and is working with these grantees to execute their agreements. Chapter 2 contains lists that illustrate the grant awards in each fiscal year.

SUPPORT TO GRANTEES

The FHWA provides crosscutting project support to all grantees through a variety of mechanisms. The FHWA-organized Early Deployer Cohort Program is a voluntary roundtable of 7 grantees (with an additional 18 grantees who chose to be informal members) that meets monthly via a Webinar conference to provide status updates, share technical knowledge, and exchange information about grantees' challenges and lessons learned.[8] In addition, FHWA provides performance measurement support and has prepared a report, *Evaluation Methods and Techniques: Advanced Transportation and Congestion Management Technologies Deployment Program,* designed to assist grantees in evaluating their projects.[9] The FHWA also responds to any grantee requests for information and shares these responses with other grantees, if applicable.

STATUS OF PERFORMANCE MEASUREMENT

As of March 31, 2021, one grantee, Greater Cleveland Regional Transit Authority (RTA), has completed its project and submitted a draft Final Report that is under FHWA review. The RTA implemented a new on-board and integrated communications system, replacing its outdated

[7] For two grantees, Ada County Highway District, Idaho (FY 2017) and Greenville, South Carolina, (FY 2017), FHWA and the grantees mutually agreed to terminate the grant. For both projects, the obligated funds were de-obligated (no ATCMTD funds were incurred for either of these projects).

[8] Informal members of the Early Deployer Cohort Program attend monthly meetings but do not present at the meetings or share status updates.

[9] *Evaluation Methods and Techniques: Advanced Transportation and Congestion Management Technologies Deployment Program:* https://ops.fhwa.dot.gov/publications/fhwahop19053/index.htm

technology with new features, including state-of-the-art vehicle alarms, priority cellular service, new radio communications towers, and a turn-by-turn navigations system. As a result of the new system's deployment, RTA reported that they experienced improvements in systems operations and real-time traveler information. The RTA also noted that the provision of complimentary Wi-Fi service on all fixed route and rail vehicles has enhanced the user experience, providing potential equity benefits.[10]

Most grantees, however, are in the planning phase of their deployment process, working on activities such as stakeholder engagement, system documentation (e.g. concept of operations), and technology procurement. Several projects have begun testing and deploying technology applications. Based on grantees' reporting as of March 2021, two grantees were deploying at least one project component, and six grantees were piloting or testing project technologies.

Grantees are using a range of performance measures (as described in their annual reports and evaluation plans) to assess the benefits of their deployments. The performance measures tend to focus most heavily on improved mobility and safety, as well as reduced emissions. Grantees also provide performance measures for enhancing access to transportation alternatives, integrating real-time information, improving equity, and improving system performance and operational efficiencies.

INSIGHTS ON GRANTEES' CHALLENGES AND LESSONS LEARNED

This report also highlights the grantees' challenges, lessons learned, and recommendations that grantees described in their quarterly reports, annual reports, and evaluation plans. Recommendations are for multiple audiences, including FHWA, grantees, other deployers, and potential ATCMTD applicants.

Grantees frequently mentioned the challenges associated with two significant events in FYs 2020 and 2021, namely the COVID-19 Pandemic and the Federal Communications Commission (FCC) action regarding the Safety Band. These events primarily impacted schedule, staffing, and cost. Grantees mentioned other challenges, categorized according to the following key themes:

- Institutional issues (stakeholder/agency coordination; Federal grant requirements/procurement processes; staffing; evaluation)
- Technical issues (technical and standards availability and maturity; equipment issues)
- Cost
- Local/External

In addition, grantees provided lessons learned and recommendations primarily related to institutional and technical issues.

[10] Greater Cleveland RTA ATCMTD Final Report

About this Report

FAST Act Section 6004, codified at 23 U.S.C. 503(c)(4), requires the development of this program report. The law directs that beginning 3 years after the first grant award, and annually thereafter, the Secretary of DOT shall post on the DOT Website an ATCMTD Program report that describes the effectiveness of grant recipients in meeting their projected deployment plans. Per the FAST Act Section 6004, codified at 23 U.S.C. 503(c)(4)(G), the report shall include data on how the program has:

- Reduced traffic-related fatalities and injuries;
- Reduced traffic congestion and improved travel time reliability;
- Reduced transportation-related emissions;
- Optimized multimodal system performance;
- Improved access to transportation alternatives;
- Provided the public with access to real-time integrated traffic, transit, and multimodal transportation information to make informed travel decisions;
- Provided cost savings to transportation agencies, businesses, and the traveling public;
- Provided other benefits to transportation users and the general public.

This report summarizes program findings for grants awarded in FYs 2016 through 2019.

CHAPTER 1. INTRODUCTION

This report is the second program-level report on the ATCMTD Program.[11] The FAST Act, a Federal law providing long-term funding for surface transportation infrastructure planning and investment from FY 2016 through FY 2020, established the ATCMTD Program, stating:

…the Secretary [of Transportation] shall establish an advanced transportation and congestion management technologies deployment initiative to provide grants to eligible entities to develop model deployment sites for large scale installation and operation of advanced transportation technologies to improve safety, efficiency, system performance, and infrastructure return on investment.[12]

BACKGROUND

The ATCMTD Program funds grantees to deploy advanced technologies in support of FAST Act safety, mobility, environmental impact, and operational efficiency goals.[13] The law sets aside $60 million each fiscal year for the grant awards,[14] with the Federal share of funding not to exceed 50 percent of the total cost of the project.[15] The law requires DOT to award grants each year to at least 5 and no more than 10 eligible entities, with not more than 20 percent

[11] Findings for FY 2020 grantees were not available at the time of writing this report, so only the summaries of FY 2020 grantee deployments are provided.
[12] FAST Act § 6004; 23 U.S.C. 503(c)(4).
[13] FAST Act § 6004; 23 U.S.C. 503(c)(4)(A).
[14] FAST Act § 6004; 23 U.S.C. 503(c)(4)(I)(i).
[15] FAST Act § 6004; 23 U.S.C. 503(c)(4)(J).

of the funds each year to a single entity. The awards must be diverse with respect to the technologies being deployed and geographic location.[16] In addition, the law requires that applicants complete an application with a technology deployment plan, quantifiable system performance objectives, anticipated results and benefit projections, a plan for partnering with other institutions, and an explanation of how applicants will leverage existing technology and infrastructure for the project.[17]

GRANTEE REPORTING REQUIREMENTS

The FAST Act outlines a number of key reporting requirements for grantees, including annual reports to the Secretary of Transportation.[18] The reporting requirements allow FHWA to understand the impact of grantees' deployments, providing insight on which technologies and types of projects are most effective at advancing FAST Act goals of improving transportation safety, efficiency, and system performance. The grantees can also use the information to improve operations of their deployments. The grantees' reporting feeds directly into this program report, allowing other State and local entities to learn from grantee successes and challenges when executing their own advanced technology deployments.

The sections below summarize grantees' key reporting requirements.

Quarterly Reports

All grantees must submit quarterly reports to FHWA, which include descriptions of current work completed and work planned for the upcoming quarter, status of procurements and key milestone dates, any significant problems encountered, tabulated costs, work performed in support of DOT goals, and any budget revisions.

Annual Reports

One year after each grantee completes its executed grant agreement, and each year thereafter, the law requires that grantees submit a report to the Secretary (referred to as "annual report" in this document) that describes deployment impacts, including:[19]

- Project deployment and operational costs compared to the benefits and savings the project provides
- Data on whether the project has helped reduce traffic crashes, congestion, costs, and other benefits of the deployed systems

[16] FAST Act § 6004; 23 U.S.C. 503(c)(4)(D).
[17] FAST Act § 6004; 23 U.S.C. 503(c)(4)(C).
[18] FAST Act § 6004; 23 U.S.C. 503(c)(4)(F).
[19] FAST Act § 6004; 23 U.S.C. 503(c)(4)(F).

- Data on the effectiveness of measuring and improving transportation system performance through the deployment of advanced technologies
- The efficacy of providing real-time integrated traffic, transit, and multimodal transportation information to the public to make informed travel decisions
- Lessons learned and recommendations for future deployment strategies to optimize transportation efficiency and multimodal system performance

Evaluation Plans

As part of their applications, many grantees proposed to develop evaluation plans, which cooperative agreements incorporated after execution. Beginning in FY 2018, it became mandatory for grantees to create evaluation plans. Evaluation plans outline project goals, evaluation methods and design, performance measures, data collection procedures, and evaluation risks.[20]

SUPPORT TO GRANTEES

The FHWA provides performance measurement support to the grantees to assist them in meeting their reporting requirements. In addition, through the Early Deployer Cohort Program outlined below, FHWA provides technical assistance to help grantees overcome any challenges or issues they may be facing in their deployments. The FHWA also responds to any grantee requests for direction. If FHWA learns information from one grantee that applies to other grantees, it shares the information.

Performance Measurement Support

The FHWA provided grantees with an annual report template that they are encouraged to use in fulfilling this evaluation plan reporting requirement (see Appendix A). The annual report template contains four sections: The **Introduction and Overview** section asks grantees to provide a project description and indicate the technologies they are deploying and the project's goals. The **Evaluation/Research Activities** section asks grantees to list their performance measures and research activities by goal area. The **Findings** section requests information on grantees' findings (tied to performance measures). The **Wrap Up** section presents grantees with the following series of questions:

- How is the project doing with respect to meeting original expectations (i.e., as stated in the project proposal)? Note here any *major* deviations or changes in scope from the original proposal due to either project-driven outcomes or other unforeseen challenges.

[20] Beginning with FY 2018 awards, all grantees are required to prepare evaluation plans. FHWA Notice of Funding Opportunity No. 693JJ318NF00010: https://www.grants.gov/web/grants/view-opportunity.html?oppId=303763

- Are there any aspects of your project that you consider cutting-edge, noteworthy, or innovative?

- How do deployment and operational costs of the project compare to the benefits and savings the project provides (i.e., can you provide an objective benefit cost analysis or alternate subjective comparison?)

- To date, what are lessons learned from your deployment, specifically regarding future deployment strategies to optimize transportation efficiency and multimodal system performance? Please note lessons learned with respect to challenges in technology deployment (e.g., technical, institutional, etc.), research (e.g., performance measurement), or other lessons learned.

- What recommendations can you provide regarding future deployment strategies in this/these area(s)?

To assist grantees in preparing their evaluation plans and conducting their evaluations, FHWA provided grantees with an "Evaluation Checklist" — a high-level list of issues and topics that grantees should consider when preparing their evaluation plans. In addition, FHWA has produced the following report, *Evaluation Methods and Techniques: Advanced Transportation and Congestion Management Technologies Deployment Program,* to assist grantees in developing credible evaluations that measure the impacts of their technology deployments.[21] The document provides an overview of evaluation design and performance measurement and includes chapters related to specific methods (benefit cost analysis, survey design, and emissions analysis), as well as a limited set of technologies that are either being commonly deployed among grantees or where additional technical assistance would be particularly useful (connected vehicles, AVs), and adaptive signal control).

Early Deployer Cohort Program

The FHWA has been providing support to grantees through the Early Deployer Cohort Program, a voluntary roundtable of 7 grantees (with 18 additional grantees who chose to be informal members) that meets monthly via Webinar conference to provide status updates and share information about their progress, challenges, and lessons learned. The Early Deployer Cohort Program has been a resource for connecting grantees facing similar technical and institutional challenges.

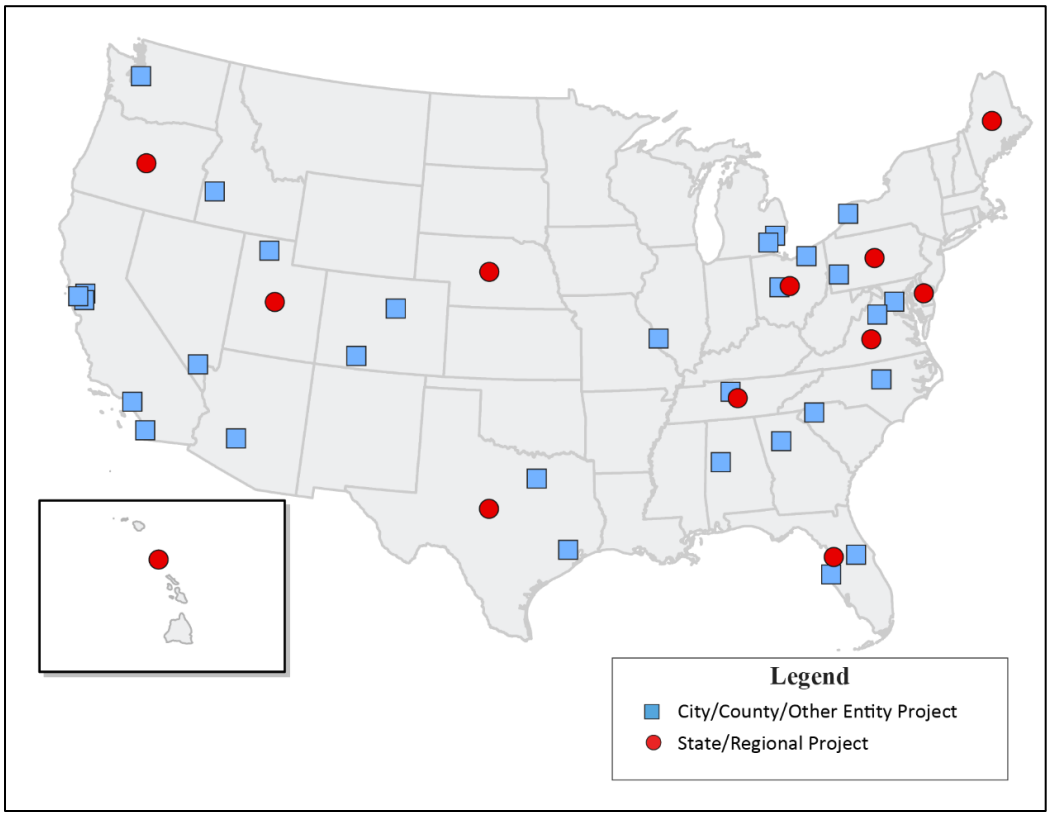
The FHWA modeled the ATCMTD Early Deployer Cohort Program on a similar program administered as part of the Connected Vehicle Pilot Demonstration (CVPD) Program, which began in 2015 and is still ongoing. Based on the success of the CVPD Cohort Program, the

[21] *Evaluation Methods and Techniques: Advanced Transportation and Congestion Management Technologies Deployment Program:* https://ops.fhwa.dot.gov/publications/fhwahop19053/index.htm

ATCMTD Program adopted the same model. The FHWA tailors the topics addressed at the meetings to the needs and interests of the grantees and has developed a file-sharing site for the exchange of relevant resources.

CHAPTER 2. OVERVIEW OF GRANTEE PROJECTS

This chapter provides a general overview of the grantee projects awarded through FY 2020. The ATCMTD Program has awarded 48 grants as of March 31, 2021, including 8 in FY 2016, 10 in FY 2017, 10 in FY 2018, 10 in FY 2019, and 10 in FY 2020.[1] The grantees represent a diverse array of U.S. metropolitan and rural areas, as shown in table 1. All grantees in FYs 2016, 2017, 2018, and 2019 have executed their agreements. In addition, all grantees in FYs 2016 and 2017 received funding obligations. As of March 31, 2021, 8 of the 10 FY 2018 grantees have received funding obligations, and 2 of the 10 FY 2019 grantees have received funding obligations. The FHWA has conducted kickoff meetings with all FY 2020 grantees and is working with these grantees to execute their agreements.



Source: FHWA

Figure 1. Map. Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program Grantees.[2]

[1] For two grantees, Ada County Highway District, Idaho, (FY 2017) and Greenville, South Carolina, (FY 2017), FHWA and the grantees mutually agreed to terminate the grant. For both projects, the obligated funds were de-obligated (no ATCMTD funds were incurred for either of these projects).

[2] See Projects by Fiscal Year for a complete list of projects.

PROJECTS BY FISCAL YEAR

The lists below identify each of the project grantees by Fiscal Year. Each bullet point contains the project name, followed by the lead entity grantee in italics. For brief descriptions about each project, please see Appendix B.

FY 2016 Awards

The ATCMTD Program awarded eight grants in FY 2016:

- Freight Advanced Traveler Information System, *Los Angeles County Metropolitan Transportation Authority*
- City of San Francisco Advanced Transportation and Congestion Management Technologies Deployment Initiative, *San Francisco Municipal Transportation Agency*
- Los Angeles DOT Implementation of Advanced Technologies to Improve Safety & Mobility with the Promise Zone, *Los Angeles Department of Transportation*
- Denver Smart City Program, *City and County of Denver*
- A Connected Region: Moving Technological Innovations Forward in the Niagara International Transportation Technology Coalition (NITTEC) Region, *Niagara Frontier Transportation Authority*
- Marysville, OH 33 Smart Mobility Corridor, *Union County Ohio, City of Marysville and City of Dublin*
- SmartPGH, *City of Pittsburgh*
- ConnectSmart: Connecting Transportation Systems Management and Operations (TSMO) and Active Demand Management, *Texas Department of Transportation*

FY 2017 Awards

The ATCMTD Program awarded 10 grants in FY 2017:

- Loop 101 Mobility Project, *Arizona Department of Transportation*
- Global Opportunities at the Port of Oakland Freight Intelligent Transportation System, *Alameda County Transportation Commission*
- Connecting the East Orlando Communities, *Florida Department of Transportation*
- Ada County Highway District SMART Arterial Management, *Ada County Highway District*
- Improving Safety and Connectivity in Four Detroit Neighborhoods, *City of Detroit*
- Connecting Cleveland Project, *Greater Cleveland Regional Transit Authority*
- Greenville Automated (A-Taxi) Shuttles, *County of Greenville*
- The Texas Connected Freight Corridors Project, *Texas Department of Transportation*
  Truck Reservation System and Automated Work Flow Data Model (Virginia), *Virginia Port Authority*

- Multimodal Integrated Corridor Mobility for All, *City of Seattle Department of Transportation*

FY 2018 Awards

The ATCMTD Program awarded 10 grants in FY 2018:

- Bay Area Mobility-On-Demand Project, *Contra Costa Transportation Authority*
- Advanced Connected Transportation Infrastructure and Operations Network (ACTION), *University of Alabama*
- Wolf Creek Pass Advanced Technology Deployment, *Colorado Department of Transportation*
- Artificial Intelligence Enhanced Integrated Transportation Management System (AIITMS) Deployment Program, *Delaware Department of Transportation*
- GDOT Connected Vehicles, *Georgia Department of Transportation*
- Multi-State Rural Integrated Corridor Management (I-80), *Nebraska Department of Transportation*
- Oregon Smart Mobility Network, *Oregon Department of Transportation*
- Work Zone Reservation and Traveler Information System, *Pennsylvania Department of Transportation*
- I-10 Corridor Coalition Truck Parking Availability System (I-10 Corridor Coalition TPAS), *Texas Department of Transportation*
- Utah Connected, *Utah Department of Transportation*

FY 2019 Awards

The ATCMTD Program awarded 10 grants in FY 2019:

- MWCOG: Deployment of Personalized and Dynamic Travel Demand Management Technology in the Washington, D.C.-Baltimore, MD-Richmond, VA Megaregion, *Metropolitan Washington Council of Governments*
- Florida Department of Transportation: I-4 Florida's Regional Advanced Mobility Elements, *Florida Department of Transportation*
- Hawaii Department of Transportation: Implementing Cellular V2X Technology to Improve Safety and ITS Management in Hawaii, *Hawaii Department of Transportation*
- Michigan Department of Transportation: Intelligent Woodward Corridor Project, *Michigan Department of Transportation*
- Missouri Department of Transportation: I-270 Predictive Layered Operation Initiative, *Missouri Department of Transportation*
- North Carolina Department of Transportation: Multimodal Connected Vehicle Pilot, *North Carolina Department of Transportation*
- Ohio Department of Transportation: DriveOhio I-70 Truck Automation Corridor, *Ohio Department of Transportation*

- Tennessee Department of Transportation: Artificial Intelligence-Powered Decision Support Tools for Integrated Corridor Management, *Tennessee Department of Transportation*
- Virginia Department of Transportation: Artificial Intelligence Meets Integrated Corridor Management: Realizing the Next Generation of Regional Mobility, *Virginia Department of Transportation*
- Washington Department of Transportation: Deployment of the Washington State Virtual Coordination Center for Multimodal Integrated Corridor Management, *Washington Department of Transportation*

FY 2020 Awards

The ATCMTD Program awarded 10 grants in FY 2020:

- Advancing Connectivity and the Economy Through Technology in the San Diego Region, *San Diego Association of Governments*
- Pinellas Connected Community, *Pinellas County Department of Public Works*
- Emergency Vehicle Preemption Using Connected Vehicle Technology, *Georgia Department of Transportation*
- Maine Advanced Signal Control and Connected Vehicle System for Safe, Efficient and Equitable Rural Transportation (MAST) Project, *Maine Department of Transportation*
- Smart Intersections: Paving the Way for a National Connected and Automated Vehicles Deployment, *University of Michigan*
- Integrated Safety Technology Corridor, *Regional Transportation Commission of Southern Nevada*
- Charlotte Avenue/Dr. Martin L King, Jr Blvd Transit Headways and Congestion Management, *Metro Government of Nashville & Davidson County, Tennessee (Public Works Department)*
- SM Wright Smart Corridor, *City of Dallas*
- Utah Broadly Connected, *Utah Department of Transportation*
- Autonomous Truck Ready, *Virginia Port Authority*

SUMMARY OF TECHNOLOGY DEPLOYMENTS

The ATCMTD grants awarded from FY 2016 through FY 2020 support the deployment of a range of advanced transportation technologies. Some of the key technologies include connected vehicles (CV) and connected infrastructure; real-time traveler information; integrated corridor management (ICM) and decision support systems (DSS); infrastructure maintenance and monitoring technologies; adaptive traffic signal control; artificial intelligence (AI), machine learning (ML), and advanced analytics; AVs; and green technology (e.g., electric vehicles). Table 1 highlights the number of deployment projects for each of these key technologies.[3] Many

[3] Table 1 is not an exhaustive list; it represents the most prevalent technologies being deployed.

projects deploy more than one technology. For a more detailed list of the deployed technologies in the projects, please see Appendix B.

Table 1. Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grantee technology deployments, Fiscal Year 2016 – Fiscal Year 2020.[4]

Technology	Number of Projects
CVs/Connected Infrastructure	38
Real-Time Traveler Information	37
Integrated Corridor Management (ICM) /Decision Support Systems (DSS)	22
Infrastructure Maintenance/Monitoring	11
Adaptive Signals	11
Artificial Intelligence/Machine Learning/Advanced Analytics	9
Automated Vehicles	7
Green Technology (light-emitting diode (LED)), electric vehicles)	4

Source: FHWA

The grantee projects also span a range of modes and service models. In addition to passenger vehicles, many of the projects either focus on or have a component that includes freight, transit, pedestrian/bicycle, or mobility-on-demand, as shown in table 2. Many projects address more than one mode or service model.

Table 2. Advanced Transportation and Congestion Management Technologies Deployment grantee project modes/services, Fiscal Year 2016 – Fiscal Year 2020 as of March 31, 2021.

Mode/Service Model	Number of Projects
Passenger Vehicle	34
Pedestrian/Bicycle	22
Transit	15
Freight	11
Mobility-on-Demand	8

Source: FHWA

GRANTEE DEPLOYMENT STATUS

One FY 2017 grantee, the Greater Cleveland Regional Transit Authority (RTA), completed their project as of March 31, 2021. However, most grantees are still in the planning phase of their deployment process, working on activities including stakeholder engagement, system documentation (e.g. concept of operations), and technology procurement. Several projects have begun testing and deploying technology applications. As of March 2021, two grantees reported deploying at least one project component, and six grantees were piloting or testing project

[4] One AV project and one CV project returned their grant awards.

technologies. Table 3 illustrates the overall deployment status of FY 2016 – FY 2018 grantees by showing the number of projects at different stages of deployment.[5]

Table 3. Advanced Transportation and Congestion Management Technologies Deployment Fiscal Years 2016 - 2018 Grantee Project Status as of March 31, 2021.

Deployment Status	Project Count
Not Yet Testing	16
Piloting/Testing	6
Completed Deployment	1
Deployed at Least One Component	1

Source: FHWA

PROJECT SCOPE CHANGES

This section summarizes the scope changes that grantees reported in their Annual reports. Some grantees noted that COVID-19 and the FCC First Order and Report factored into scope changes.

Two grantees increased the scope of their projects to improve deployment impact:

- One grantee added two elements to its project scope: (1) a real-time performance measurement system to allow the system to continuously improve in order to meet its goals, and (2) a multimodal adaptive signal system to optimize performance by mode.

- One grantee increased its project scope to allow for a more complete system.

Other grantees needed to decrease their project scope to prioritize certain components or avoid duplicating parallel efforts:[6]

- After prioritizing use cases in the system engineering process, a grantee decided not to pursue certain CV applications (n=2).

- One grantee was initially planning a rideshare application, but since the private sector is growing that market, the grantee decided not to pursue the application.

- A grantee discovered other city departments are already pursuing similar or identical elements of its project, so it removed those elements from its project scope.

[5] The chart excludes two FY 17 grantees who mutually agreed with FHWA to terminate their grants and two FY 2018 grantees who have not executed their agreements. Two FY 2019 grantees and no FY 2020 grantees have received funding obligations. The two FY 2019 grantees with funding obligations in place are still early in their deployment processes.

[6] If more than one grantee dealt with a given challenge, the specific number is included in parentheses after the challenge description, e.g. (n=3).

Some grantees changed a technology, process, or component in their project scope, without explicitly referencing whether this resulted in an increase or decrease to their scope:

- One grantee, initially focused on providing content for mobility-as-a-service, changed its scope, as the private sector began developing more content. The grantee shifted its scope to provide data and develop data standards to support content development.

- While a stakeholder was reviewing a project's concept of operations, it discovered the grantee needed to revise its project's architecture to allow multiple CV applications to run simultaneously.

- A grantee changed its transit signal priority system from a CV approach to a cloud-based central system approach to minimize risk and allow other modes that use the same technology to integrate into the system.

CHAPTER 3. GRANTEE PERFORMANCE MEASUREMENT

This chapter presents the overall status of performance measurement among the FY 2016 – FY 2020 grantees and describes key findings from the Greater Cleveland RTA Project. In addition, the chapter highlights common performance measures grantees are using to measure deployment effectiveness.

OVERALL STATUS OF PERFORMANCE MEASUREMENT

As part of the ATCMTD Program application process, the FAST Act requires grantees to include:

> Quantifiable safety, mobility, and environmental benefit projections such as data-driven estimates of how the project will improve the region's transportation system efficiency and reduce traffic congestion.[1]

As a result, all grantees from FY 2016 through FY 2020 included proposed performance measures or targets in their applications. In addition, as noted in chapter 1, executed agreements require many grantees to develop evaluation plans that outline project goals, evaluation methods and design, performance measures, and data collection procedures. As of March 2021, 20 grantees had submitted evaluation plans: 4 FY 2016 grantees, 5 FY 2017 grantees, 7 FY 2018 grantees, and 4 FY 2019 grantees.

As of March 31, 2021, one grantee, RTA, has submitted a draft Final Report that is under FHWA review. Nine grantees are collecting or have finished collecting baseline data for their project evaluations. All other grantees are still in the early stages of deployment or in the planning phase, so it is too early for them to have findings related to performance measurement.

PERFORMANCE MEASUREMENT FINDINGS: GREATER CLEVELAND RTA

The RTA, an FY 2017 grantee, became the first ATCMTD grantee to complete its deployment project in August 2020. The RTA replaced and upgraded its transit communication, computer-aided dispatch (CAD), and automatic vehicle (AV) locator systems, implementing a number of new features, including state-of-the-art vehicle alarms, priority cellular service, new radio communications towers, and turn-by-turn navigations. The 2021 Trapeze-Vontas Conference honored RTA with an award of "Most Innovative" at its recent meeting.[2]

The RTA anticipated these technology upgrades would provide safe and reliable radio communication while improving user experience for its riders. Table 4 includes a detailed list of

[1] FAST Act § 6004; 23 U.S.C. 503(c)(4)(C)(ii)(III).
[2] http://www.riderta.com/news/rta-named-most-innovative-2021-trapeze-vontas-conference

RTA's project components, with a side-by-side comparison of how RTA's previous technology compares to its newly installed technology.[3]

Table 4. Greater Cleveland Regional Transit Authority Technology Upgrades.

Feature	Previous Technology	Enhanced Technology
Vehicle Alarms	Covert alarms are audio only.	Coverts alarms are audio and visual (future). The visual video will allow RTA to perform a live look into the vehicle.
Priority Cellular Service	No cellular service	With FirstNet, if there is a major event or catastrophe, RTA has priority over the public. Our cell service won't slow-down/go out due to high capacity.
Radio Communication	4 Radio Tower with significant coverage gaps	13 towers that covers the entire county and utilizes towers across the State. The RTA can now communicate with 1st responders during emergencies.
Paratransit Contractors	No direct communication or scheduling of vehicles	Direct scheduling of manifests with contractors. Each contractor has a tablet with software application managed by RTA dispatchers.
Navigation	No navigation available. Utilizing route books and maps.	Turn-by-turn navigation including re-routes, special events, etc.
Pre-Trip Inspection	Operators review their vehicle and complete paper forms for defects.	Operator performs the inspection (paperless) on the new vehicle tablet.
Predictive Maintenance	Limited monitoring tools	Real-time predictive maintenance and monitoring of vehicle components, allowing RTA to inform operators/maintenance of errors before the vehicle breaks down.
Vehicle Location	Poll rate = 1 minute	Poll rate = 15 seconds
Equipment Maintenance	No maintenance available due to obsolete parts	Long-term maintenance contracts with all vendors
Wi-Fi	No Wi-Fi	Complimentary Wi-Fi on all RTA buses and trains
Enhanced Data	Significant loss of reliable data	Accurate data including, but not limited to ridership, cellular usage, real-time information, vehicle diagnostics, etc. Fields available to app developers.

Source: Greater Cleveland RTA

[3] Greater Cleveland RTA ATCMTD Final Report

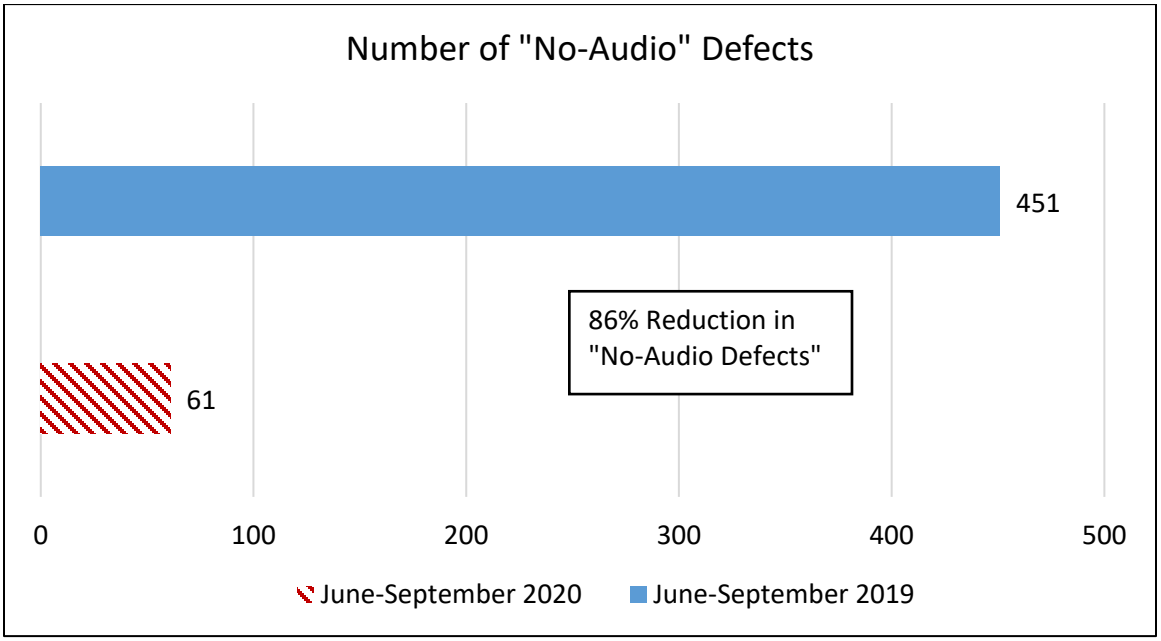
After installing these technology components, RTA observed numerous benefits, including improved system and operational efficiency, a more robust traveler information system, and an improved and more equitable user experience for RTA's riders.

Improved System and Operational Efficiency

The RTA's project improved system and operational efficiencies in a number of ways, including stronger asset management, improved radio defect reporting, improved data related to on-time performance, and the adoption of paperless pre-trip inspections.

To notify staff members of maintenance issues and capture historical data, RTA installed on-board computers on its transit fleet with real-time monitoring capabilities. The RTA also installed device management software that allows Agency staff to troubleshoot and repair vehicles remotely, monitors the on-board intelligent transportation system equipment, updates remotely, and provides performance metrics on the health and status of transit vehicles. These hardware and software upgrades greatly improved RTA's asset management capabilities, as the agency can operate its fleet 24/7 and use predictive maintenance strategies.

Prior to the installation of new technology, RTA's radio system had frequent dead zones where staff could not communicate with dispatchers, causing significant operational problems. Figure 2 illustrates how the new radio system lowered the number of "no-audio" defects by 86 percent after installation.



Source: Greater Cleveland RTA

Figure 2. Graph. Greater Cleveland RTA Number of "No Audio" Defects Before and After New Radio System.

Before the ATCMTD Project technology upgrades, only 50-60 percent of RTA's on-time performance data was reliable, making it difficult for operators and planners to make system adjustments. After the upgrades, Cleveland never had below 70 percent usable data for a month, and most months had at least 80 percent usable data.

In addition, RTA adopted a paperless pre-trip inspection system. Before the ATCMTD Project, operators recorded all pre-trip information on paper, which was inefficient and led to lost data. Now, operators can record information in a database, and the system provides a daily report to maintenance staff, allowing for an efficient reporting model, historical tracking, and a reduction of 240,000 pieces of paper annually.[4]

Improved Traveler Information

The RTA reported that its technology upgrades also improved the agency's traveler information by increasing vehicle location accuracy, changing the polling rate from 60 seconds to 15 seconds, providing real-time service alerts, and adding passenger capacity for real-time app developers. Overall, RTA believes these upgrades provide a greater quantity of data and higher quality data to RTA's riders, enhancing traveler information that is available to the public.

Addressing Equity and User Experience

The RTA installed complimentary Wi-Fi on all of its fixed-route and rail vehicles and reported that this deployment has provided equity and user experience benefits for riders. One in five homes in Cuyahoga County, where Cleveland is located, lacks reliable internet access.[5] In February 2021, riders used roughly 10 terabytes of Wi-Fi data, an all-time high for the RTA system.

SUMMARY OF GRANTEE PERFORMANCE MEASURES

Grantees tailor performance measures to their specific projects; however, for many projects, the core metric is similar. For example, a grantee with a transit project may use "improved transit vehicle travel time," whereas a grantee with a freight project uses "reduction in travel times along key port access corridors." While these performance measures vary by mode and geographic location depending on the scope of their respective projects, the core of both metrics is travel time. Table 5 lists the most common core performance measures grantees use across reported goal areas, with the number of grantees using each performance measure in parentheses, e.g. (n=3). The goals shown in table 4 align with requirements in the FAST Act and impacts identified by the Secretary in the Notices of Funding Opportunity (NOFO).[6]

[4] Greater Cleveland RTA ATCMTD Final Report
[5] Greater Cleveland RTA ATCMTD Final Report

Grantees are not reporting on all of the goal areas that align with requirements in the FAST Act. Grantees provide performance measures and report on key areas relevant to their deployments. Appendix C includes a full list of grantee performance measures.

Table 5. Common Advanced Transportation and Congestion Management Technologies Deployment Grantee Performance Measures by Goal Area.[7]

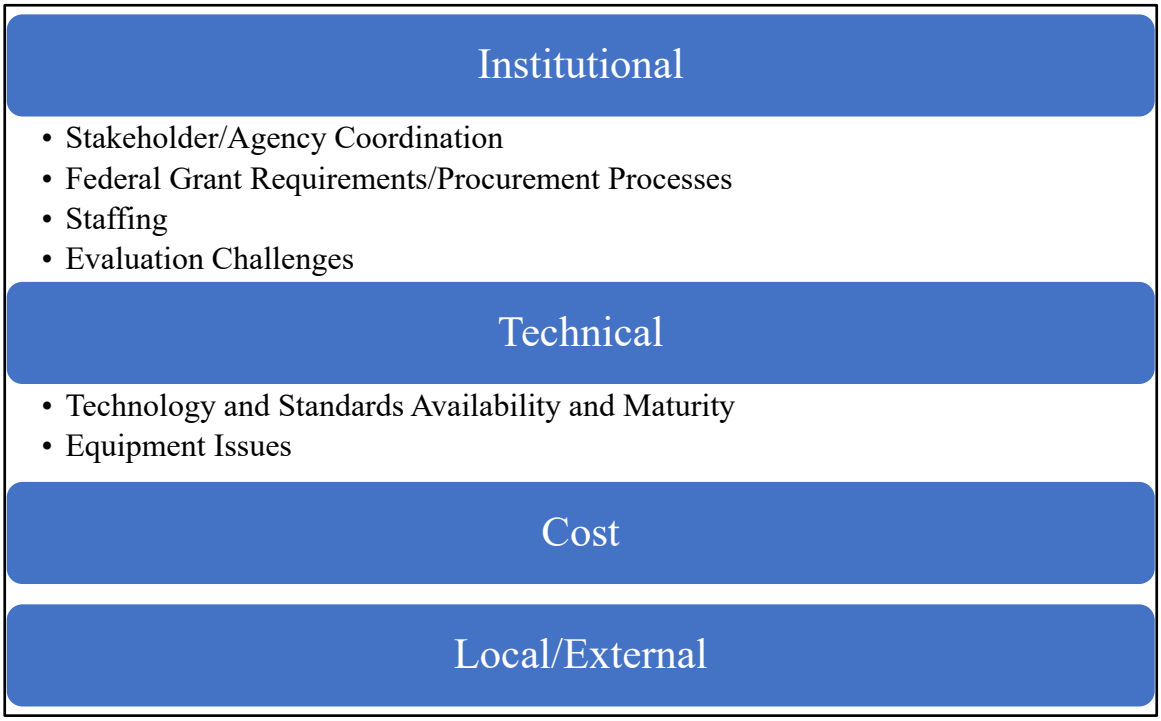
Goal Area	Common Performance Measures
Improved safety (e.g., reduced crashes)	• Number/rate of crashes (vehicle, bike, pedestrian) (n=19) • Perceived safety (driver/transit user/non-user impressions) (n=7) • Incident detection/response time (n=7) • Number/rate of fatalities (vehicle, bike, pedestrian) (n=5)
Reduced congestion/improved mobility (e.g., travel time reliability)	• Travel time (n=19) • Delay (n=15) • Travel time reliability (n=15) • Speed (n=9) • Traveler behavior/satisfaction (n=9)
Reduced environmental impacts	• Reduced emissions (n=12) • Fuel savings/fuel consumption (n=12) • Reduced idling (n=5)
Improved system performance (including optimized multimodal system performance)	• Mobility measures (e.g., travel time, delay) (n=8) • Improved data (e.g. frequency, quality, etc.) (n=7) • System/technology performance (n=5) • On-time performance (n=4) • Perceived effectiveness of technology (n=4)
Enhanced access to transportation alternatives	• Mode share (n=4) • Number of trips/rides (e.g., single occupancy vehicle (SOV), people with disabilities, bike/pedestrian) (n=3) • Number of passengers (n=3)
Effectiveness of providing integrated real-time transportation information to the public to make informed decisions	• User satisfaction (n=6) • Number of altered trips (n=4) • Number of travelers aware of/using information (n=4)
Reduced costs	• Benefit-cost ratio (n=5) • Reduced fuel costs/emissions savings (n=3) • Cost per passenger/revenue hour (n=3)
Institutional and/or administrative benefits	• Planning/preparing for future technologies (n=4) • Data, resource, or equipment sharing (n=2) • Improved understanding/awareness of technologies (n=2)

Source: FHWA

[7] The number of grantees using each performance measure is in parentheses, e.g. (n=3).

CHAPTER 4: GRANTEE CHALLENGES AND LESSONS LEARNED

This chapter presents grantees' challenges and lessons learned as of March 31, 2021, based on their experiences deploying advanced technologies. Through the required annual and quarterly reports, as well as the Early Deployer Cohort Program, grantees have identified challenges and lessons learned of interest to FHWA, other grantees, and deployers more generally. Figure 3 illustrates a framework that organizes challenges and lessons learned into key categories.



Source: FHWA

Figure 3. Chart. Grantee Challenges and Lessons Learned Framework.

Two significant events in FYs 2020 and 2021, the COVID-19 Pandemic and FCC action regarding the Safety Band, led to crosscutting challenges and lessons learned for grantees. The two subsections below will discuss challenges and lessons learned specifically related to these events. The rest of the chapter will then discuss other challenges and lessons learned that grantees reported during the period October 2019 through March 2021. The 2020 Program Report included challenges and lessons learned reported before October 2019, and Appendix D includes a summary of those findings. Grantees provide all challenges and lessons learned; this report does not present FHWA recommendations.

COVID-19 PANDEMIC

The COVID-19 Pandemic led to many unique challenges for grantees. Most government entities asked staff to work from home for a significant portion of FY 2020, causing stakeholder engagement difficulties and project construction delays. Furthermore, due to reduced travel

demand, grantees faced evaluation related challenges on how to measure baseline conditions. COVID-19 also affected project budgets, material costs, staffing capacity, and even project scope. For example, one grantee planned to deploy a dynamic ride matching service as part of its project. However, this involved sharing vehicle space with other passengers, which became less popular after the Pandemic started. The grantee is currently re-evaluating this project component to address community priorities.

Grantees also reported several lessons learned directly related to COVID-19 challenges. The text box below lists these lessons learned.[1]

Grantee Lessons Learned: COVID-19

- Webinars and virtual meetings helped mitigate some of the stakeholder engagement challenges COVID-19 presented (n=2).
- Expediting feasible project tasks and finishing them ahead of schedule reduces total delay while some project tasks are on hold (n=2).
- Collect baseline data as soon as possible to observe the impact of COVID-19 on data collection efforts.

FCC ACTION REGARDING THE SAFETY BAND

The FCC's November 10, 2020, First Report and Order, approved on November 18, and published in the Federal Register May 3, 2021, describe changes to the allocated 75 MHz of radio spectrum in the 5.9 GHz band used for vehicle and infrastructure communications, also known as the Safety Band. The changes to the allocation significantly reduce the amount of spectrum reserved for transportation. The spectrum changes in the First Report and Order became effective July 2, 2021. The First Report and Order reduces the amount of spectrum reserved for transportation by reallocating the Safety Band spectrum into two bands; the lower 45 MHz for Wi-Fi and the upper 30 MHz for transportation. Grantees reported challenges associated with the First Report and Order, including roadblocks and added risk for CV-related projects. Several grantees reported they put their projects on hold in order to determine a solution. Some grantees were able to receive licenses for their Dedicated Short Range Communication (DSRC) units, while others changed their communication devices to dual units capable of using either DSRC or cellular vehicle-to-everything (C-V2X). In addition to delaying projects and requiring additional effort from project staff, grantees reported that procuring dual units also increased project costs.

[1] If more than one grantee mentioned a given challenge, the specific number is included in parentheses after the challenge description, e.g. (n=3).

Grantees reported several lessons learned directly related to the FCC First Report and Order. The text box on the next page lists these lessons learned.[2]

Grantee Lessons Learned: FCC First Report and Order

- Use DSRC and C-V2X dual-band communication devices to futureproof CV deployments (n=4).
- Use Early Deployer Cohort meetings help grantees keep up with the proposed FCC rulings and potential changes to the 5.9 GHz channels.
- Shift more installations to RSUs on existing traffic signal infrastructure.
- Perform interoperability testing during equipment evaluation.

The remainder of this chapter summarizes other grantee challenges and lessons learned based on the framework in Figure 3.

INSTITUTIONAL ISSUES

To date, grantees have reported institutional issues as the most common type of challenge they face. Given the early stages of many of the projects, this is consistent with issues that grantees may face in the planning phases. Grantees reported institutional challenges such as: coordinating among large numbers of stakeholders and jurisdictions; navigating Federal, State, and stakeholder processes; staff and contractor turnover; and evaluation challenges.

Stakeholder/Agency Coordination Challenges

Numerous grantees described the challenges posed by coordinating across agencies, jurisdictions, and stakeholders, with specific examples listed below: [3]

- Collaboration through electronic means can limit the effectiveness of work being performed (n=3).
- Engagement with freight partners is a challenge due to the uncertainty on the ownership of on-board units (OBUs) and time commitment required to ensure OBUs are functional and operating as expected. Unless these partners commit to operating and maintaining these OBUs, it is difficult to deploy them.
- It is difficult to conduct outreach to the trucking community in order to receive user input for the systems engineering process.

[2] Ibid

[3] If more than one grantee dealt with a given challenge, the specific number is included in parentheses after the challenge description, e.g. (n=3).

- Acquiring permits from utility companies and other agencies proved challenging and led to project delays.

The text box below illustrates grantee lessons learned from stakeholder and agency coordination challenges. Most notably, grantees stated the importance of meeting with project stakeholders early and often in the deployment process.

Grantee Lessons Learned: Stakeholder/Agency Coordination

- Meet with project stakeholders early in the deployment process to help drive project success. Grantees found that early engagement allows partners to provide useful feedback, information, resources, and data to project staff. It also allows the grantee to tailor their Concept of Operations, pilots, or other pre-deployment activities to partners' needs, which garners excitement from partners. In addition to early engagement, consistent coordination helps stakeholders understand their impacts on the project scope, increases transparency, and improves the overall project management process (n=10).

- Participate in communities of practice such as the CV Pilot calls and the Early Deployer Cohort to gain comprehensive understanding from other opportunities, challenges, and levels of effort faced by other grantees.

- Identify elements of a proposed operations strategy as 'opt in' so that stakeholders do not feel pressured to adopt strategies that they are not fully comfortable implementing.

- Form a leadership committee comprised of regional agencies that can provide leadership and resource investment (e.g., staff, data, funding, etc.) to help the long-term success of the grantee's project.

Federal Grant Requirements and Procurement Processes Challenges[4]

Grantees also reported challenges related to Federal grant requirements and procurement processes.

Two grantees described challenges specific to Federal grant program requirements:

- There are limitations to using Federal funds in the ATCMTD Program concerning procuring equipment for testing, requiring grantees to use alternative funding sources.

- A vendor could not meet FHWA grant requirements, including the Davis-Bacon Act and Buy America Act, causing scope changes and project delays.

[4] These challenges are not necessarily endemic to ATCMTD grantees.

Grantees dealt with other challenges related to the procurement process as well. While government entities often strive to develop and institute procurement rules that keep up with technology, there are often challenges with first or early real-world deployments of new technology, as described below: [5]

- Issues regarding acquisition of data sources to feed into ICM systems can lead to project delays.

- Certain elements of Federal procurement policies do not cater to new and innovative technologies ATCMTD grantees are deploying.

- The request for proposal (RFP) and equipment procurement process can lead to project delays (n=2).

The text box below illustrates some lessons learned grantees reported on related to Federal grant requirements and procurement processes.

Grantee Lessons Learned: Federal Grant Requirements and Procurement Processes

- Have a strong understanding of local/State government procedures surrounding sole source procurement.

- Vet private sector match participation with FHWA prior to grant proposal submittal.

- Clearly state in advertised project specifications whether new equipment needs to interface with a legacy system and how the interim system will operate before it is fully complete.

- Try to reduce the total number of contracts issued and include a system integration team as early as possible in the process.

Staffing

Staffing issues, including staff turnover and limited capacity, also hindered grantees' project development:

- Internal staff turnover can lead to resource constraints and project risks.

- Staff transitions within project partner organizations can lead to stakeholder engagement challenges.

[5] If more than one grantee dealt with a given challenge, the specific number is included in parentheses after the challenge description, e.g. (n=3).

- Limited internal staffing capacity makes it difficult to provide focused and timely review of project deliverables.

- Technical staff capacity can cause resource constraints and delay equipment deployment and integration.

- Non-dispatching staff in trucking companies are now managing dispatching responsibilities due to an increase in port imports. Staff resources originally allocated to support the grantee's project are no longer available.

- Government budget cuts can impact agency staffing.

Two grantees provided lessons learned related to staffing issues, detailed in the text box below.

Grantee Lessons Learned: Staffing

- Retain supplemental staffing services to ensure the project had adequate capacity for successful delivery.

- Build agility related to team resources and skills to allow for diversification and quick response when unexpected situations such as COVID-19 arise.

Evaluation Challenges

While only one grantee has finished deploying its project, grantees are still performing evaluation activities, including collecting baseline data and establishing evaluation frameworks. Grantees noted a couple of evaluation-related challenges in their reporting, listed below:

- For software technologies that feed into an entire transportation system, it is difficult to identify system improvements occurring directly from the ATCMTD Project. This is especially relevant when other efforts to improve the system aspects are occurring simultaneously.

- One grantee with a ML/AI component to its project has found it difficult to measure performance since ML is a process established over time. The system performing tasks efficiently and effectively could be successful implementation, but the system will only improve over time given that the ML and AI algorithms need time to learn human behaviors.

General Institutional Lessons Learned

In addition to providing lessons learned related to stakeholder coordination, procurement processes, staffing, and evaluation challenges, grantees also provided some general lessons learned related to planning and project management. The text box on the next page details these findings.

COST ISSUES

Issues related to project cost have resulted in multiple grantees working with FHWA to adjust the size and scope of their projects to fit within their budgetary constraints. The bullet points below list specific cost challenges:[6]

- There is a lack of information regarding costs on new, innovative technologies, which makes it difficult to create budget estimates. This issue is magnified when all of a project's elements are not fully defined (n=2).

- Funding limitations can decrease the overall project scope (n=2).

Grantee General Lessons Learned: Institutional

- Identify all external and third-party data sources, as well as necessary data flows, connections, and/or application programming interfaces (APIs) for software development early on in the project. Contact data information providers to see data availability and cost (n=2).

- Start small and do not jump into large RFPs or contracts with a consultant at the start of the project. Starting small helps deployers adjust quickly to changes and gain valuable experience with the technologies they are deploying. This experience informs and prepares for deployers as they scale up their projects.

- Early in the deployment process, identify tasks that can start quickly or need additional dedicated resources. This will help the deployment progress and ensure support exists for project tasks.

- Recognize needs early on and as a situation develops to allow for proper contributions, participation, data collection, or design of systems based on learnings and developments.

- Allow significant time for in-depth up-front planning regarding future deployment strategies.

[6] If more than one grantee dealt with a given challenge, the specific number is included in parentheses after the challenge description, e.g. (n=3).

- Escalated construction costs for variable message signs caused a grantee to remove the technology from its project scope.

- Cost and funding constraints can inhibit expediting a particular project activity.

The text box below details one grantee's lesson learned related to a cost issue.

Grantee Lesson Learned: Cost

- Before letting and including funds in an RFP, AV Deployers should ensure they have provided enough funding to accommodate for necessary infrastructure, such as signing and markings, electrical charging stations, conduit, boxes, and wiring.

TECHNICAL ISSUES

While many grantees are still in the planning phases of their projects, grantees in the testing, piloting, and deployment phases provided updates on technology-related issues that they encountered. Some of these technical issues may be unique to specific projects, but others are likely to provide valuable insight for other grantees and future deployers. Grantees identified themes related to technology and standards maturity and availability, and equipment issues.

Technology and Standards Maturity and Availability

Grantees are sometimes unaware of the immaturity or lack of availability of a given technology due to asymmetric information between technology providers and deployers. The bullet points below list several examples grantees reported about this issue:

- Dynamic traffic signal phasing, timing, and pre-emption using DSRC has not fully matured. Focusing on these applications is costly and time intensive.

- There is a lack of open APIs and support from current operation system vendors.

- The radio-frequency identification technology that one grantee needed is very specialized and only provided by one manufacturer and vendor. This reduced the grantee's financial and operational maneuverability in that aspect of the project.

- One grantee received offers from several manufacturers for radio prototypes but was unsure over which manufacturer could meet its specifications. It noted that information from FHWA on the matter would be helpful.

Grantees deploying CV-related projects gathered all the lessons learned for technology and standards maturity and availability. The text box on the next page illustrates these lessons learned.

Grantee Lessons Learned: Technology and Standards Maturity and Availability

- CV deployers should coordinate with FHWA to understand a vision for CV technology, deployments, and strategy.
- Build flexibility into technology and budgets for CV projects.
- CV deployers should commit to long-term deployment efforts instead of a single project.

Equipment Issues

In addition to maturity and availability issues, grantees face issues in which a technology does not perform as expected. The bullet points below list specific examples:

- One grantee had difficulties with fiber installation near a roadside unit site, delaying completion of a full local loop.
- An advanced traffic detection sensor did not perform as anticipated and the grantee is exploring other options for the signalized intersection portion of its project.
- Some signal sensor systems performed below expectations during one grantee's testing period.
- Lead times on advanced warning signs were taking longer than usual, causing potential schedule delays.

Two grantees reported lessons learned on dealing with technical equipment issues. The text box below lists these lessons learned.

Grantee Lessons Learned: Technical Equipment

- Proof of concept strategies or pilots establish a higher comfort level with technologies before a larger scale deployment.
- It is important to work closely with vendors of existing infrastructure to troubleshoot compatibility issues and ensure smooth integration of newer technologies and devices.

LOCAL/EXTERNAL ISSUES

Occasionally, grantees face external project issues completely out of their control, as previously described with the COVID-19 pandemic and the First Report and Order. Other external events may include natural disasters, poor economic conditions, local events, and supply-chain incidents.

The list below illustrates several examples of these types of issues:

- A local bridge closed due to structural failures, which affected a construction crew's work capacity on one grantee's project.
- Decreasing exports caused an imbalance in freight chassis availability, leading to other operational issues at the port site of a grantee's project.
- Wildfires have created project delays and limited resources for one grantee.
- A manufacturing facility responsible for the electrical vehicle charging stations for one grantee closed, leading to project delays.
- A State government notified a local grantee recipient that it might not support modifications of two traffic signals, potentially removing those signals from the project scope.
- An AV shuttle vendor that a grantee was working with was ordered to cease carrying passengers after an incident in another location. The suspension lasted for 4 months causing project delays, cost impacts, and staffing issues for the grantee.

GRANTEE PROJECT INNOVATIONS

In their annual reports, grantees highlighted innovative or noteworthy project components. Table 6 presents these innovations according to whether they relate to technology, process, or data. See Appendix D for innovations that grantees noted prior to March 2021, as summarized in the 2020 Program Report.[7]

Table 6. Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Innovative Project Components.

[7] Petrella et al. (2021). *2020 Program Report Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program,* Report No. FHWA-HOP-20-031, Washington, DC, obtained from: https://ops.fhwa.dot.gov/publications/fhwahop20031/fhwahop20.

Technology Innovations
Development and integration of artificial intelligence and machine learning software into a transportation management system to provide technical functions and monitoring capabilities not previously available.
Integration of video analytics into a transportation network to allow traffic signals to modify operations based on pedestrian movement.
Use of CV technology to provide traveler information messages to freight providers to assist with route determination to and from ports.
Deployment of cyclist detection in an adaptive traffic signal system, first of its kind in the U.S.
Use of LiDAR sensor technology to classify objects as a way to influence traffic signal timing and to calculate near miss incidents, which is considered a first of its kind application.
Deployment of advanced transportation technologies through a platform and mobile application that enables users to dynamically discover mobility options to create and encourage travel behavior changes.
A connected freight priority system using DSRC, C-V2X, and cellular vehicle-to-network technology, creating an innovative and flexible system.
Process Innovations
Adjusting pedestrian crossing traffic signal timing based on approaching and waiting pedestrian volumes at high pedestrian volume locations.
Integration of multiple different advanced traffic management systems operated by different agencies to inform a robust decision support system approach.
An optimization engine with various historical and real-time data feed inputs to improve current drayage processes and truck operational efficiencies.
An advanced multimodal adaptive signal system that includes multiple optimization algorithms and can emphasize different modes of travel. Traffic management center (TMC) operators can change the system by schedule and in real-time.
Data Innovations
An Advanced Performance Metric Suite will develop statistical clusters of multimodal travel conditions (Summer, snow, typical day, heavy traffic, special event) based on historical data.
Fusion of real-time traffic congestion with AV location or CAD fire vehicle location data to produce the appropriate traffic signal response during emergencies.
Integration of disparate data sets including CV data to provide improved operations, management, and situational awareness.
Implementation of a Connected Vehicle Data Framework with an interface to share and consume third-party data, based on the output of the Connected Vehicle Pooled Fund Study.

Source: FHWA

CHAPTER 5. GRANTEES' CONCLUSIONS

The FAST Act established the ATCMTD Program to develop model deployments to improve safety, efficiency, system performance, and infrastructure return on investment. The DOT has awarded 48 projects in FY 2016 through FY 2020, including city and county projects, as well as projects that are statewide or regional. The projects represent a diverse set of advanced technology deployments across the United States. Some of the key technology deployments include CVs, advanced traveler information systems, ICM, maintenance and monitoring technologies, adaptive traffic signal control, AVs, and green technology (e.g., electric vehicles, light-emitting diode [LED]). The projects span a range of modes/service models—vehicle, freight, transit, pedestrian/bicycle, and mobility on demand. The FHWA has provided the grantees with support to facilitate their deployments and to assist them in meeting their reporting requirements. The law requires each grantee to submit annual reports that describe the impacts of their deployments.[1]

This program-level report presents findings from the Greater Cleveland RTA, the first project completed under the ATCMTD Program. The RTA implemented a new on-board and integrated communications system, replacing its outdated technology with a number of new features, including state-of-the-art vehicle alarms, priority cellular service, new radio communications towers and a turn-by-turn navigations system. As a result of its deployment, RTA has experienced improvements in systems operations, and real time traveler information. The provision of complimentary Wi-Fi service on all fixed route and rail vehicles has also enhanced the user experience, providing potential equity benefits.[2]

To date, other grantees are too early in their deployments to report on impacts. While one grantee has deployed a project component, and six grantees are piloting or testing technologies, the majority of grantees are still in the planning phases. As a result, this program report summarizes core performance measures that grantees are using, as described in their annual reports and evaluation plans. The performance measures tend to focus most heavily in the areas of improved mobility and safety, as well as reduced emissions. Grantees also provide performance measures for enhancing access to transportation alternatives, delivering integrated real-time information, improving equity, and enhancing system performance and operational efficiencies.

This report also highlights the grantees' challenges, lessons learned, and recommendations, as described in their quarterly and annual reports. Key challenges revolve around:

- Institutional issues (stakeholder/agency coordination, Federal grant requirements and procurement processes, staffing, evaluation, and other institutional issues).
- Technical issues (technology and standards availability and maturity, as well as equipment issues).

[1] FAST Act § 6004; 23 U.S.C. 503(c)(4)(F).
[2] Greater Cleveland RTA ATCMTD Final Report

- Cost.
- Local/External factors.

Numerous grantees also mentioned COVID-19 and the FCC First Order and Report as challenges; these two crosscutting issues tended to create schedule, staffing, and cost challenges, as the grantees reported in their quarterly and annual reports.

In their lessons learned and recommendations, grantees largely focused on institutional issues, and also provided a number of suggestions related to the technical aspects of their projects. The paragraphs below summarize grantee lessons learned in these two areas.

Institutional: Multiple grantees recommended **meeting with project stakeholders early** in the deployment process. One grantee also suggested forming a **leadership committee** of stakeholders that can provide resources to the project, while another grantee indicated that stakeholders should be allowed to "**opt-in**" for certain operational strategies. Grantees also emphasized the importance of **upfront planning**; sufficient time should be allotted for this project phase, so that needs can be identified early on. Regarding procurement, one grantee recommended having a strong understanding of **local/State government procedures** and another grantee indicated that advertised project specifications should clearly state whether new equipment needs to interface with a legacy system and how the interim system will operate before it is fully complete. One grantee emphasized **reducing the total number of contracts issued** and including a system integration team as early as possible in the process. Another grantee recommended **starting small** and not jumping into a large RFP from the start.

Technical: One grantee stressed the importance of **working closely with vendors** of existing infrastructure to troubleshoot compatibility issues and ensure smooth integration of newer technologies and devices. Another grantee recommended the **use of pilots** before deploying a technology full-scale. Grantees also identified a number of the technical lessons learned related to CV projects. One grantee recommended that CV deployers should **build flexibility into technology and budgets**, and another indicated the importance of committing to long-term deployment of CV (not just a single project).

APPENDIX A. ANNUAL REPORT TEMPLATE

The purpose of this template is to assist grantees in preparing uniform annual reports. This template, while not required, is highly recommended, as FHWA intends to use the information from the grantees' annual reports to prepare the required Program Level Reports on the effectiveness of the ATCMTD grantees in meeting their projected deployment plans. FHWA first issued this template to the grantees on February 11, 2019.

Reporting Requirement:

23 U.S.C. 503(c)(4)(F) provides: *"For each eligible entity that receives a grant under this paragraph, not later than 1 year after the entity receives the grant, and each year thereafter, the entity shall submit a report to the Secretary that describes----*

(i) deployment and operational costs of the project compared to the benefits and savings the project provides; and

(ii) how the project has met the original expectations projected in the deployment plan submitted with the application, such as—

I. data on how the project has helped reduce traffic crashes, congestion, costs, and other benefits of the deployed systems;

II. data on the effect of measuring and improving transportation system performance through the deployment of advanced technologies;

III. the effectiveness of providing real-time integrated traffic, transit, and multimodal transportation information to the public to make informed travel decisions; and

IV. *lessons learned and recommendations for future deployment strategies to optimize transportation efficiency and multimodal system performance."*

This template has 4 parts:

- **Part 1 of 4: Introduction and Overview**
- **Part 2 of 4: Evaluation/Research Activities**
- **Part 3 of 4: Findings**
- **Part 4 of 4: Wrap Up**

SAMPLE

PART 1 of 4: INTRODUCTION AND OVERVIEW

Project Title:
Grant Award Recipient:
Annual Report Period *[insert date range]*:
Prepared by: *[name, agency and title]*
NOTE: Responses to questions 1 through 3 should reflect ***current*** *project scope and goals. If there have been no changes in project scope or goals (since the last annual report), responses to questions 1 through 3 should be the same as the previous annual report.* 1. **Please provide a *high-level* description of your project, including intended beneficiaries. (Please limit to approximately 350 words or less.)** ***Note: in Part 4 of 4, Q 1, you will be asked to note any major deviations or changes in scope due to either project-driven outcomes or other unforeseen challenges.***
2. **Please indicate which ATCMTD-targeted technologies your project covers** *(Check all that apply)***.** ☐ Advanced traveler information systems ☐ Advanced transportation management technologies ☐ Infrastructure maintenance, monitoring, and condition assessment ☐ Advanced public transportation systems ☐ Transportation system performance (monitoring) data collection, analysis and dissemination ☐ Advanced safety systems, including vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, autonomous vehicle development or deployment, and associated technologies that would enable V2V or V2I, including cellular or other technology ☐ Integration of intelligent transportation systems using Smart Grid or similar energy distribution and charging systems ☐ Electronic pricing and payment systems ☐ Advanced mobility and access technologies, such as dynamic ridesharing and information systems to support human services for elderly, disabled, or disenfranchised individuals

SAMPLE

☐ Other (Describe)

_____

3. What are your project's goals? (*Check all that apply.)* Note: For each goal identified, you will be asked in Part 2 and Part 3 to map your project's "Performance Measures" and "Findings" to date, respectively.

☐ Improved safety

☐ Reduced congestion and/or improved mobility (e.g., travel time reliability)

☐ Reduced environmental impacts (e.g., emissions and/or energy)

☐ Improved system performance/optimized multimodal system performance

☐ Enhanced access to transportation alternatives

☐ Effectiveness of providing integrated real-time transportation information to the public to make informed travel decisions

☐ Reduced costs

☐ Institutional or administrative benefits (e.g., increased inter-agency coordination)

☐ Other benefits (please specify:_____)

☐ Other goals (Please specify:_____)

SAMPLE

PART 2 of 4: EVALUATION/RESEARCH ACTIVITIES

Please complete the following table regarding your evaluation activities. For each goal area that is applicable to your project, provide the performance measures and a status update on your research activities. The update should include the status of baseline data collection (if applicable) and any challenges or data limitations. If research is completed, please indicate that here in Part 2, but please reserve "Findings" for Part 3.

Goal Area	Performance Measures - Quantitative and Qualitative (if multiple technologies apply, please note the different technologies)	Research Update (e.g., baseline data collection, challenges, milestones achieved, etc.)
Improved safety (e.g., reduced crashes)	1. 2. 3. Etc.	
Reduced congestion/improved mobility (e.g., travel time reliability)	1. 2. 3. Etc.	
Reduced environmental impacts	1. 2. 3. Etc.	
Improved system performance (including optimized multimodal system performance)	1. 2. 3. Etc.	
Enhanced access to transportation alternatives	1. 2. 3. Etc.	

SAMPLE

Effectiveness of providing integrated real-time transportation information to the public to make informed travel decisions	1. 2. 3. Etc.	
Reduced costs	1. 2. 3. Etc.	
Institutional or administrative benefits	1. 2. 3. Etc.	
Other benefits: Please specify:		
Other benefits: Please specify:		
Other goals [ADD IF NEEDED] Please specify:		

SAMPLE

PART 3 of 4: FINDINGS

For each applicable goal area, please describe the impacts of your project based on findings from the performance measures. If data collection is still underway (i.e., findings are not yet available), indicate "In Progress" in the Findings column. Please use the "Notes/Considerations" column to include any other relevant information regarding the evaluation. Note: the numbering for the Findings should correspond to the numbering used for Performance Measures in Part 2.

Goal Area	Findings (tied to performance measures; also include any anecdotal evidence)	Notes/Considerations
Improved safety (e.g., reduced crashes)	1. 2. 3. Etc.	
Reduced congestion/improved mobility (e.g., travel time reliability)	1. 2. 3. Etc.	
Reduced environmental impacts	1. 2. 3. Etc.	
Improved system performance (including optimized multimodal system performance)	1. 2. 3. Etc.	
Enhanced access to transportation alternatives	1. 2. 3. Etc.	

SAMPLE

Effectiveness of providing integrated real-time transportation information to the public to make informed decisions	1. 2. 3. Etc.	
Reduced costs	1. 2. 3. Etc.	
Institutional and/or administrative benefits	1. 2. 3. Etc.	
Other benefits: Please specify:	1. 2. 3. Etc.	
Other benefits: Please specify:	1. 2. 3. Etc.	
Other goals [ADD IF NEEDED] Please specify:	1. 2. 3. Etc.	

PART 4 of 4: WRAP UP

1. In your view, how is the project doing with respect to meeting original expectations (i.e., as stated in the project proposal)? Note here any *major* deviations or changes in scope from the original proposal due to either project-driven outcomes or other unforeseen challenges; e.g., unavailability of presumed data, unforeseen legal or administrative constraints, unexpected stumbling blocks, obvious delays, time-consuming tasks, or executive decisions to alter course.
2. Are there any aspects of your project that you consider cutting edge, noteworthy, or innovative? If yes, please describe.
3. How do deployment and operational costs of the project compare to the benefits and savings the project provides; i.e., can you provide an objective benefit cost analysis or alternate subjective comparison?
4. What are lessons learned-to-date from your deployment, specifically regarding future deployment strategies to optimize transportation efficiency and multimodal system performance? Please note lessons learned with respect to challenges in technology deployment (e.g., technical, institutional, etc.), research (e.g., performance measurement), or other lessons learned.
5. What recommendations can you provide regarding future deployment strategies in this/these area(s)?
6. Do you have any final comments or feedback?

APPENDIX B. ADVANCED TRANSPORTATION AND CONGESTION MANAGEMENT TECHNOLOGIES DEPLOYMENT PROJECT DESCRIPTIONS

This section provides a summary of each of the ATCMTD projects as selected for award, including grant amount, project goals, and technologies being deployed.

> The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this report solely because they are considered essential to the objective of this report. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.

FISCAL YEAR 2016 PROJECTS

Freight Advanced Traveler Information System (FRATIS) *(Los Angeles County Metropolitan Transportation Authority: Los Angeles, California)*

- Grant Amount: $3,000,000
- Project Goals: FRATIS will reduce truck congestion and fuel usage by optimizing freight routes.
- Technologies Being Deployed: Truck trip dispatching optimization software, real-time information exchange system, and eco-drive applications.

Los Angeles DOT Implementation of Advanced Technologies to Improve Safety & Mobility with the Promise Zone *(Los Angeles DOT: Los Angeles, California)*

- Grant Amount: $3,000,000
- Project Goals: This project uses advanced technology on Los Angeles's transit vehicles to improve safety and traffic flow and provides real-time information to transit riders in low-income neighborhoods.
- Technologies Being Deployed: Upgrades to the automatic traffic control and surveillance connected signal system, Bluetooth® low energy beacons, real-time bus arrival signs, and interactive digital kiosks with real-time information about transportation services.

City of San Francisco ATCMTD Initiative (*San Francisco Municipal Transportation Agency: San Francisco, California*)

- Grant Amount: $10,990,760
- Project Goals: This project uses a series of advanced technologies to lower congestion in heavily trafficked areas, increase public transit speeds, reduce pedestrian collisions, decrease emergency vehicle response times, reduce truck signal delay, and lower truck speeds through sensitive neighborhoods.
- Technologies Being Deployed: (1) New highway high occupancy vehicle lanes for transit/carpools, (2) Transit signal priority and emergency vehicle preemption, (3)

Electronic, autonomous shuttles, (4) Curb space for pick-up/drop-off by carpools and ridesourcing services, (5) Multimodal intelligent traffic signal systems located roadside and in-vehicle, (6) A connected, electronic toll system for the congestion pricing program.

Denver Smart City Program (*City and County of Denver: Denver, Colorado*)

- Grant Amount: $6,000,007
- Project Goals: This project uses connected fleets and Dedicated Short Range Communications (DSRC) technology to improve travel time reliability, freight efficiency, traffic management, and make safer pedestrian crossings.
- Technologies Being Deployed: DSRC in 1,500 city fleet vehicles, automated pedestrian detection devices, a connected vehicle operational environment at the Denver traffic management center and flashing beacons for slower pedestrians.

A Connected Region: Moving Technological Innovations Forward in the NITTEC Region (*Niagara Frontier Transportation Authority: Erie and Niagara Counties, New York*)

- Grant Amount: $7,813,256
- Project Goals: This project deploys technologies and strategies to improve border crossing performance, travel time, commercial vehicle operations and safety. Additionally, the project will improve incident management and promote operational integration within Niagara Frontier Transportation Authority.
- Technologies Being Deployed: Connected vehicle applications supporting in-vehicle dissemination of alerts, advisories, and parking, traffic, and weather information, improved traffic signal system, parking management analytics engine, decision support system.

NW 33 Smart Mobility Corridor (*Union County Ohio, City of Marysville and City of Dublin: Ohio*)

- Grant Amount: $5,997,500
- Project Goals: This project creates a smart mobility corridor with connected vehicle applications across multiple communities to improve safety and congestion, while enhancing access to large employment sites and economic development.
- Technologies Being Deployed: Connected vehicle technology for queue warning and speed harmonization, dynamic signal phase and timing, pedestrian warning systems on the local street network; and real-time road weather performance data.

SmartPGH (*City of Pittsburgh: Pittsburgh, Pennsylvania*)

- Grant Amount: $10,899,318
- Project Goals: SmartPGH deploys "Smart Spine" corridors in Pittsburgh that layer environmental, communications, energy, and transportation infrastructure technologies to improve connections between isolated neighborhoods and major centers of employment. This will improve real-time information access and optimize transit operations.

- Technologies Being Deployed: Conversion of nearly 40,000 City of Pittsburgh streetlights to light-emitting diode technology with integrated control systems and installation of supplemental sensor technology, including pedestrian detection and air quality monitoring along Smart Spine corridors. In addition, Pittsburgh will deploy real-time adaptive traffic signals and DSRC units on buses for transit signal priority, advanced traveler information systems, and optimized mobility.

ConnectSmart: Connecting TSMO and Active Demand Management (*Texas DOT: Houston, Texas*)

- Grant Amount: $8,939,062
- Project Goals: ConnectSmart integrates various mobility technologies for carpooling, ridesharing, and shared electric bicycles to provide reliable multimodal travel time information.
- Technologies Being Deployed: The ConnectSmart model platform will integrate various mobility technologies including various regional existing advanced traveler information systems and data sources to provide predictive multi-/inter-modal travel time, cost, and reliability information. This information will be delivered to travelers to give them live information and incentivize better mobility decisions, give stakeholders access to data to improve operations and connect transportation supply and demand.

FISCAL YEAR 2017 PROJECTS

Loop 101 Mobility Project (*Arizona DOT: Maricopa County, Arizona*)

- Grant Amount: $6,000,000
- Project Goals: This project improves safety and existing arterial capacity in the Loop 101 corridor by deploying technology and systems to support integrated corridor management (ICM), public transportation, SMARTDrive, and other connected traffic management and real-time information technologies.
- Technologies Being Deployed: A decision support system, adaptive signal control technology, connected vehicle applications including transit and emergency vehicle signal priority, ramp metering technology, and an ICM mobile applications suite.

GoPort Freight Intelligent Transportation Systems (*Alameda County Transportation Commission: Alameda County, California*)

- Grant Amount: $9,720,000
- Project Goals: This project improves traffic flow and goods movement to and within the Port of Oakland, reduce congestion, improve safety, provide improved traveler information, and reduce emissions. Collectively, these benefits will significantly improve port operational efficiencies, increasing the competitiveness of the port in the global market.
- Technologies Being Deployed: A new port-specific traffic management center, traffic sensors, advanced traveler information, traffic messaging, trucking information for mobile apps, rail grade warning, and terminal queue information.

Connecting the East Orlando Communities (*Florida Department of Transportation: Orlando, Florida*)

- Grant Amount: $11,946,279
- Project Goals: This project improves pedestrian and bicycle safety, enhance multimodal transportation, provide integrated real-time information for travelers and connect/integrate data sources created and utilized by Florida Department of Transportation.
- Technologies Being Deployed: An innovative pedestrian and bicycle collision avoidance system, roadside units, parking sensors, active detection technology, digital kiosks, advanced traffic signal controls, dynamic ridesharing, and information systems for elderly and disabled individuals.

SMART Arterial Management (*Ada County Highway District: Ada County, Idaho*)
Note: This project is canceled and obligated funds were returned.

- Grant Amount: $2,250,000
- Project Goals: This project was designed to optimize signal timing on five corridors to reduce congestion, increase safety, and enhance traffic flow.
- Technologies Being Deployed: Dedicated Short Range Communications radios, onboard units, radar technology for bicycle and vehicle detection, traffic software, and accessible pedestrian signals.

Improving Safety and Connectivity in Four Detroit Neighborhoods (*City of Detroit: Detroit, Michigan*)

- Grant Amount: $2,182,000
- Project Goals: This project improves safety at intersections, improves connectivity for residents, and increases the capacity for data communications.
- Technologies Being Deployed: Video detection and analytics, sensors, vehicle-to-infrastructure communications, vehicle preemption, digital kiosks, Dedicated Short Range Communications, and Internet of Things gateway.

Connecting Cleveland Project (*Greater Cleveland Regional Transit Authority: Cleveland, Ohio*)

- Grant Amount: $5,850,000
- Project Goals: This project improves communications infrastructure, enhances rider and passenger safety, and reduces rider travel time. The project also enhances the overall efficiency of the transportation system while contributing to community revitalization.
- Technologies Being Deployed: Advanced on-board equipment, real-time information and maintenance software, and an upgraded radio system.

Greenville Automated (A-Taxi) Shuttles (*County of Greenville: Greenville, South Carolina*)
Note: This project was canceled and obligated funds were returned.

- Grant Amount: $4,000,000
- Project Goals: This project improves access to transportation for disadvantaged and mobility-impaired residents.
- Technologies Being Deployed: Automated taxi shuttles using vehicle-to-vehicle and vehicle-to-infrastructure technology, automated vehicle data collection and analysis, and real-time traveler information.

The Texas Connected Freight Corridors Project (*Texas DOT: Texas*)

- Grant Amount: $6,090,221
- Project Goals: This project integrates high-quality data from the I-35 Advanced Traveler Information systems into an existing route optimization software platform to enhance/optimize pre-trip and enroute planning for regional carriers, leading to safety and congestion improvements.
- Technologies Being Deployed: Advanced traveler information systems and transportation management technologies, infrastructure condition-monitoring technologies, connected vehicle-to-infrastructure and vehicle-to-vehicle technologies, freight parking system technologies, truck platooning technology, and border crossing technologies.

Truck Reservation System and Automated Work Flow Data Model (*Virginia Port Authority: Virginia*)

- Grant Amount: $1,550,000
- Project Goals: This project creates a two-way data flow with the port and truckers, railroads, etc. The data model will model the size of scheduling windows and estimate the effects of congestion on mobility. Radio frequency identification (RFID) tag readers will automate workflow of arriving trucks, reducing turnaround time.
- Technologies Being Deployed: RFID tag readers, software integration with container inventory management system and a data model for standardizing status updates to truck dispatchers.

Multimodal Integrated Corridor Mobility for All (*City of Seattle DOT: Seattle, Washington*)

- Grant Amount: $4,091,000
- Project Goals: This project improves traveler safety and mobility and creates real-time traveler plans.
- Technologies Being Deployed: Traffic signal system upgrades, communications network, closed-circuit television, dynamic message signs, passive pedestrian detection and pedestrian demand-based signal timing, bicycle detection and mobile application, integrated corridor management solutions, Mobility-as-a-Service software, and kiosks.

FISCAL YEAR 2018 PROJECTS

Bay Area Mobility-On-Demand Project (*Contra Costa Transportation Authority: Contra Costa County, California*)

- Grant Amount: $8,000,000
- Project Goals: This project provides Mobility on Demand (MOD) to create a "one-stop shop" for viable mobility options by providing real-time, data-driven traffic updates and trip planning so travelers can make informed decisions about cost, travel time, mode, and route choices for their daily travel needs. The project will improve mobility trip reliability and congestion in the county.
- Technologies Being Deployed: MOD applications and services, mobility assets, and systems integration.

Advanced Connected Transportation Infrastructure & Operations Network (ACTION) (*University of Alabama: West Central Alabama, Alabama*)

- Grant Amount: $8,034,003
- Project Goals: This project deploys connected vehicle and intelligent transportation system technologies to allow the regional traffic management center to implement adjustments to traffic control strategies across the system. Data will enhance long-term planning in the region and information will be shared with drivers.
- Technologies Being Deployed: Communications, DSRC radios, advanced data-logging traffic controllers, active signal control, wireless vehicle detection, traveler information systems, cable median crash sensors, and an end-user mobile application that provides benefits including pedestrian detection, work zone warnings, curve warning, emergency vehicle preemption detection, and more.

Wolf Creek Pass Advanced Technology Deployment (*Colorado DOT: Wolf Creek Pass, Colorado*)

- Grant Amount: $2,366,298
- Project Goals: This project transmits real-time information to travelers and dispatch emergency responders and incident management teams faster to improve safety on Wolf Creek Pass.
- Technologies Being Deployed: DSRC RSUs, weigh-in-motion technology and dynamic warning signs, road sensor systems, variable speed limits, cameras, variable message signs, and a fiber-optic and electric power network.

AIITMS Deployment Program (*Delaware DOT: Delaware*)

- Grant Amount: $4,996,949
- Project Goals: This project enables deployment of an AIITMS and an artificial intelligence (AI)-enhanced next-generation TMC to improve transportation systems performance for enhanced traffic safety, mobility, and air quality. In addition, the project will support people in making better transportation decisions by providing real-time information about incidents, travel times, anticipated delays, and routes.

- Technologies Being Deployed: Multimodal AI-enhanced transportation management and control system that collects and analyzes data to automatically detect anomalies and inefficiencies, disseminate real-time travel information, and generate congestion-mitigation solutions.

GDOT CV (*Georgia DOT: Metro Atlanta, Georgia*)

- Grant Amount: $2,500,000
- Project Goals: This project creates and operates a region-wide connected vehicle network, providing SPaT messages at all key intersections and freeway ramps, which will enable connected vehicle applications using this network to improve road safety and operations.
- Technologies Being Deployed: DSRC RSUs at signalized intersections, metered ramps, supporting infrastructure, and an open data portal.

Multi-State Rural ICM (*Nebraska DOT: I-80 through Nebraska, Wyoming, and Utah*)

- Grant Amount: $2,755,000
- Project Goals: This project provides information to travelers by expanding Wyoming's CV Pilot, deploys a variable speed limit in Nebraska, provides critical messages directly to freight vehicles, and disseminates truck parking information.
- Technologies Being Deployed: Information and communication management, regional data sharing, variable speed limits, DSRC, V2I apps, and a mobile road weather information system.

Oregon Smart Mobility Network (*Oregon Department of Transportation: Oregon)*

- Grant Amount: $12,000,000
- Project Goals: This project creates a multimodal integrated network and helps Oregon Department of Transportation with performance measurement, decision support, and active traffic, incident and weather management.
- Technologies Being Deployed: Automatic traffic recorders, bicycle and pedestrian counters Bluetooth travel time systems, road weather decision support and information dissemination, CCTV monitoring cameras, adaptive ramp metering, dynamic speed limits, freight signal priority, queue warning systems, SPaT, dynamic routing, next-generation transit signal priority, vehicle-to-everything pedestrian/bicycle, automated speed enforcement, red-light-running crash mitigation systems, unmanned aerial systems crash reconstruction, and battery back-up systems.

Work Zone Reservation and Traveler Information System (*Pennsylvania Department of Transportation: Pennsylvania and Ohio)*

- Grant Amount: $2,697,750
- Project Goals: This project enhances work zone operations and safety by providing accurate, standardized, and real-time work zone information across 40,551 miles of roadway traversing through Ohio and Pennsylvania. The system will also streamline

work zone coordination between maintenance crews, construction crews, and traffic operation centers by removing the redundant and manual data inputs used today to schedule work zones.
- Technologies Being Deployed: Advanced traveler information systems, advanced transportation management technologies and a digital road work reservation system.

I-10 Corridor Coalition Truck Parking Availability System (*Texas Department of Transportation: California, New Mexico, Arizona, and Texas)*
- Grant Amount: $6,850,000
- Project Goals: This project provides real-time parking information to truck drivers and dispatchers to make informed parking decisions. This will increase public safety by reducing fatigue-related crashes with associated reductions in congestion and delay.
- Technologies Being Deployed: Advanced traveler information systems, advanced transportation management technologies, infrastructure assessment technologies, and transportation system performance data collection, analysis, and dissemination systems.

Utah Connected (*Utah Department of Transportation: Utah*)
- Grant Amount: $3,000,000
- Project Goals: This project measures and improves the operational performance of the system to gain additional capacity, improves safety and preserves infrastructure, implements connected vehicle technology to improve safety and mobility, and uses automated vehicle technology to help solve the first mile/last mile problem.
- Technologies Being Deployed: Autonomous shuttle(s), fiber sensing, connected vehicle applications (plows, signals, transit, curve speed warning, weather impact warning), and a data-sharing portal.

FISCAL YEAR 2019 PROJECTS

Deployment of Personalized and Dynamic Travel Demand Management Technology (*Metropolitan Washington Council of Governments: Washington, D.C.-Baltimore, MD-Richmond, VA Megaregion*)
- Grant Amount: $2,970,000
- Project Goals: This project leverages the best available technology to maximize the cost-effectiveness of a megaregion travel demand management program, integrates and expands existing travel demand management programs with a shared technology platform among all public and private-sector partners, provides personalized, timely, and accurate travel information to all residents and visitors, and enhances multimodal transportation access and system performance for all user groups with rewards and gamification.
- Technologies Being Deployed: Advanced traveler information systems, travel demand management, advanced transportation management technologies, advanced public and shared transportation systems, advanced mobility and access technologies, multimodal trip planner/travel demand management programs for rural, low income, and

elderly/disabled persons, personalized and dynamic traveler incentives, and multimodal payment and reward integration.

I-4 Florida's Regional Advanced Mobility Elements (FRAME) (Florida Department of Transportation: I-4 Corridor)

- Grant Amount: $10,071,600
- Project Goals: This project will work towards Florida DOT's strategic plan vision of increasing the delivery rate of fatality-free and congestion-free transportation systems by implementing connected vehicle and other emerging technology solutions, bringing safety and mobility benefits to the I-4 corridor.
- Technologies Being Deployed: 689 CV RSUs and 670 on-board units with roadside-to-vehicle messages for lane closures, work zones, delays, congestion, end of queue, incidents signal phase and timing, speeds, and pedestrian-bicyclist safety. The project will also deploy advanced traffic signal controllers with automated traffic signal performance measures, blank-out signs for route diversion, transit and freight signal priority, advance railroad crossing warnings, and wrong-way driving alerts.

Implementing Cellular V2X Technology to Improve Safety and ITS Management in Hawaii *(Hawaii Department of Transportation: Hawaii)*

- Grant Amount: $6,855,000
- Project Goals: This project reduces costs and improves return on investments through the enhanced use of existing transportation capacity, delivers environmental benefits that alleviate congestion and streamline traffic flow, reduces the number and severity of traffic crashes and increases safety, collects, disseminates, and uses real-time transportation related information, monitors transportation assets to improve infrastructure management, delivers economic benefits by reducing delays, and accelerates deployment of vehicle-to-vehicle, vehicle-to-infrastructure and automated vehicle applications.
- Technologies Being Deployed: A cellular-based vehicle-to-everything system for all traffic devices and in-field devices in the State of Hawaii, C-V2X and Dedicated Short Range Communications equipment for motor vehicles, a remote browser-based platform for traffic operations personnel, a smartphone application for travelers and preemption for emergency vehicles.

Intelligent Woodward Corridor Project *(Michigan Department of Transportation: Detroit, Michigan)*

- Grant Amount: $5,500,000
- Project Goals: This project provides increased safety for pedestrians, cyclists, and vehicle traffic, reduced congestion, more efficient public transportation, integrated multimodal transportation, transportation resiliency, operational effectiveness, and reduced maintenance and operating costs
- Technologies Being Deployed: Pedestrian detection, prioritization, and alerts, traffic intersection preemption and signal priority for authorized vehicles, vehicle-to-vehicle and

vehicle-to-infrastructure communications, transportation system optimization through data analytics and edge computing, wrong way driver detection and alerts.

I-270 Predictive Layered Operation Initiative (PLOI) *(Missouri Department of Transportation: St. Louis Metropolitan Area, Missouri)*

- Grant Amount: $1,000,000
- Project Goals: This project predicts crashes and properly equips patrol officers to forestall crashes, lowering the number of incidents along I-270 North, improving incident detection time, and reducing arrival time for emergency response vehicles.
- Technologies Being Deployed: Predictive analytics and artificial intelligence for incident management, advanced video analytics for improving pedestrian safety and wrong way driving, and integrated modeling for road condition prediction.

Multimodal Connected Vehicle Pilot *(North Carolina Department of Transportation: Raleigh, North Carolina)*

- Grant Amount: $2,117,750
- Project Goals: This project improves mobility, reduces safety incidents, reduces environmental impacts, improves agency efficiency, and allows North Carolina Department of Transportation to more effectively deploy connected vehicle technology and applications within the State of North Carolina for further safety, mobility, and environmental benefits.
- Technologies Being Deployed: Vehicle-to-vehicle and vehicle-to-infrastructure connected vehicle applications, including transit signal priority, multimodal applications (pedestrian, driver, bike rider, etc.), intelligent traffic signal timing, red light violation warning, speed warning, as well as traveler information, high resolution data, automated traffic signal performance measures, and pedestrian presence detection accessible pedestrian signal system.

DriveOhio I-70 Truck Automation Corridor *(Ohio Department of Transportation: I-70 Corridor, Ohio and Indiana)*

- Grant Amount: $4,400,000
- Project Goals: This project facilitates and provides host fleets and truck automation vendors an opportunity to deploy technology in revenue service, accelerates truck automation technology adoption, prepares standards and regulations for use by other deploying entities, and shares data and field experiences with the logistics industry.
- Technologies Being Deployed: Truck automation, including truck platooning, L2, and L4 automation in revenue service by host fleets, as well as roadway automation readiness audit and related roadway repairs.

Artificial Intelligence-Powered Decision Support Tools for Integrated Corridor Management *(Tennessee Department of Transportation: I-24 Corridor, Tennessee)*

- Grant Amount: $2,617,653

- Project Goals: This project develops decision support systems and subsequent strategies through the use of artificial intelligence, reduces the cost to deploy, operate, and maintain ICM Systems, builds a more scalable system to support traffic operations on corridors statewide, and improves the efficiency of ICM. This creates a balanced, responsive, and equitable system that monitors and controls traffic, shares traveler information with the public, improves system and travel time reliability, encourages mode shift, and improves the safety, efficiency, maintenance, operations, and mobility of all users (motorists, transit riders, transit operators, and freight haulers) along the corridor.
- Technologies Being Deployed: Artificial intelligence-based ICM decision support system, Web interface for ICM partners, and traffic management center ICM software integration.

AI Meets ICM: Realizing the Next Generation of Regional Mobility *(Virginia Department of Transportation: Northern Virginia, Virginia*)

- Grant Amount: $4,355,000
- Project Goals: This project will use advanced data management and communications technologies to provide transportation system operators, service providers, commuters, and travelers with multi-modal information and tools that enhance safety, optimize system performance, mitigate congestion, improve travel-time reliability, and support on-demand, multi-modal trip options.
- Technologies Being Deployed: Decision support system, artificial intelligence, a cloud-based data store, and a portal regional commuter parking management system.

Deployment of the Washington State Virtual Coordination Center (VCC) for Multimodal Integrated Corridor Management *(Washington Department of Transportation: Greater Seattle Metro Area, Washington)*

- Grant Amount: $3,424,361
- Project Goals: This project enhances both individual and interconnected agency operations in the day-to-day management of regional mobility to ensure the region's transportation system is safe, reliable, sustainable, and promotes economic vitality for the entire region. It also enables real-time information flow to allow shared map-based situational awareness, facilitates joint action in a virtual workspace to speed incident response, mitigate traffic impacts, and manage congestion on a daily basis, provides actionable information and alerts to agencies, mobility providers, and the traveling public, and enhances coordinated regional planning and operations through data analytics and predictive modeling.
- Technologies Being Deployed: A robust cloud-based system that enables multi-agency, multimodal integrated corridor management through real-time information data collection, analysis, modeling, and dissemination.

FISCAL YEAR 2020 PROJECTS

Advancing Connectivity and the Economy through Technology in the San Diego Region *(San Diego Association of Governments: San Diego, California)*

- Grant Amount: $9,298,300
- Project Goals: This project improves safety, expands transportation services and choices, provides the tools for actively managing all transportation systems, enhances access and services to transportation information, and adapts to transportation trends and services for all modes.
- Technologies Being Deployed: Mobility hub technologies, smart intersection system, connected vehicle roadside and onboard equipment, border wait time monitoring system, next generation traveler information, connected vehicle border tolling, and commercial vehicle inspection technology.

Pinellas Connected Community *(Pinellas County Department of Public Works: Pinellas County, Florida)*

- Grant Amount: $9,298,300
- Project Goals: This project improves safety of pedestrians and intersections within the region, improves mobility within the region, accelerates deployment of vehicle-to-everything technologies, reduces the number and severity of traffic crashes, and increases driver, passenger, and pedestrian safety.
- Technologies Being Deployed: Connected vehicle technologies, including emergency vehicle preemption, transit signal priority, speed warning, intersection warning, vehicle hazard warning, and emergency vehicle warning. The project will also deploy demand management, decision support, work zone monitoring, mobile phone based OBU app, and video analytics technologies.

Emergency Vehicle Preemption Using Connected Vehicle Technology (*Georgia Department of Transportation: Metro Atlanta Region, Georgia)*

- Grant Amount: $3,206,809
- Project Goals: This project reduces incident response time, reduces ambulance transport time, decreases pedestrian crashes, facilitates arterial traffic flow and reduce delay, measures and reports quantifiable system performance measures, and enables system reproducibility and transferability to other Metro Atlanta regions and national locations.
- Technologies Being Deployed: 15 Dual-Mode (DSRC & C-V2X) RSUs, 170 Dual-Mode onboard units installed in incident management vehicles and ambulances, a real-time information Smartphone application, and a security credential management system.

Maine Advanced Signal Control and Connected Vehicle System for Safe, Efficient and Equitable Rural Transportation (MAST) Project *(Maine Department of Transportation: Maine)*

- Grant Amount: $3,471,615
- Project Goals: This project maximizes investments, lessens environmental impacts by monitoring and rapidly correcting operating deficiencies, measures operational performance, reduces crash severity, increases traveling public awareness, responds rapidly to changing operational status, improves economic benefits, increases operational connected vehicle footprint and integration of advanced technologies, and enhances understanding of traffic flow.
- Technologies Being Deployed: Advanced traffic controllers, traffic detection system, Dedicated Short Range Communications and C-V2I infrastructure and units, cellular modem and hardwire communication infrastructure, automated traffic signal performance measures, and traffic signal control data analytics based on artificial intelligence.

Smart Intersections: Paving the Way for a National Connected and Automated Vehicles (CAV) Deployment *(University of Michigan: Ann Arbor, Michigan)*

- Grant Amount: $9,950,098
- Project Goals: This project reduces accidents and fatalities, improves safety for drivers, passengers, vulnerable road users, and first responders, reduces carbon emissions, improves operational performance, reduces infrastructure costs, improves return on investment, and paves the way for a national CAV deployment.
- Technologies Being Deployed: C-V2X and Dedicated Short Range Communications dual mode RSUs, Dedicated Short Range Communications and vehicle-to-vehicle fleets, smart sensors with edge computing, authentication, authorization and accounting server, data analytics, and an advanced vehicle-to-everything technology living lab.

Integrated Safety Technology Corridor *(Regional Transportation Commission of Southern Nevada: Las Vegas Metropolitan Area, Nevada)*

- Grant Amount: $6,000,000
- Project Goals: This project streamlines traffic flow, enhances use of real-time data and analytics, reduces number and severity of crashes, and enhances monitoring of infrastructure to identify and prioritize repairs.
- Technologies Being Deployed: Active traffic management, wrong way driver notifications, strategic traffic management sites, high occupancy vehicle detection, and an integrated data platform and interface.

Charlotte Avenue/Dr. Martin L King, Jr Blvd Transit Headways and Congestion Management *(Metro Government of Nashville & Davidson County, Public Works Department: Nashville, Tennessee)*

- Grant Amount: $1,500,000

- Project Goals: This project uses technology to enhance connectivity to employment, institutional, and cultural destinations, transforming the operation of a key transit corridor and setting the stage for future technology investments throughout the region. It also improves safety, mobility, equity, choice, and the overall quality of life for City residents.
- Technologies Being Deployed: Connected transit vehicle technology, connected vehicle-to-infrastructure intersection upgrades, transit signal priority, congestion management technology, fleet headway management software, and real-time bus occupancy data.

SM Wright Smart Corridor *(City of Dallas: Dallas, Texas)*

- Grant Amount: $4,000,000
- Project Goals: This project improves the system performance of the SM Wright corridor, provides advanced performance measures for evaluating operations, reconnects and revitalizes economically disadvantaged areas as well as connecting high-density residential areas with small-scale neighborhood commercial uses, and provides information to other entities for deploying the project's technologies.
- Technologies Being Deployed: Smart traffic signal packages, smart bus shelters, autonomous vehicles, advanced emissions monitoring, roadside units, on-board units, roadside control units, connected mobility control center, connected mobility platform, deep learning versatile platform, Derq data analytics platform, EcoTrafiX interface, connected vehicle transit pedestrian alert system, and traffic management system improvements.

Utah Broadly Connected *(Utah Department of Transportation: Utah)*

- Grant Amount: $ 5,450,000
- Project Goals: This project leverages real-time information to improve safety, mobility, and system efficiency, enhance quality of life, and prepare Utah's transportation network for future deployments.
- Technologies Being Deployed: Connected vehicle applications using vehicle-to-everything technology, including Dedicated Short Range Communications and C-V2X for curve speed warning, spot weather impact warning, intersection safety, roadway departure warning, variable speed limit, infrastructure monitoring, and transit signal priority applications. The project also deploys data analytics, including machine learning, deep reinforcement learning, artificial intelligence, and vehicle image reidentification, as well as cellular telematics technology, automated traffic signal performance metrics, third-party probe data (e.g. Bluetooth), and data sharing tools.

Autonomous Truck Ready *(Port of Virginia: Virginia)*

- Grant Amount: $ 2,102,500
- Project Goals: This project improves safety, reduces freight turnaround times, prepares Virginia's ports for increased shipping activity in the future, and develops and shares best practices with other ports.

- Technologies Being Deployed: Autonomous truck movement, Dedicated Short Range Communications and C-V2X communications infrastructure, mobile communications infrastructure, traffic map integration.

APPENDIX C: SUMMARY OF PERFORMANCE MEASURES FOR FY16 THROUGH FY20 PROJECTS

The tables in this chapter present grantee performance measures, broken out by the goal areas outlined in the FAST Act and updated as of March 31, 2021.

Table 7. Summary of Current Projects' Safety Performance Measures.

Safety Performance Measures	Count
Number/rate of crashes (vehicle, bike, pedestrian)	19
Perceived safety (driver/transit user/non-user impressions, etc.)	7
Incident detection/response time	7
Number /rate of fatalities (vehicle, bike, pedestrian)	5
Crash severity (vehicle, bike, pedestrian)	4
Number/rate of injuries	4
Number of safety notifications/connected vehicle activations	4
Number of conflicts (vehicle, bike, and/or pedestrian)	3
Number of hard-braking incidents	3
Number of traffic violations	3
Speed data	3
User feedback/Changes in behavior	3
Improved situational awareness/data	2
Number of near-miss events	1
Other Safety Measures • Adjusted crossing time • Alarm features • Crash reconstruction • Connected vehicle data • Detection camera accuracy • Flow uniformity • Increased active snowplow time • Interoperability with transit police • Number of re-routed vehicles • Number of trucks on terminal • Percent of pedestrians using crosswalk during their phase • Reduced decisions within the dilemma zone • Time to collision • Truck weight-in motion • Vehicle miles traveled • Weather detectors	N/A[1]

Source: FHWA

[1] Each 'Other' measure was used only by one grantee.

Table 8. Summary of Current Projects' Mobility Performance Measures.

Reduced Congestion/Improved Mobility Performance Measures	Count
Travel time	19
Delay	15
Travel time reliability	15
Speed	9
Traveler behavior/satisfaction	9
On-time performance (transit)	8
Vehicle/person miles traveled	5
Throughput	4
Turns/turn time	2
Increased ridership rates	2
Queue length	2
Peak-period distribution	2
Curb occupancy/double-parking	2
Number of notifications	2
Planning time	2
Other mobility performance measures: • Lane clearance • Number of bobtails • Percent arrival on green	N/A[2]

Source: FHWA

Table 9. Summary of Current Projects' Environmental Performance Measures

Environmental Performance Measures	Count
Reduced emissions	12
Fuel savings/consumption	12
Reduced idling	5
Vehicle occupancy	3
Delay reduction	2
Vehicle speed	1
Reduced hard braking	1
Noise improvement	1
Quality of life	1
Reduced vehicle miles traveled	1
Carbon footprint	1

Source: FHWA

[2] Each 'Other' measure was used only by one grantee.

Table 10. Summary of Current Projects' System Performance Measures.

System Performance Measures	Count
Mobility measures (e.g., travel time, delay, congestion)	8
Improved data (e.g., frequency, quality)	7
System/technology performance	5
On-time performance/reliability	4
Perceived quality/effectiveness of system/technology	4
Number of users	3
Reduced system downtime/disengagement (or system uptime)	3
Incident response/clearance time	2
Number of trips	2
Parking activity	2
Use of recommended response plans	2
Other System Performance Measures: • App testing • Lane/road closure duration • Level of service • Mode share • Number of calls • Number of devices connected • Number of notifications received • Number of vehicles detected • Reliable information transfers • V/C ratio	N/A[3]

Source: FHWA

Table 11. Summary of Current Projects' Equity Performance Measures.

Equity	Count
Accessible vehicles	1
EMS trips in communities of concern	1
Injuries in communities of concern	1
Mobility in communities of concern	1
Tracking demographics	1

Source: FHWA

[3] Each 'Other' measure was used only by one grantee.

Table 12. Summary of Current Projects' Reduced Costs Performance Measures.

Reduced Costs Performance Measures	Count
Benefit-cost ratio	5
Reduced fuel/emissions savings	3
Cost per passenger/revenue hour	3
Reduced agency resources needed	2
Vehicle maintenance/operating costs	1
Crash reduction savings	1
Economic costs	1
Farebox recovery ratio	1
Number of dual transactions	1
Travel time savings	1

Source: FHWA

Table 13. Summary of Current Projects' Real-Time Infomation Performance Measures.

Real-Time Information Performance Measures	Count
User satisfaction	6
Number of altered trips	4
Number aware of/using information	4
Number of multimodal or non-SOV trips	2
Equipped vehicle/widget counts	2
Number/Percent of completed requests	2
Volume of data	1
Other real-time information performance measures: • Number of calls against data • Number of private sector app developers using data • Speed of messages	N/A[4]

Source: FHWA

Table 14. Summary of Current Projects' Institutional Benefits Performance Measures.

Institutional Benefits Performance Measures	Count
Planning/preparation for future technologies	4
Data/resource and equipment sharing	2
Improved understanding/awareness of technology	2
Improved Interagency coordination	1
Strengthened public-private partnerships	1

Source: FHWA

[4] Each 'Other' measure was used only by one grantee.

Table 15. Summary of Current Projects' Enhanced Access to Alternatives Performance Measures.

Enhanced Access to Alternatives Performance Measures	Count
Mode share	4
Number of trips/rides (e.g., SOV, people with disabilities, bicycles/pedestrians)	3
Number of passengers/ridership	3
Transit reliability/on-time performance	2
Travel pattern changes	2
Other Measures: • Number of app developers • Open data standards • Value-of-time • Vehicle occupancy	N/A[5]

Source: FHWA

[5] Each 'Other' measure was used only by one grantee.

APPENDIX D: SUMMARY OF CHALLENGES, LESSONS LEARNED, AND PROJECT INNOVATIONS IN 2020 PROGRAM REPORT

CHALLENGES

In the 2020 Program Report, grantees reported challenges related to institutional issues, cost/scope, and technical issues. Table 16 presents a summary of the challenges presented in the 2020 Program Report.

Table 16. Grantee Challenges in 2020 Program Report.

Institutional: Stakeholder Agency Coordination
One grantee was coordinating with nine partner agencies, developing intergovernmental agreements for all, and proceeding with each agency's unique legal and review process
One grantee experienced unexpected delay with the execution of often-complicated, multiple participant off-system right-of-way agreements.
Institutional: Processes and Procurement[1]
Two grantees (both deploying AV technologies) reported to FHWA that AVs on the market did not comply with Buy America and Federal Motor Vehicle Safety Standards (FMVSS).[2]
One grantee reported an unexpected 30-month delay in complying with State contracting requirements with the project's service contractors during the procurement process.
One grantee indicated that ATCMTD-encouraged public-private partnerships required them to take innovative approaches to meet procurement requirements that restrict contracting until a funded project is in place.
One grantee experienced delays with the execution of its autonomous vehicle shuttle contract, as the awarded vendor had difficulty in providing the required insurance premiums under the required procurement timeline.
Cost/Scope Issues
A few grantees reported difficulty in estimating costs due to innovative technologies, lack of historical cost data, or not having project elements fully defined.
One grantee reported that it had underestimated the number of easements that were required for the project (+65), with each easement ranging from $1,000 to $28,500 (and most costing more than $10,000). There were also additional unanticipated costs to get electric service to each RSU.

[1] FHWA issued a memorandum clarifying the Federal-aid procedures for procurement of operational improvements using Federal-aid highway program funding: https://ops.fhwa.dot.gov/plan4ops/resources/memorandum/itsprocurementmemo092519.htm

[2] Due to lessons learned from early grantee experience, FHWA provided clarification on FMVSS in the 2019 ATCMTD Notice of Funding Opportunity: https://www.grants.gov/web/grants/view-opportunity.html?oppId=316761.

Table 16. Grantee Challenges in 2020 Program Report (Continuation).

Cost/Scope Issues (continued)
Another grantee indicated that it was considering a potential decrease in the number of on-board units (OBUs) that will be installed as part of the project.
Technical: Technology and Standards Maturity and Availability
One grantee conveyed the private vendor community is less mature in its technology development than advertised. This caused the grantee to dedicate extra time to device bench testing, integration work, and foundation building.
One grantee noted that many of the applications the grantee wants to deploy on top of the base layer connected vehicle (CV) technology are still undeveloped by vendors, and are not available in an open source format. Furthermore, integrating onboard equipment into a vehicle data bus has been technically challenging, and the grantee is vetting solutions that different companies are offering.
One grantee chose not to pursue dynamic traffic signal phasing, timing, and preemption using Dedicated Short Range Communication (DSRC), a wireless communication technology, because focusing on that less-mature application would have consumed a significant portion of budget and schedule.
The same applicant indicated that standard practices for deploying infrastructure components have not been developed, since the technology has never been deployed in their State and has not been significantly deployed elsewhere in the country. As an example, the grantee noted that determining the appropriate pole on which to mount the RSUs was challenging.
Another applicant reported that the pilot program established for the CVPD has not been available to subsequent deployers, so the team had to investigate requirements of a production Security Credential Management System (SCMS) and vendors that could provide the service.[3]
One grantee reported that several DSRC vendors were unable to fulfill the small orders submitted to them when the grantee sought two of every RSU and OBUs known to be available in the U.S. market. Two vendors stopped responding to inquiries by the City's purchasing staff.
Technical: Interoperability
One grantee noted that it was not able to find a set of CV devices that worked within the City's existing intelligent transportation systems (ITS) infrastructure, particularly for integration with the traffic signal controller. As a result, the program manager added technical testing to the scope of work approved by FHWA to identify a working model.
Through testing, one grantee learned that there were a number of nuances between manufacturers of OBUs, and that nothing was seamlessly "plug and play" or "fully interoperable."
Other Technical
One grantee stated that during the planning phase of the project, the project team explored the use of the Agile Process, a particular approach to project management that is used in software development. While switching to this process did not significantly impact the project schedule, the grantee indicated that the Agile Process could have been explored earlier and presented to FHWA prior to the start of concept exploration.

[3] SCMS is a proof-of-concept message security solution for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, designed to facilitate trusted and secure communication.

Table 16. Grantee Challenges in 2020 Program Report (Continuation).

Other Technical (Continued)
Deployment of CV equipment may require additional considerations from partner maintaining agencies outside of their typical arrangements. For example, if a maintaining agency's network design includes multiple virtual local area networks to separate device types, the grantee suggested that it may need to be revised to ensure communication between the controller and RSU at an intersection for broadcasting signal phase and timing (SPaT) information to motorists.

LESSONS LEARNED

In the 2020 Program Report, grantees reported lessons learned related to institutional findings and technical findings. Table 17 presents a summary of the challenges presented in the 2020 Program Report.

Table 17. Grantee Lessons Learned in 2020 Program Report

Institutional: Stakeholder Agency Coordination
Multiple grantees emphasized the importance of coordination and organization across agencies and stakeholders (public and private) early in the project. Having consensus on project objectives, decisionmaking framework, and a communications plan at the onset would have simplified initial challenges.
One grantee found it valuable to identify a small group of key individuals empowered to make decisions and convenes regularly to review current issues.
One grantee found that acquisitions guidelines permitted holding early stakeholder discussions on autonomous vehicle operation insurance premiums and requirements far in advance of procurement advertisement. If appropriate, future grantees may be able to share autonomous vehicle insurance requirements with vendors in early coordination efforts to undertake market research on prospective firms and to enable vendors to determine the feasibility of obtaining required premiums.
Institutional: Processes and Procurement
Grantees suggested that FHWA contract administration staff should develop a primer package of resources for emerging technology projects like connected vehicle CVs. The grantees suggested that such a welcome packet for recipients include links to key resources, support teams, and software projects to help the receiving party get a strong lay of the land before deciding on a procurement structure and strategy.
Grantees believe that recipients should review Federal source code guidelines and strongly consider mandating a minimum percentage of software code acquired (i.e. through procurement) or developed with public dollars be made open source for other deployer communities.
Technical: Technology and Standards Maturity and Availability
Grantees stated that vendor involvement in deployments is critical to success. Continuous engagement with industry, specifically vendors, to outline desired functionality, applications, and/or use cases has proven the best method for driving development. Engage technology vendors/manufacturers to provide hands-on demonstration and training for equipment deployment to validate and verify technology capabilities and readiness.

Table 17. Grantee Lessons Learned in 2020 Program Report (Continuation).

Technical: Technology and Standards Maturity and Availability (Continued)
Because of the newness of technologies involved in ATCMTD deployments, grant recipients say that entities involved should be flexible and may need to consider adjusting existing practices or standards as appropriate. Recipients believe that it is key to have the necessary parties in the discussion early on, having ownership defined, and establishing final decision authority.
Grantees recommend that recipients perform on-site pilots or laboratory setting tests of all equipment prior to deployment.
Other Technical
Recipients say that grantees should coordinate with maintaining agencies well in advance of the design phase to understand and incorporate network design, limitations, etc. into the project(s).
If considering Agile software development processes, grant recipients might explore and present these processes prior to the start of concept exploration.

INNOVATIONS

In their annual reports, grantees highlight innovative or noteworthy project components. Table 18 presents innovative components published in the 2020 Program Report according to whether the innovation related to technology, process, or data.

Table 18. Grantee Innovative Project Components in 2020 Program Report.

Technology Innovations
Use of new technology to provide enhanced traveler information in a region that spans the U.S.-Canada border
Exploration of the use of unmanned aerial systems to monitor traffic and roadway conditions
Development of an OBU emulator software, capable of utilizing internal sensors and hardware within a mobile phone to transmit and receive messages necessary for CV applications (also serves as a platform for third-party developers to submit CV applications to run, as well as enable users to determine what applications are important to them)
Process Innovations
New and innovative ways to improve and enhance the systems that FHWA had invested in the earlier pilots and proof of concepts
Use of vehicle intelligence software to monitor each component of the vehicle in real-time, and to perform predictive maintenance across the fleet, thus enabling staff to make service decisions before any equipment failure impacts the riders
Use of a scenario-based approach for the concept of operations, an approach which included stakeholder workshops to walk through the scenarios and stakeholder surveys to prioritize the proposed applications for scoping purposes

Table 18. Grantee Innovative Project Components in 2020 Program Report (Continuation).

Data Innovation
Integration of existing traveler round trip information with an existing port truck appointment system (which has never been attempted)

U.S. Department of Transportation
Federal Highway Administration
Office of Operations
1200 New Jersey Avenue, SE
Washington, DC 20590

Office of Operations Website
https://ops.fhwa.dot.gov

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