2022 Program Report

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program

January 2024

U.S. Department of Transportation

Federal Highway Administration

FOREWORD

The Fixing America's Surface Transportation Act, or "FAST Act," (Pub. L. 114-94) 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 (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, 2022, including key technologies grantees are planning to deploy. It also highlights performance measures grantees are using and initial grantee insights and lessons learned regarding their technology deployments.

Cover photo: Alyson West/*A view of Wacker Drive at dusk*, n.d. Available at: PBIC Image Library (pedbikeimages.org), last accessed October 11, 2022.

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16. Abstract The Fixing America's Surface Transportation Act, or "FAST Act," (Pub. L. 114-94) established the 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 shall post on the DOT Website a report about the ATCMTD Program (23 U.S.C. 503(c)(4)(G)). The report should provide credible, useful information on the effectiveness of grantees in meeting their projected deployment plans, as well as findings on the safety, mobility, environmental impacts, operational efficiency, and other impacts of the technology deployments. This report represents the third report. It provides an overview of FYs 2016–2020 ATCMTD projects and describes the findings from one completed project. It also highlights performance measures grantees are using and grantee insights and lessons learned regarding their technology deployments.		
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LIST OF ABBREVIATIONS

Abbreviation	Definition
ACTION	Advanced Connected Transportation Infrastructure and Operations Network
ADM	active demand management
ADOT	Arizona Department of Transportation
AI	artificial intelligence
AI-ITMS	Artificial Intelligence Enhanced Integrated Transportation Management System
AI-TOMS	Artificial Intelligence Enhanced Transportation Operations Management System
ATCMTD	Advanced Transportation and Congestion Management Technologies Deployment
AV	automated vehicle
AVL	automatic vehicle location
CCTV	closed-circuit television
CV	connected vehicle
C-V2X	cellular vehicle-to-everything
CVPD	Connected Vehicle Pilot Demonstration
DelDOT	Delaware Department of Transportation
DOT	U.S. Department of Transportation
DrayFLEX	Drayage, Freight, and Logistics Exchange
DSRC	dedicated short-range communication
DSS	decision support system
FAST Act	Fixing America's Surface Transportation Act
FCC	Federal Communications Commission
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FRATIS	Freight Advanced Traveler Information System
FY	fiscal year
HOV	high-occupancy vehicle
ICM	integrated corridor management
ITS	intelligent transportation system
LA Metro	Los Angeles County Metropolitan Transportation Authority
LED	light-emitting diode
ML	machine learning
MOD	mobility-on-demand
NITTEC	Niagara International Transportation Technology Coalition
OBU	onboard unit
PE	professional engineer
RFID	radio-frequency identification
RSU	roadside unit
RTA	Regional Transit Authority
SPaT	signal phase and timing

TMC	traffic management center
TPAS	Truck Parking Availability System
TSMO	Transportation Systems Management and Operations
TxDOT	Texas Department of Transportation
UAS	unmanned aircraft systems
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle
V2X	vehicle-to-everything

EXECUTIVE SUMMARY

BACKGROUND

This report is the third program report on the ATCMTD Program. The multiyear, comprehensive surface transportation reauthorization FAST Act (Pub. L. 114-94) 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 each FYs 2016-2020, for the grant awards[2] and requires .DOT to award grants[3] each year to at least 5 and no more than 10 eligible entities.[4] This authority was extended through FY 2021 by the Continuing Appropriations Act, 2021 and the Other Extensions Act.[5]

The FAST Act outlines key reporting requirements for the grantees, including annual reports to the Secretary of Transportation.[6] These reporting requirements allow DOT to understand grantees' progress and the outcomes of their project deployments, providing insight into which technologies and types of projects are most effective at advancing FAST Act goals of improving transportation safety, efficiency, and system performance. In addition, FAST Act prescribes that DOT must make publicly available a program report beginning 3 years after the first grant award and annually thereafter.[7] 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.[8]

[1] FAST Act, § 6004 (codified at 23 U.S.C. 503(c)(4) (2018)).
[2] 23 U.S.C. 503(c)(4)(I)(i) (2018).
[3] The term "grant" is used throughout this document for brevity to describe all ATCMTD financial assistance awards, but all awards under the ATCMTD Program meet the definition of a cooperative agreement pursuant to 31 USC 6305.
[4] 23 U.S.C. 503(c)(4)(D)(i) (2018).
[5] Pub. L. 116-159, div. B, title I, § 1101, 134 Stat. 709, 725 (2020).
[6] 23 U.S.C. 503(c)(4)(F) (2018).
[7] 23 U.S.C. 503(c)(4)(G) (2018).
[8] 23 U.S.C. 503(c)(4)(G)(i)-(viii) (2018).

STATUS OF GRANT AWARDS

The ATCMTD Program has awarded 58 grants through FY 2020, including 8 in FY 2016, 10 in FY 2017, 10 in FY 2018, 10 in FY 2019, 10 in FY 2020, and 10 in FY 2021.[9] The details of the FY 2021 awards are not included in this program report from this point forward because the grants were awarded after the reporting period (April 1, 2021–March 31, 2022). Unless otherwise specified, information included in this report is as of March 31, 2022, which includes the 48 grantees which received awards in FY 2016, FY 2017, FY 2018, FY 2019, and FY 2020. The grantees represent a diverse set of metropolitan and rural areas from across the United States. They 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., light-emitting diode, electric vehicle shuttles), artificial intelligence/machine learning, and infrastructure maintenance and monitoring systems, among other technologies.

All grantees in FYs 2016–2019 have executed their agreements. In addition, all grantees in FYs 2016–2018 received funding obligations. As of March 31, 2022, 9 of the 10 FY 2019 grantees have received funding obligations, and 5 of the 10 FY 2020 grantees have received funding obligations. Chapter 2 lists 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 20 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.[10] 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.[11] The FHWA also responds to any grantee requests for information and shares these responses with other grantees, if applicable.

STATUS OF PERFORMANCE MEASUREMENT

[9] For two grantees, Ada County Highway District, ID, (FY 2017) and Greenville, SC, (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 expended for either of these projects).

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

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

As of March 31, 2022, 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, a FY 2017 grantee, implemented a new onboard and integrated communications system, replacing its outdated technology with new features, including state-of-the-art vehicle alarms, priority cellular service, new radio communications towers, and a turn-by-turn navigation system. As a result of the new system's deployment, RTA reported that it 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.[12]

While many grantees are in the planning phase of their deployment process, working on activities such as stakeholder engagement, system documentation (e.g., the concept of operations), and technology procurement, a growing number of projects have begun testing and deploying technology applications. This report includes a more detailed status update (referred to as project highlights) for eight projects. These projects were selected as highlights to demonstrate the range of technologies being deployed, with an emphasis on projects that have reached the testing or piloting phase.

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 safety and mobility, as well as improving system performance and operational efficiencies. Grantees also provide performance measures for reducing emissions, integrating real-time information, reducing costs, improving institutional efficiency, enhancing access to transportation alternatives, and advancing equity.

INSIGHTS ON GRANTEES' CHALLENGES AND LESSONS LEARNED

This report also highlights the grantees' challenges and lessons learned that grantees described in their quarterly reports and annual reports. Grantees continued to mention the challenges associated with national events, which have impacted different project aspects, such as internal project coordination, staffing, and costs. Several grantees also cited supply chain issues as a new challenge in 2021. Grantees mentioned other challenges, with some of the top mentions including:

- Technology, equipment, or data issues
- Project costs
- Staffing
- Vendors/contracts
- Stakeholder coordination
- Internal project coordination

[12] *Advanced Transportation and Congestion Management Technologies Final Report*. Greater Cleveland RTA ATCMTD Final Report (Draft July 2021).

For a number of grantees, these challenges have led to schedule delays. In addition, grantees provided lessons learned and recommendations primarily related to stakeholder engagement and project management, including lessons learned that had not been reported previously.

About This Report

Section 6004 of the FAST Act, codified at 23 U.S.C. 503(c)(4)(G), 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 Transportation shall post on the DOT Website an ATCMTD Program report that describes the effectiveness of grant recipients in meeting their projected deployment plans. Per 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.

CHAPTER 1. INTRODUCTION

This report is the third program-level report on the ATCMTD Program. The FAST Act, a Federal law providing long-term funding for surface transportation infrastructure planning and investment from FY2016-2020, 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.[1]

This authority was extended through FY 2021 by the Continuing Appropriations Act 2021, and the Other Extensions Act[2].

BACKGROUND

The ATCMTD Program funds grants to deploy advanced technologies in support of FAST Act safety, mobility, environmental impact, and operational efficiency goals.[3] The law sets aside $60 million each FY from FY 2016-FY 2020 for the grant awards,[4] with the Federal share of funding not to exceed 50 percent of the total cost of the project.[5] The law requires DOT to

[1] 23 U.S.C. 503(c)(4) (2018).
[2] Pub. L. 116-159, div. B, title I, § 1101, 134 Stat. 709, 725 (2020).
[3] 23 U.S.C. 503(c)(4)(A) (2018).
[4] 23 U.S.C. 503(c)(4)(I)(i) (2018).
[5] 23 U.S.C. 503(c)(4)(J) (2018).

award grants each year to at least 5 and no more than 10 eligible entities, with not more than 20 percent of the funds each year to a single entity. The awards should be diverse with respect to the technologies being deployed and geographic location.[6] In addition, the law requires that candidates' applications include a technology deployment plan,[7] quantifiable system performance objectives,[8] quantifiable safety, mobility, and environmental benefit projections, a plan for partnering with other institutions, and an explanation of how applicants will leverage existing technology and infrastructure for the project.[9]

GRANTEE REPORTING REQUIREMENTS

The ATCMTD Program includes a number of key reporting requirements for grantees, including annual reports to the Secretary of Transportation.[10] The reporting requirements allow FHWA to monitor grantees' deployment progress and to understand the impacts of grantees' projects, providing insight into 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 the 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 advanced technology deployments.

The following sections summarize grantees' key reporting requirements.

Quarterly Reports

All grantees 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, the 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 the "annual report" in this document) that describes deployment impacts, including:[11]

- Project deployment and operational costs compared to the benefits and savings the project provides;

[6] 23 U.S.C. 503(c)(4)(D) (2018).
[7] 23 U.S.C. 503(c)(4)(C)(ii)(I) (2018).
[8] 23 U.S.C. 503(c)(4)(C)(ii)(II) (2018).
[9] 23 U.S.C. 503(c)(4)(C)(ii) (2018).
[10] 23 U.S.C. 503(c)(4)(F) (2018).
[11] 23 U.S.C. 503(c)(4)(F).

- Data on whether the project has helped reduce traffic crashes, congestion, costs, and other benefits of the deployed systems;

- 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; and

- 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 were incorporated into their cooperative agreements 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.[12]

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 later in this section, 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:

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

- 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.

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

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

- What lessons have been learned to date from your deployment, specifically regarding future deployment strategies to optimize transportation efficiency and multimodal system performance? Please note lessons learned regarding challenges in technology deployment (e.g., technical, institutional), 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 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.[13] 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 (CVs, AVs, and adaptive signal control).

Early Deployer Cohort Program

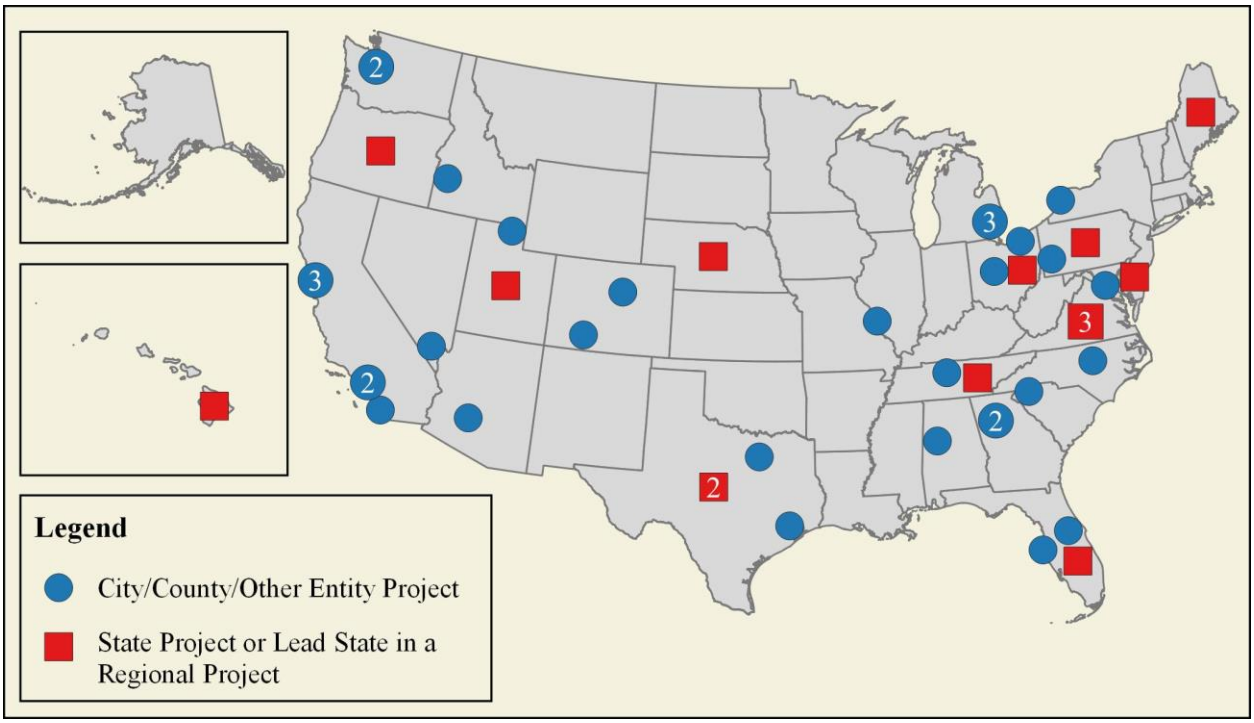
The FHWA has been providing support to grantees through the Early Deployer Cohort Program, a voluntary roundtable of 7 grantees (with 20 additional grantees who chose to be informal members) that meets monthly via Webinar conference to provide status updates and share information about their progress, challenges, and lessons learned. The Early Deployer Cohort Program has been a resource for connecting grantees facing similar technical and institutional challenges.

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

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 cohort CVPD Program, the 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 to exchange relevant resources.

CHAPTER 2. OVERVIEW OF GRANTEE PROJECTS

This chapter provides a general overview of the grantee projects awarded through FY 2020 (FY 2021 awards are not included because the grants were awarded after the reporting period for this program report (April 1, 2021–March 31, 2022)). The ATCMTD Program has awarded 48 grants as of March 31, 2022, including 8 in FY 2016, 10 in FY 2017, 10 in FY 2018, 10 in FY 2019, and 10 in FY 2020.[14] The grantees represent a diverse array of U.S. metropolitan and rural areas, as shown in Figure 1. All grantees in FYs 2016–2019 have executed their agreements. In addition, all grantees in FYs 2016–2018 received funding obligations. As of March 31, 2022, 9 of the 10 FYv 2019 grantees have received funding obligations, and 5 of the 10 FY 2020 grantees have received funding obligations. The FHWA has conducted kickoff meetings with all FY 2020 grantees, and 9 of the 10 FY 2020 have executed their agreements.



Source: FHWA.

Figure 1. Map. Advanced Transportation and Congestion Management Technologies Deployment Program grantees.[15]

[14] For two grantees, Ada County Highway District, ID, (FY 2017) and Greenville, SC, (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 expended for either of these projects).

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

PROJECTS BY FISCAL YEAR

The lists that follow 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 of each project, please see appendix B.

Fiscal Year 2020 Awards

The ATCMTD Program awarded the following 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 Public Works Department*
- Emergency Vehicle Preemption Using Connected Vehicle Technology, *Georgia DOT*
- Maine Advanced Signal Control and Connected Vehicle System for Safe, Efficient, and Equitable Rural Transportation (MAST) Project, *Maine DOT*
- Smart Intersections: Paving the Way for a National Connected and Automated Vehicles Deployment (CAV), *University of Michigan*
- Integrated Safety Technology Corridor, *Regional Transportation Commission of Southern Nevada*
- Charlotte Avenue/Dr. Martin L King, Jr Boulevard Transit Headways and Congestion Management, *Metro Government of Nashville and Davidson County, TN (Public Works Department)*
- S.M. Wright Smart Corridor, *City of Dallas, TX*
- Utah Broadly Connected, *Utah DOT*
- Autonomous Truck Ready, *Virginia Port Authority*

Fiscal Year 2019 Awards

The ATCMTD Program awarded the following 10 grants in FY 2019:

- Deployment of Personalized and Dynamic Travel Demand Management Technology in the Washington, DC, Baltimore, MD, Richmond, VA, megaregion, *Metropolitan Washington Council of Governments*
- I–4 Florida's Regional Advanced Mobility Elements (FRAME), *Florida DOT*
- Implementing Cellular V2X Technology to Improve Safety and Intelligent Transportation Systems (ITS) Management in Hawaii, *Hawaii DOT*
- Intelligent Woodward Corridor Project, *Michigan DOT*
- I–270 Predictive Layered Operation Initiative (PLOI), *Missouri DOT*
- Multimodal Connected Vehicle Pilot, *North Carolina DOT*
- DriveOhio I–70 Truck Automation Corridor, *Ohio DOT*
- Artificial Intelligence-Powered Decision Support Tools for Integrated Corridor Management, *Tennessee DOT*
- Artificial Intelligence Meets Integrated Corridor Management: Realizing the Next Generation of Regional Mobility, *Virginia DOT*
- Deployment of the Washington State Virtual Coordination Center (VCC) for Multimodal Integrated Corridor Management, *Washington State DOT*

Fiscal Year 2018 Awards

The ATCMTD Program awarded the following 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 DOT*

- Artificial Intelligence Enhanced Integrated Transportation Management System (AI-ITMS) Deployment Program, *Delaware DOT*
- Georgia Department of Transportation Connected Vehicles, *Georgia DOT*
- Multi-State Rural Integrated Corridor Management (I–80), *Nebraska DOT*
- Oregon Smart Mobility Network, *Oregon DOT*
- Work Zone Reservation and Traveler Information System, *Pennsylvania DOT*
- I–10 Corridor Coalition Truck Parking Availability System (TPAS) (I–10 Corridor Coalition TPAS), *Texas DOT*
- Utah Connected, *Utah DOT*

Fiscal Year 2017 Awards

The ATCMTD Program awarded the following 10 grants in FY 2017:

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

Fiscal Year 2016 Awards

The ATCMTD Program awarded the following eight grants in FY 2016:

- Freight Advanced Traveler Information System (FRATIS), *Los Angeles County Metropolitan Transportation Authority (LA Metro)*
- 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 and Mobility with the Promise Zone, *Los Angeles DOT*
- Denver Smart City Program, *City and County of Denver, CO*
- 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, City of Marysville, and City of Dublin, OH*
- SmartPGH, *City of Pittsburgh, PA*
- ConnectSmart: Connecting Transportation Systems Management and Operations (TSMO) and Active Demand Management (ADM)

SUMMARY OF TECHNOLOGY DEPLOYMENTS

The ATCMTD grants awarded from FY 2016-FY 2020 support the deployment of a range of advanced transportation technologies.[16] Some of the key technologies include CVs and connected infrastructure; real-time traveler information; 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., light-emitting diode (LED) lighting, electric vehicle shuttles). Table 1 highlights the number of deployment projects for each of these key technologies.[17] Many

[16] For two grantees, Ada County Highway District, ID, (FY 2017) and Greenville, SC, (FY 2017), FHWA and the grantees mutually agreed to terminate the grant. These two projects are not included in this section or any following sections of this report.

[17] 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 grantee key technology deployments, as of March 31, 2022.

Technology	Number of Projects (46 Projects Total)
Real-Time Traveler Information	41
Connected Vehicles/Connected Infrastructure	37
Integrated Corridor Management/Decision Support Systems	22
Infrastructure Maintenance/Monitoring	11
Adaptive Signals	11
Artificial Intelligence/Machine Earning/Advanced Analytics	10
Automated Vehicles	7
Green Technology (LED lighting, electric vehicle shuttles)	4

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/bicyclist, or mobility-on-demand (MOD), 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, as of March 31, 2022.

Mode/Service Model	Number of Projects (46 Projects Total)
Passenger Vehicle	32
Pedestrian/Bicyclist	22
Transit	22
Freight	11
Mobility-on-Demand	6

GRANTEE DEPLOYMENT STATUS

One FY 2017 grantee, the Greater Cleveland RTA, completed its project as of March 31, 2022. However, many grantees are still in the planning phase of their deployment process, working on activities including stakeholder engagement, system documentation (e.g., the concept of operations), and technology procurement. A growing number of projects have begun testing and

deploying technology applications. Table 3 illustrates the overall deployment status of FY 2016-FY 2020 grantees by showing the number of projects at different stages of deployment.[18]

Table 3. Advanced Transportation and Congestion Management Technologies Deployment fiscal years 2016–2020 grantee project status as of March 31, 2022.

Deployment Status	Number of Projects (46 Projects Total)
Planning Stages	30
Piloting/Testing/Partial Deployment	15
Completed Deployment	1

PROJECT HIGHLIGHTS

This section of the report highlights the activities of eight grantees, providing a more detailed description of their progress. The eight projects were selected to demonstrate the range of technologies being deployed, emphasizing projects that have reached the testing or piloting phase. These projects also demonstrate the diverse modes that are being addressed. The eight project highlights include:

- Connecting East Orlando Communities
- Artificial Intelligence Enhanced Integrated Transportation Management System (AI-ITMS) Deployment Program
- Denver Smart City Program
- ConnectSmart: Connecting Transportation Systems Management and Operations (TSMO) and Active Demand Management (ADM)
- Loop 101 Mobility Project
- Freight Advanced Traveler Information System
- Oregon Smart Mobility Network
- Truck Reservation System and Automated Workflow Data Model

Connecting East Orlando Communities (Fiscal Year 2016)

The Connecting East Orlando Communities project is led by Florida DOT (FDOT) in collaboration with MetroPlan Orlando, the University of Central Florida, the City of Orlando, and Orange County and includes three interrelated initiatives. GreenWay deploys ICM strategies to reroute drivers during incident conditions on more than 55 miles of I–4 (south of the attractions to the north of Orlando's urban boundary; 35 interchanges) with signal timing updates on more than 40 different roadways involving 4 counties and numerous cities integrated into a single system to improve travel time reliability and reduce environmental impacts. Two key

[18] The chart excludes two FY 2017 grantees who mutually agreed with FHWA to terminate their grants and one FY 2020 grantee who has not executed their agreement. For one FY 2019 grantee and five FY 2020 grantees, funding has not yet been obligated by FHWA.

technologies being deployed are intersection movement count technology with automated traffic signal performance measures that adjust traffic signal timing in realtime and traffic signal priority technology for local buses.

As part of SmartCommunity, two electric AV shuttles will operate on the University of Central Florida campus. These buses will connect the outer areas of the campus to the academic buildings in the center. Testing has been underway, and one AV shuttle started running in early 2022, with a second expected online later in the year. SmartCommunity also has a broader transit component, including a trip planning application, automatic vehicle location (AVL), and transit kiosks to provide real-time multimodal travel information. A MOD component seeks to integrate rideshare information into the trip planning application. Transit signal priority also will be deployed to connect disadvantaged communities more efficiently with employment and services.

PedSafe is designed to connect advanced signal controller capability, CV technologies, and existing communication capabilities to reduce the occurrence of pedestrian and bicyclist crashes. The FDOT will integrate the software with its existing 511 application, enabling a smartphone to act as an onboard unit (OBU), providing mobile application users with safety messages. The deployment of roadside units (RSUs) facilitates communication between the infrastructure (e.g., traffic signals, pedestrian signals) and travelers using the mobile application. The OBUs on buses and fleets will communicate with the infrastructure. Through two-way communication, these connections will provide alerts to reduce collisions.

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Artificial Intelligence Enhanced Integrated Transportation Management System (AI-ITMS) Deployment Program (Fiscal Year 2018)

Source: DelDOT.

Figure 2. Graphic. Artificial Intelligence Integrated Transportation Management System logo.

Delaware DOT (DelDOT) is enhancing its integrated transportation management system with AI and ML algorithms to make operations and management more efficient. With consistent data monitoring and analysis, the system will advise traffic management center (TMC) technicians by anticipating and mitigating traffic anomalies, including incidents and congestion. The system predicts traffic flow in the short term and leverages simulation tools to predict traffic flow more accurately in the long term. In conjunction with other applications, this system will better predict when congestion will occur based on advanced traffic demand detection and integrate with DelDOT's traffic control system to optimize response by adjusting signal timing and improving efficiency.

The software team upgraded its representational state transfer Web services with a Web-based AI-Enhanced Transportation Operations Management System (AI-TOMS). During the project's second year, the team made significant improvements to the AI-TOMS, including adding and testing algorithms for the AI-TOMS modules. For example, incident detection and simulation model calibration continues to improve for optimal solution development. The AI-TOMS modules use a variety of data sources and integrate with DelDOT's existing detection systems. Plans are underway to enhance DelDOT's technology testbed along US 13 in Smyrna, DE, with machine vision cameras. The DelDOT has upgraded 3 out of 11 planned CV-enabled RSUs to dual-mode and installed them in this testbed. In addition, as an initial test, one DelDOT fleet vehicle is currently outfitted to collect CV data. The project team plans to equip more vehicles with data loggers to gain information that will help the AI-ITMS monitor and predict traffic flows on Delaware's roadway beyond fixed detection.

The current version of AI-TOMS includes five modules to support the TMC operations:

- Traffic data analytics for congestion and incident management
- High resolution data for traffic signal operation assessment
- Machine vision for traffic monitoring and vehicle re-identification
- Connected and probed vehicles, transit
- System health monitoring

The DelDOT project team has reported findings on incidents from January 2021 to August 2021 that the DelDOT TMC confirmed. The AI software can detect most incidents in less than 5 minutes on freeways and 10 minutes on arterial roads. The AI system can currently detect 100 percent of major incidents, 90.47 percent of medium incidents, and 88.88 percent of minor

incidents within the urban study area of New Castle County. Those that took longer to detect were minor, and those not detected at all occurred at night, causing minimal traffic disturbance. It is anticipated that as the system operates, it will use ML and AI to "learn" like a human and improve these metrics over time. The deployment will occur after the software is validated offline, allowing for constant real-time traffic operations; testing has shown the speed of incident response suggestions will meet DelDOT's goal of taking less than 3 minutes following incident detection. By enhancing DelDOT's existing system, the AI-ITMS provides the foundation for further advanced technology, including machine vision, in transportation. The system is designed to eventually be able to autonomously take action without relying on human technicians and to learn to improve over time. All efforts lead to the ultimate goal of operating a fully predictive and adaptive transportation management system.

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Denver Smart City Program (Fiscal Year 2016)

The City and County of Denver, CO, are collaborating on a project that leverages CV technology, advanced detection systems, and cloud-based technologies to improve safety, reduce congestion, and provide improved real-time information. Through this project, Denver is advancing its enterprise data management system, a central data repository to ingest, process, analyze, and share actionable data from a wide range of sensors, Internet of Things devices, and CV technologies.

The project is composed of three components:

- Connected TMC and fleet
- Connected TMC/transit/freight
- Connected pedestrian

For its connected fleet project, Denver is deploying CV technology on city snowplows in a small geographic area. The team installed OBUs on 25 heavy-duty city snowplows with validated communication between OBUs and RSUs. During snowstorms, snowplows will receive signal priority, increasing the fleet's efficiency as well as driver safety. The resulting CV data will also increase TMC situational awareness. More broadly, this deployment will be used to understand how vehicle communication can improve residents' commuting experiences and how to provide better data to citizens. Baseline data is being collected, and Denver anticipates full deployment during the 2022–2023 winter season.

Additionally, due to a Federal Communications Commission (FCC) Report and Order in 2020, the deployed RSUs and OBUs utilized in the initial phase of the connect fleet program have been swapped for a dual-mode dedicated short-range communication (DSRC)/cellular vehicle-to-

everything (C-V2X) capability. Denver's goal is to have a functional C-V2X system by the 2022–2023 winter season, as this technology will serve as the basis for future deployments.

Denver is also creating a connected freight/transit corridor, using lessons learned from the snowplow deployment. Buses will be equipped with transit signal priority in 2022, enabling greater transit time reliability. The city can use the same communication interface with traffic signals as the snowplow project, reducing the amount of specialized equipment and maintenance costs. Freight companies will also be able to leverage the technology to improve delivery time reliability and achieve cost savings.

Denver anticipates an expanded transit corridor deployment by the fourth quarter of 2022. This deployment will consist of an additional 38 RSUs and 67 OBUs. These devices will be operating in the C-V2X system.

Pedestrian detection and notification technology is being deployed to extend pedestrian "walk" signs if someone, such as a young child or sight-impaired individual, needs more time to cross the street. Video analytics are integrated into the transportation system to alert the traffic signal controller of pedestrians within the region of interest. The controller (see figure 3) can then modify traffic signal operations as needed. In addition, RSUs will transmit data to OBUs on CVs, providing those drivers with advance warning of pedestrians. Denver is currently testing the integration of its pedestrian detection and notification system in several downtown locations and is collecting baseline data.

Source: City of Denver.

Figure 3. Photo. Traffic management center.

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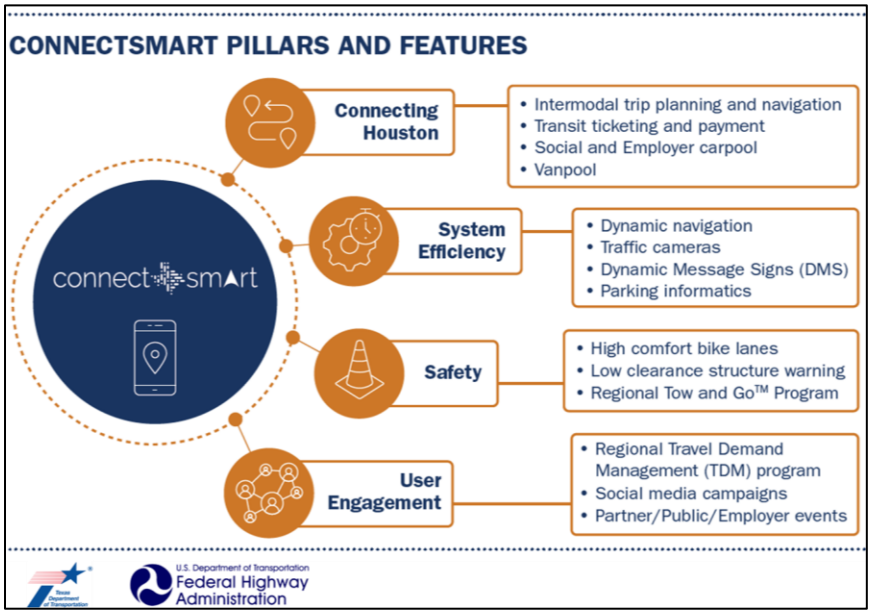
ConnectSmart: Connecting Transportation Systems Management and Operations (TSMO) and Active Demand Management (ADM) (Fiscal Year 2016)

Houston's ConnectSmart project is a regional collaboration led by Texas DOT (TxDOT) in coordination with the Houston-Galveston Area Council, Houston METRO, TranStar, the City of

Houston, and regional counties to deploy an advanced technology and multimodal mobility platform and mobile application. The project seeks to encourage travelers to adopt new travel behaviors incrementally, helping to make the Houston region less congested and more connected. The ConnectSmart platform integrates TSMO and ADM to enable users to discover new mobility options that help improve system efficiency and safety (see figure 4). The project aims to disperse travel demand across time, space, and modes by presenting users with information on more efficient and sustainable travel options, such as leaving at a less congested time, changing their route, sharing a ride, or taking public transit. While aiming to reduce the drive-alone rate, the project seeks to benefit the local community by filling critical mobility connectivity gaps and increasing access to available current and emerging mobility options choices via the application. The application introduces innovative tactics and features, such as gamified social rewards, unified payment across modes, travel demand management, and safe routing options for bikes and trucks. Field testing of the mobile application began in the summer of 2021, and users' feedback has informed ongoing improvements to both the application and the data platform. The full launch of the application occurred in September 2022.



Source: TxDOT.

Figure 4. Graphic. Houston ConnectSmart project pillars, integrated platform, and application features.

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Loop 101 Mobility Project (Fiscal Year 2017)

The Arizona Department of Transportation (ADOT) and the Maricopa County, AZ DOT have collaborated to implement an ICM System on the Loop 101 corridor in the Phoenix metropolitan area. The Loop 101 Mobility Project deploys various technologies to improve existing arterial capacity, reduce congestion, and improve incident and event management. The project leverages existing resources and investments to be more cost effective and easier to expand to other corridors in the region.

The Loop 101 project includes five key technologies:

- DSS
- Adaptive signal control technology
- CV applications for transit and incident response vehicles
- Adaptive ramp metering
- Integrated traveler mobility application

Using ICM facilitates improved real-time freeway-arterial coordination when incidents impact Loop 101 and divert traffic onto local streets. This initiative increases agency awareness of incidents, promotes cross-agency information sharing, and provides advanced warnings and alerts to travelers on the corridor to promote improved trip decisionmaking. The DSS will use a network simulation engine to predict traffic conditions for recurring and nonrecurring congestion and recommend specific responses. The project's CV applications will support incident management and transit operations. In 2022, there will be preliminary testing at a testbed in Anthem with devices obtained from the DOT. This testing will occur before procuring RSUs and equipping transit vehicles in Scottsdale.

In addition to providing real-time information on transit services, the integrated traveler mobility application will help users with physical disabilities safely cross the street at a crosswalk by triggering extended pedestrian crossing time. The adaptive metering capability will continue to be deployed in 2022 through various capital improvement projects. Ramp meters will be connected to mainline detection to coordinate release rates to optimize traffic flow onto the mainline on a corridor-wide basis. Testing of the adaptive traffic signal control system, which will be deployed in the City of Glendale, is scheduled for the fall of 2022.

Stakeholder engagement is critical to this project to ensure that key routes are included and that there is connectivity among alternative routes. The ADOT has facilitated meetings with strong participation to coordinate technical tasks, discuss needs, and share information. The project Website has been a valuable resource for centralizing project documentation and background information for stakeholders. The stakeholders include the Maricopa Association of Governments, Arizona Department of Public Safety, Valley Metro (transit and light rail), seven cities, the Salt River Pima-Maricopa Indian Community, and two local universities.

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Freight Advanced Traveler Information System (Fiscal Year 2016)

Source: LA Metro.

Figure 5. Logo. Drayage, Freight, and Logistics Exchange Project.

Through the Drayage, Freight, and Logistics Exchange (DrayFLEX) project, LA Metro leverages ICM and CV technologies to reduce emissions and fuel consumption while improving mobility and relieving congestion. DrayFLEX uses information from truck management systems, trucking companies, and traveler information to provide drayage operators and truck drivers the ability to efficiently plan daily container pick-ups and drop-offs at the Ports of Long Beach and Los Angeles. This initiative integrates currently disparate systems and builds on the successes of recent small-scaled testing with the DOT to provide visibility on the real-time movement of cargo and improve freight coordination.

The DrayFLEX Core system optimizes dray operations through automation by integrating and processing data on turn times, equipment management, port and terminal conditions, truck location, real-time and historical traffic information, and routing information. This component maximizes productivity, efficiency, and customer service levels by identifying the best time to schedule trips. Minimizing wait times reduces truck idle times, fuel consumption, and emissions and increases trucking productivity and terminal throughput.

The DrayFLEX-Trip mobile application provides truck operators with dynamic truck-specific routing recommendations to optimize travel time or fuel efficiency based on real-time traffic, incident, roadway construction, truck location and destination, and truck-permitted route information. Slowdown-ahead warnings and speed advisories will also be provided via audible alerts.

Both applications have completed the design and development phases and have entered testing and validation. LA Metro is in the process of recruiting participants for DrayFLEX Core DrayFLEX-Trip.

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Oregon Smart Mobility Network (Fiscal Year 2018)

Nine projects comprise Oregon DOT's Oregon Smart Mobility Network, which aims to improve safety and travel time reliability through real-time traffic management and expedited recovery from unexpected events.

The project includes innovative technologies such as:

- Automated active traffic management
- Cloud-based transit signal priority
- Adaptive pedestrian safety systems
- Bike-specific signal timing
- Radar-based conditional red clearance extension
- UAS crash reconstruction

While most of the projects are in the construction stages, the adaptive pedestrian safety system (Cornelius Pass Road Arterial Corridor Management project with Washington County) has shown successful operation in preliminary testing, and the unmanned aircraft systems (UAS) Crash Reconstruction project is complete. For UAS crash reconstruction, which is shown in figure 6, Oregon DOT assisted the Oregon State Police with procuring equipment, training troopers, and deploying five small UAS aircraft to expedite site investigations following serious injury or fatality crashes. Shortening the time needed to collect data on traffic incidents alleviates congested conditions sooner and lowers the risk that responders could be struck on the road.

Source: Oregon DOT.

Figure 6. Photo. Drone deployment.

Findings from the field indicate that UAS reconstruction significantly reduced reconstruction times. The 25 UAS reconstructions in 2020 had an average duration of 106 minutes, compared to 162 minutes, on average, for the 161 non-UAS reconstructions.[19] Using a drone saved approximately 1 hour per investigation. However, there was a negligible difference in lane clearance times between UAS and non-UAS reconstructions.

One contributing factor is that lane closure times include the amount of time taken for trained personnel to arrive at the scene, which was about 10 minutes longer for UAS reconstructions. The quality of the data captured during a UAS reconstruction was improved and more valuable to end users. The UAS collected more than 20 million data points in a test, whereas the other technologies collected fewer than 200 points. The drones could provide a more comprehensive context for an event, including factors that otherwise may not be considered at the time of the investigation (e.g., vehicle orientation, the debris field, surrounding obstructions, or the impact of weather). Standardizing the scope of data captured preserves potentially critical information that may be lost when reconstructions are limited to the deliberate choices made by responding investigators during potentially chaotic or unsafe scenes. In more than 90 percent of cases,

[19] Technologies included robotic total measuring stations and terrestrial scanners.

equipped investigators preferred the combination of UAS and satellite navigation to collect data and clear roadways. Oregon DOT concluded that this approach is the most cost effective and efficient method of scene data capture, particularly when evidence spans a significant linear distance of roadway.

The case study also summarized a number of lessons learned about the use of UAS for crash reconstruction.

Key lessons learned from the project include:

- Training can be easily designed to achieve basic proficiency, but it can be difficult to integrate atypical scenes into a training curriculum, and ongoing training is required to maintain proficiency.
- The costs, size, and maintenance demands of equipment (e.g., software and hardware) can be prohibitive; data volume and network speed/availability also must be considered.
- The constantly changing regulatory environment creates challenges.
- The number of UAS systems was a limiting factor and achieving safety goals will depend on having a sufficient number of UAS.

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Truck Reservation System and Automated Workflow Data Model (Virginia) (Fiscal Year 2017)

Source: Virginia Port Authority.

Figure 7. Photo. The Port of Virginia.

The Virginia Port Authority (see arial view in figure 7) addresses port congestion through enhancements to its cloud-based second-generation truck reservation system. This client-facing cloud software communicates with a multitude of hardware and software components, through backend systems, to facilitate rapid access for motor carriers to the marine terminals. By increasing system efficiency, the reservation system will reduce the congestion associated with entry gate processing time, improve throughput, and lower emissions from idling trucks. A secondary endeavor of this project is to improve port-centric visibility to supply chain events. Through a real-time data subscription, the port and other supply chain stakeholders (e.g., motor carriers, railroads, shippers, and brokers) can now receive data about where their goods are and when they can access their cargo.

The Virginia Port Authority implemented an initial reservation system using radio-frequency identification (RFID) technology in 2007; however, there was no limit to the number of trucks that could arrive at the terminal at any given time, which contributed to congestion. A newer RFID system was deployed starting in 2016 to provide enhanced functionality. Meanwhile, the deployment of mandatory reservations at other ports demonstrated the feasibility and value of structuring the access to container terminals. It became clear that a second-generation system would be necessary to best utilize the port's container handling resources. For this project, the port adopted a mandatory reservation system strategy, which resulted in numerous other enhancements to the reservation system and a programmatic interface to facilitate stakeholders' event-data access. A mobile application is being deployed in 2022 with test users, which allows them to view and modify reservations using their smartphones. At the conclusion of the grant, the Virginia Port Authority will publish a document to be used as an implementation guide by other ports.

Anticipated features of the mobile application include:

- A mobile version of the container availability feature
- Truck-specific reservation status inquiry capability
- The ability to add container details to existing reservations
- The ability to obtain mobile application-based equipment interchange receipt
- Direct messaging capabilities from the port to the drivers using the mobile application

Throughout 2021, congestion was common across ports, and the flow of container cargo volumes at the Port of Virginia was sustained at levels consistent with peak season throughout the year. Video audits and preliminary data confirm that there has been a reduction in turn times through the expansion of the truck reservation system. As a result, missed rates fell from a high of 25 percent in 2019, before deployment, to lows of 5.5 percent in 2020 and 6.1 percent in 2021. Video audits and sampling also revealed that the truck reservation system positively impacted safety inside the terminals, especially at the landside queuing areas. The frequency of drivers exiting their tractors was reduced by mitigating queuing congestion. Prior to deployment, potential safety incidents classified as near misses were common as drivers would exit their trucks to discuss who would back into the transfer zone parking slot next.

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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, applicants are required 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.[20]

As a result, all grantees from FY 2016-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 2022, 20 grantees had submitted evaluation plans: 4 FY 2016 grantees, 5 FY 2017 grantees, 8 FY 2018 grantees, 8 FY 2019 grantees, and 4 FY 2020 grantees.

As of March 31, 2022, one grantee—Greater Cleveland RTA—has submitted a draft final report that is under FHWA review, and Oregon DOT has completed one component of its project, the UAS reconstruction, which was described in chapter 2 under Project Highlights. All other grantees are in the piloting/testing or 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, and its draft final report is under FHWA review. The RTA replaced and upgraded its transit communication, computer-aided dispatch (CAD), and AVL 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. 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. The 2021 American Public Transportation

[20] 23 U.S.C. 503(c)(4)(C)(ii)(III).

Association (APTA) Think Transit Conference honored RTA with an award for "Most Innovative."[21] The 2021 program report described the key findings of RTA's completed project.

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 may use "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 4 lists the most common core performance measures grantees use across reported goal areas. If multiple grantees use a performance measure, the number of grantees is noted in parentheses, e.g., (*n*=3). The goals shown in Table 4 align with requirements in the FAST Act, which are reflected in the Notices of Funding Opportunity.

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.

Table 4. Common advanced transportation and congestion management technologies deployment grantee performance measures by goal area, 2022.[22]

Goal Area	Common Performance Measures
Improved safety	• Number/rate of crashes (vehicle, bike, pedestrian) (*n*=23) • Incident response time (*n*=9) • Crash type/trend (*n*=9) • Speed (*n*=8) • Perceived safety (driver/transit user/nonuser impressions) (*n*=8)
Reduced congestion/improved mobility	• Travel time (*n*=13) • Travel time reliability (*n*=10) • Delay (*n*=9) • Speed (*n*=7) • Miles traveled (*n*=5)
Reduced environmental impacts	• Emissions (*n*=11) • Fuel savings/fuel consumption (*n*=8) • Idling (*n*=5) • Occupancy per vehicle (*n*=4)

[21] "RTA Named "Most Innovative" at the 2021 Trapeze-Vontas Conference," Greater Cleveland Regional Transit Authority, April 27, 2021, http://www.riderta.com/news/rta-named-most-innovative-2021-trapeze-vontas-conference.

[22] If multiple grantees use a performance measure, the number of grantees is noted in parentheses, e.g., (*n*=3).

Table 4. Common advanced transportation and congestion management technologies deployment grantee performance measures by goal area, 2022 (continuation).

Goal Area	Common Performance Measures
Improved system performance (including optimized multimodal system performance)	• Mobility measures (travel time, delay) (*n*=8) • On-time performance (*n*=7) • System efficiency/performance (*n*=6) • Number of users (*n*=5) • Technology effectiveness (*n*=5)
Enhanced access to transportation alternatives	• Number of passengers/ridership (*n*=4) • User satisfaction (*n*=4) • Number of trips/rides (*n*=3)
Effectiveness of providing integrated real-time transportation information to the public to make informed decisions	• User feedback/perception (*n*=12) • Number aware of/using information (*n*=6) • Information accuracy (*n*=2) • Data type/availability (*n*=2) • Equipped vehicle/widget counts (*n*=2) • Number of actions/alerts (*n*=2)
Equity	• Demographic information • Non-single-occupancy vehicle mode share • Number of riders • Number of traffic-related injuries (in communities of concern) • Number of trips (from communities of concern/provided to people with disabilities) • Response time (for trips from communities of concern/provided to people with disabilities) • User satisfaction
Reduced costs	• Cost comparison (*n*=4) • Net present value (*n*=3) • Reduced fuel costs/emissions savings (*n*=3) • Benefit-cost analysis/benefit-cost ratio (*n*=3) • Congestion costs (*n*=2) • Trips/miles traveled reduced (*n*=2)
Institutional and/or administrative benefits	• Information sharing between agencies/stakeholders (*n*=5) • Improved efficiency/access to data (*n*=4) • Improved understanding/awareness of technologies (*n*=3) • Perceived benefit/stakeholder feedback (*n*=2)

CHAPTER 4. GRANTEE CHALLENGES AND LESSONS LEARNED

This chapter presents grantees' reported challenges and lessons learned as of March 31, 2022 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.

GRANTEE CHALLENGES

Various challenges cited by the grantees in their quarterly and annual reports include technology/equipment/data problems, cost issues, stakeholder and project coordination, staffing problems, evaluation challenges, vendor and contract issues, the FCC ruling regarding the Safety Band,[23] and other administrative and external issues. A number of grantees also cited schedule/project delays.

In particular, national events continued to affect projects in multiple ways. For example, grantees cited challenges related to their inability to meet in person or to conduct onsite work, difficulty with technology installation and stakeholder coordination, supply chain delays, and staffing changes. Travel demand changes caused by national events continue to affect data baselines for certain projects. These issues also are reflected in impacts on some projects' costs and schedules.

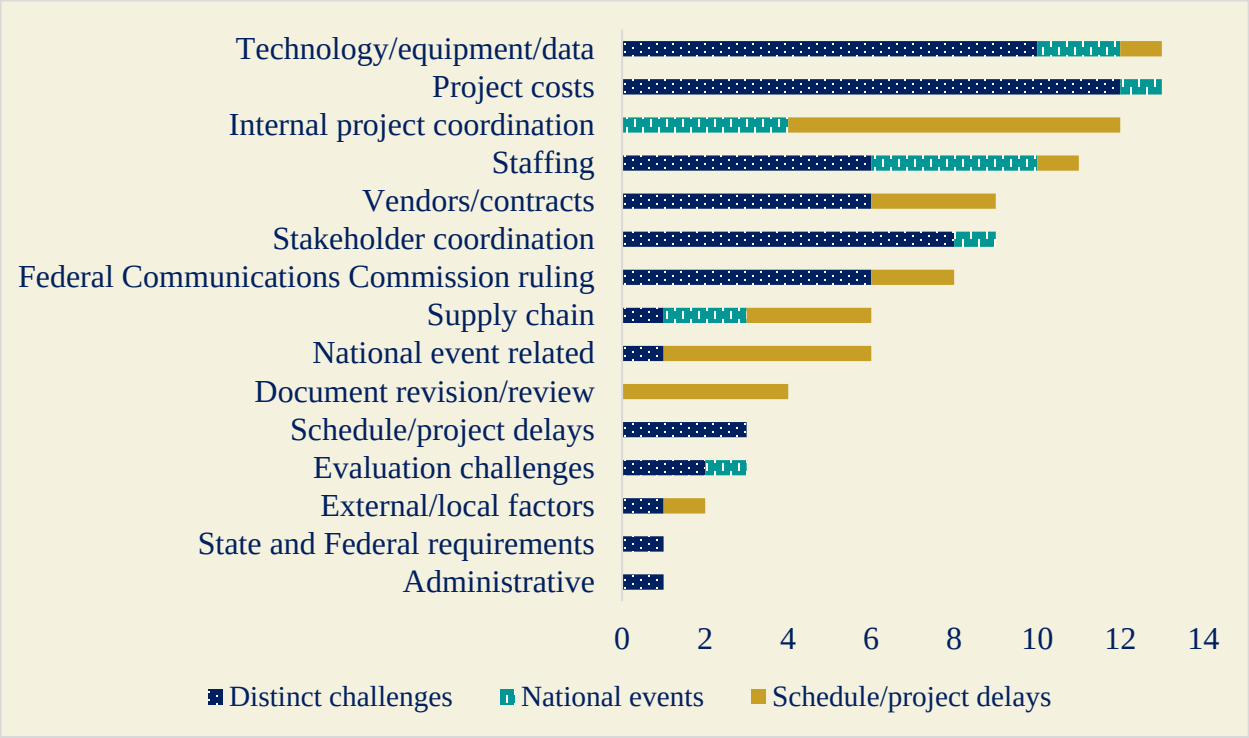
A challenge that grantees had not previously reported—supply chain issues—emerged during the last year (i.e., between April 2021 and March 2022). Several grantees noted this issue, which impacted grantees' schedules, staffing, and agency coordination.

Figure 8 shows the relative frequency of the different challenge categories reported by grantees. The crosscutting impact of national events and schedule/project delays is reflected in the chart, based on the context in which the grantee mentioned the challenge. For example, if the grantee mentioned the staffing impacts of national events, this response is highlighted under staffing with the national events color coding. There also are separate categories for national events and schedule/project delays because, in some cases, a grantee mentioned this challenge without providing additional information (e.g., on how national events impacted their project or the cause of the project/schedule delay).

Overall, technology/equipment/data issues were mentioned most often. Challenges mentioned by somewhat fewer grantees include project costs, stakeholder coordination, internal project coordination, vendor and contract issues, and the FCC ruling. A number of the challenges were

[23] The FCC's November 10, 2020 First Report and Order, approved on November 18, 2020 and published in the Federal Register on May 3, 2021, describes 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.

crosscutting; for example, one of the items coded as a cost issue referenced high procurement costs, which could also be viewed as a vendor and contract issue or a technology issue. For the list of specific challenges categorized under each topic, please see appendix C.



Source: FHWA.

Figure 8. Chart. Relative frequency of key challenges across grantees' reports from April 2021 through March 2022.

GRANTEE LESSONS LEARNED

In their annual reports, grantees also described project lessons learned. Grantees mentioned topics related to stakeholder and agency coordination, vendor collaborations, project management, project costs, technology/equipment/data problems, the FCC ruling, and evaluation challenges. Several of the lessons learned were repeated from previous reports, so Table 5 highlights the lessons that grantees either had not previously reported or that included a new dimension to a familiar lesson learned. For example, while early and consistent engagement with stakeholders had been recommended last year, grantees newly noted the distinct value when many agency partners were involved or if the project spanned a large geographic area. If multiple grantees mentioned a lesson learned, the number of grantees is noted in parentheses, e.g., (*n*=3). The lessons learned that were reported last year (April 2021–March 2022) and in previous years are listed in Table 9 in appendix C.

Table 5. Grantees' new lessons learned, April 2021–March 2022.

Category	Grantees' New Lessons Learned[24]

Stakeholder/ agency coordination	• Meet with project stakeholders early in the deployment process and maintain consistent coordination to help drive project success (*n*=7):
	  ○ An integral part of concept development with many project stakeholders is understanding each collaborator's concerns, challenges, operating environment, and system capabilities.
	  ○ Discussions with collaborators about translating user needs into system requirements should be held before the design phase.
	  ○ Early and consistent engagement is important, especially if there are many collaborators or if the project spans a large geographic area.
	  ○ Grantees recommended early coordination with technical personnel.
	  ○ Workshops and educational material help address the challenges in adaptation posed by working with a disparate suite of end users, such as the trucking community.
	  ○ A scenario-based approach to the concept of operations effectively demonstrates for stakeholders how users interact and interface with a new system.
	  ○ Early coordination of legal agreements is necessary when equipment is located in another jurisdiction's right of way.
	• Coordinate with collaborating agency stakeholders to obtain a detailed understanding of network connectivity (*n*=3):
	  ○ Identify the complex business rules related to firewall and data protocols when discussing the nature of local agency networks.
	  ○ Consider network user agreements before construction. For complex applications, understanding local agency networks is key to successful data transfer; otherwise, conflicts may arise between agency firewalls and the protocols set by other parties.
	  ○ Deploying connected vehicles may involve additional considerations from collaborators' maintaining agencies outside of their typical arrangements. A maintaining agency's network schema that includes multiple virtual local area networks to separate device types may need to be revised to ensure communication between the controller and roadside unit at an intersection for broadcasting signal phase and timing information to motorists.
	• Form an advisory committee composed of regional agencies that can provide leadership and support in a collaborative environment to help the long-term success of the grantee's project.

[24] If multiple grantees mentioned a lesson learned, the number of grantees is noted in parentheses, e.g., (*n*=3).

Table 5. Grantees' new lessons learned, April 2021–March 2022 (continuation).

Category	Grantees' New Lessons Learned
Vendors/ industry collaborators	• Collaborating with industry in a design-build fashion saves iterations and project costs. • Engaging with telematics and third-party software companies early in the process helps determine if there are opportunities to integrate the project data feed into the existing infrastructure.
Project management	• The number of qualified technicians can be a limiting factor, and achieving project goals may depend on having sufficient coverage. • The existing mounting locations and line of sight for adaptive pedestrian safety systems can impact the effectiveness and increase the number of detection sensors needed per intersection. • A detailed project scoping and site survey should be conducted before the development of the initial project estimate and schedule to avoid project delays from unanticipated complications. • Overlapping construction schedules should be identified early to coordinate disposition. • Deployers should account for testing, validation, and correction time in delivery schedules to allow for repeated testing phases for complex applications.
Project costs	Confirm existing space within the infrastructure to add new system components such as detection units and audible pedestrian buttons or account for the full cost of new in-ground infrastructure, including Americans with Disabilities Act enhancements.
Technology, equipment, or data	• Developing Advanced Traffic Management Systems software that is configurable expands its applications, lowers support costs, and creates a more seamless travel experience. Automation can address fast-changing conditions but requires error detection. • Combining advanced deep learning models with engineering judgment for AI applications of traffic operation management helps manage missing and corrupted data. • Having test zones inside the traffic management center provides developers with external access to the network and operation systems with safety protection and firewall regulations. • Understanding the environmental challenges posed by extreme summer heat and interior climate control may be important for automated vehicle shuttle deployers.
Federal Communications Commission (FCC) ruling	As a result of the pending decision by the FCC on the 5.9-gigahertz spectrum, a grantee determined that Channel 180 provides the necessary bandwidth for connected vehicle applications such as signal phase and timing and traffic incident management.
Evaluation	When collecting data for project evaluation, data gathered by separate collaborators using separate systems may be incompatible and can create complexity and introduce gaps in the data.

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 from FY 2016-FY 2020, including city and county projects, as well as statewide or regional projects. 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., LED lighting and electric vehicle shuttles). The projects span a range of modes/service models: vehicle, freight, transit, pedestrian/bicyclist, and MOD. The law requires each grantee to submit annual reports that describe the impacts of their deployments.[1] FHWA has provided the grantees with support to facilitate their deployments and assist them in meeting their reporting requirements.

This 2022 ATCMTD program report summarizes key findings from the Greater Cleveland RTA, the first project completed under the ATCMTD Program. 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] Oregon DOT has also completed one component of its overall project—the deployment of UAS for crash reconstruction. Oregon DOT achieved significant time savings in crash reconstruction using UAS and documented numerous lessons learned. However, due to several factors, there were no significant differences in lane clearance time between UAS and non-UAS reconstructions.

To date, other grantees are too early in their deployments to report on impacts. While 15 grantees are piloting, testing, or beginning to deploy technologies, the majority of grantees are still in the planning phases. As a result, this program report provides project highlights for eight grantees who are either currently testing or soon to be testing technologies. It also 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 on improved safety and mobility, as well as improving system performance and operational efficiencies. Grantees also provide performance measures for reducing emissions, integrating real-time information, reducing costs, improving institutional efficiency, enhancing access to transportation alternatives, and advancing equity.

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

- Technology, equipment, or data

[1] 23 U.S.C. 503(c)(4)(F).
[2] *Advanced Transportation and Congestion Management Technologies Final Report*. Greater Cleveland RTA ATCMTD Final Report (Draft July 2021).

- Project costs
- Staffing
- Vendors/contracts
- Stakeholder coordination

Numerous grantees also mentioned national events, schedule delays, and supply chain issues as challenges. These issues were cross-cutting, as they tended to impact multiple other challenge categories.

In their lessons learned, grantees largely focused on stakeholder or agency coordination and also provided a number of suggestions related to project management and the technical aspects of projects, such as using technology, equipment, or data. The following paragraphs summarize several grantee lessons learned in these three areas:

- Stakeholder and agency coordination: Multiple grantees recommended several lessons learned related to meeting with project stakeholders early in the deployment process and maintaining consistent coordination. One grantee noted the distinct value of early stakeholder engagement when many agency partners were involved or if the project spanned a large geographic area. Another grantee emphasized the importance of workshops and educational material to help address the challenges in adaptation posed by working with a disparate suite of end users, such as the trucking community. One grantee also suggested forming an advisory committee of regional agencies that can provide leadership and support a collaborative environment. When partnering with agency stakeholders, grantees recommended obtaining a detailed understanding of network connectivity and rules related to firewall and data protocols.

- Project management: One grantee recommended that a detailed project scoping and site survey be conducted before development to avoid project delays. While one grantee indicated that the number of qualified technicians could be a limiting factor and that achieving project goals may depend on having sufficient coverage, another grantee noted that the existing mounting locations and line of sight could impact the effectiveness of adaptive pedestrian safety systems and increase equipment needs. One grantee emphasized the importance of accounting for testing, validation, and correction time in delivery schedules to allow for repeated testing phases.

- Technology, equipment, or data: One grantee emphasized that developing Advanced Traffic Management Systems software that is configurable would expand its applications, lower support costs, and create a more seamless travel experience. One grantee recommended using test zones inside the TMC to provide developers with external access to the network and operation systems with safety protection and firewall regulations. Another grantee stressed the importance of understanding the environmental challenges posed by extreme summer heat for AV deployers.

As more grantees complete their projects in the next few years, subsequent program reports will highlight the impacts of the ATCMTD technology deployments, challenges, and lessons learned.

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

Federal statute 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 four 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 1–3 should reflect the **current** project scope and goals. If there have been no changes in project scope or goals (since the last annual report), responses to questions 1–3 should be the same as the previous annual report.* **1. Please provide a *high-level* description of your project, including the intended beneficiaries. (Please limit to approximately 350 words or less.) *Note: in Part 4 of 4, question 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 ITS using a 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 ☐ Other (Describe) _____

SAMPLE

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)
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.	
Effectiveness of providing integrated real-time transportation information to the public to make informed travel decisions	1. 2. 3. Etc.	

SAMPLE

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)
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.	
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.	

SAMPLE

Goal Area	Findings (tied to performance measures; also include any anecdotal evidence)	Notes/Considerations
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), 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 ATCMTD project selected for an award, including grant amount, project goals, and technologies being deployed.

FISCAL YEAR 2020 PROJECTS

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

- 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, CV roadside and onboard equipment, border wait time monitoring system, next-generation traveler information, CV border tolling, and commercial vehicle inspection technology.

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

- Grant Amount: $9,298,300
- Project Goals: This project improves the safety of pedestrians and intersections within the region, improves mobility within the region, accelerates deployment of vehicle-to-everything (V2X) technologies, reduces the number and severity of traffic crashes, and increases driver, passenger, and pedestrian safety.
- Technologies Being Deployed: CV technologies, including emergency vehicle preemption, transit signal priority, speed warning, intersection warning, vehicle hazard warning, and emergency vehicle warning; demand management; decision support; work zone monitoring; mobile phone-based OBU application; and video analytics technologies.

Emergency Vehicle Preemption Using Connected Vehicle Technology (*Georgia DOT: Metro Atlanta Region, GA)*

- 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 reduces 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: Includes 15 dual-mode (DSRC and C-V2X) RSUs, 170 dual-mode OBUs 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 DOT: 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 CV footprint and integration of advanced technologies, and enhances understanding of traffic flow.
- Technologies Being Deployed: Advanced traffic controllers, traffic detection system, DSRC 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 AI.

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

- 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 DSRC dual-mode RSUs; DSRC and V2V fleets; smart sensors with edge computing, authentication, authorization, and accounting server; data analytics; and an advanced V2X technology living lab.

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

- Grant Amount: $6,000,000
- Project Goals: This project streamlines traffic flow, enhances the use of real-time data and analytics, reduces the 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 (HOV) detection, and an integrated data platform and interface.

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

- 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 V2I intersection upgrades, transit signal priority, congestion management technology, fleet headway management software, and real-time bus occupancy data.

S.M. Wright Smart Corridor *(City of Dallas: Dallas, TX)*

- Grant Amount: $4,000,000
- Project Goals: This project improves the system performance of the S.M. Wright corridor, provides advanced performance measures for evaluating operations, reconnects and revitalizes economically disadvantaged areas, connects 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, RSUs, OBUs, roadside control units, connected mobility control center, connected mobility platform, deep learning versatile platform, data analytics platform, integrated mobility interface, CV transit pedestrian alert system, and traffic management system improvements.

Utah Broadly Connected *(Utah DOT: Utah)*

- Grant Amount: $ 5,450,000
- Project Goals: This project leverages real-time information to improve safety, mobility, and system efficiency, enhance the quality of life, and prepare Utah's transportation network for future deployments.
- Technologies Being Deployed: CV applications using V2X technology, including DSRC 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; data analytics, including ML, deep reinforcement learning, AI, and vehicle image reidentification: and 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, DSRC and C-V2X communications infrastructure, mobile communications infrastructure, and traffic map integration.

FISCAL YEAR 2019 PROJECTS

Deployment of Personalized and Dynamic Travel Demand Management Technology *(Metropolitan Washington Council of Governments: Washington, DC, 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) *(FDOT: I–4 Corridor)*

- Grant Amount: $10,071,600
- Project Goals: This project will work toward FDOT's strategic plan vision of increasing the delivery rate of fatality-free and congestion-free transportation systems by implementing CV and other emerging technology solutions, bringing safety and mobility benefits to the I–4 corridor.
- Technologies Being Deployed: Includes 689 CV RSUs and 670 OBUs with roadside-to-vehicle messages for lane closures, work zones, delays, congestion, end of the queue, incidents signal phase and timing (SPaT), speeds, and pedestrian-bicyclist safety, 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 Intelligent Transportation Systems (ITS) Management in Hawaii *(Hawaii DOT: Hawaii)*

- Grant Amount: $6,855,000
- Project Goals: This project reduces costs and improves return on investment 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 V2V, V2I, and AV applications.
- Technologies Being Deployed: A cellular-based V2X system for all traffic devices and in-field devices in the State of Hawaii, C-V2X and DSRC 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 DOT: Detroit, MI)*
- 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, V2V and V2I communications; transportation system optimization through data analytics and edge computing; wrong-way driver detection; and alerts.

I–270 Predictive Layered Operation Initiative (PLOI) *(Missouri DOT: St. Louis Metropolitan Area, MO)*
- 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 AI 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 DOT: Raleigh, NC)*
- Grant Amount: $2,117,750
- Project Goals: This project improves mobility, reduces safety incidents, reduces environmental impacts, improves agency efficiency, and allows North Carolina DOT to more effectively deploy CV technology and applications within the State of North Carolina for further safety, mobility, and environmental benefits.
- Technologies Being Deployed: V2V and V2I CV applications, including transit signal priority, multimodal applications (e.g., pedestrian, driver, bicyclist); 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 DOT: 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, partial automation (Level 2), and high automation (Level 4) 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 DOT: I–24 Corridor, Tennessee)*

- Grant Amount: $2,617,653
- Project Goals: This project develops DSS and subsequent strategies through the use of AI; 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 system creates a balanced, responsive, and equitable arrangement 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: AI-based ICM DSS, Web interface for ICM partners, and TMC ICM software integration.

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

- 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 multimodal information and tools that enhance safety, optimize system performance, mitigate congestion, improve travel-time reliability, and support on-demand, multimodal trip options.
- Technologies Being Deployed: DSS, AI, 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 *(Wisconsin DOT: Greater Seattle Metro Area, WA)*

- 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, and sustainable, and it 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 multiagency, multimodal ICM through real-time information data collection, analysis, modeling, and dissemination.

FISCAL YEAR 2018 PROJECTS

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

- Grant Amount: $8,000,000
- Project Goals: This project provides 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 and Operations Network (ACTION) (*University of Alabama: West Central Alabama, AL*)

- Grant Amount: $8,034,003
- Project Goals: This project deploys CV and ITS technologies to allow the regional TMC 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, CO*)

- Grant Amount: $2,366,298
- Project Goals: This project transmits real-time information to travelers and dispatches 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.

AI-ITMS Deployment Program (*DelDOT: Delaware*)

- Grant Amount: $4,996,949
- Project Goals: This project enables the deployment of an AI-ITMS and an 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.

Georgia DOT Connected Vehicles (*Georgia DOT: Metro Atlanta, GA*)

- Grant Amount: $2,500,000
- Project Goals: This project creates and operates a regionwide CV network, providing SPaT messages at all key intersections and freeway ramps, which will enable CV applications to use 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, deploying a variable speed limit in Nebraska, providing critical messages directly to freight vehicles, and disseminating truck parking information.
- Technologies Being Deployed: Information and communication management, regional data sharing, variable speed limits, DSRC, V2I applications, and a mobile road weather information system.

Oregon Smart Mobility Network (*Oregon DOT: Oregon)*

- Grant Amount: $12,000,000
- Project Goals: This project creates an integrated multimodal network and helps the Oregon DOT with performance measurement, decision support, and active traffic, incident, and weather management.
- Technologies Being Deployed: Automatic traffic recorders, bicyclist and pedestrian counters, Bluetooth travel-time systems, road weather decision support and information dissemination, closed-circuit television (CCTV) monitoring cameras, adaptive ramp metering, dynamic speed limits, freight signal priority, queue warning systems, SPaT, dynamic routing, next-generation transit signal priority, V2X pedestrian/bicyclist, automated speed enforcement, red-light-running crash mitigation systems, UAS crash reconstruction, and battery backup systems.

Work Zone Reservation and Traveler Information System (*Pennsylvania DOT: 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 (*TxDOT: 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 project 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 DOT: 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 CV technology to improve safety and mobility, and uses AV technology to help solve the first mile/last mile problem.
- Technologies Being Deployed: Autonomous shuttle(s), fiber sensing, CV applications (plows, signals, transit, curve speed warning, weather impact warning), and a data-sharing portal.

FISCAL YEAR 2017 PROJECTS

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

- 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 ICM, public transportation, the Maricopa County DOT's SMARTDrive Program℠, and other connected traffic management and real-time information technologies.

- Technologies Being Deployed: A DSS; adaptive signal control technology; CV 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, CA*)

- Grant Amount: $9,720,000
- Project Goals: This project improves traffic flow and goods movement to and within the Port of Oakland, reduces congestion, improves safety, provides improved traveler information, and reduces 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 TMC, traffic sensors, advanced traveler information, traffic messaging, trucking information for mobile applications, rail grade warning, and terminal queue information.

Connecting the East Orlando Communities (*FDOT: Orlando, FL*)

- Grant Amount: $11,946,279
- Project Goals: This project improves pedestrian and bicyclist safety, enhances multimodal transportation, provides integrated real-time information for travelers, and connects/integrates data sources created and utilized by FDOT.
- Technologies Being Deployed: An innovative pedestrian and bicyclist collision avoidance system, RSUs, 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, ID*)
Note: This project was 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: DSRC radios, OBUs, 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, MI*)

- 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, V2I communications, vehicle preemption, digital kiosks, DSRC, and Internet of Things gateway.

Connecting Cleveland Project (*Greater Cleveland RTA: Cleveland, OH*)

- 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 onboard equipment, real-time information and maintenance software, and an upgraded radio system.

Greenville Automated (A-Taxi) Shuttles (*County of Greenville: Greenville, SC*)
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 V2V and V2I technology, AV data collection and analysis, and real-time traveler information.

The Texas Connected Freight Corridors Project (*TxDOT: 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 pretrip and en route 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 V2I and V2V 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. The RFID tag readers will automate the 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 (*Seattle DOT: Seattle, WA*)

- 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, CCTV, dynamic message signs, passive pedestrian detection and pedestrian demand-based signal timing, bicycle detection and mobile application, ICM solutions, mobility-as-a-service software, and kiosks.

FISCAL YEAR 2016 PROJECTS

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

- 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 and Mobility with the Promise Zone *(Los Angeles DOT: Los Angeles, CA)*

- Grant Amount: $3,000,000
- Project Goals: This project uses advanced technology on Los Angeles' 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 Advanced Transportation and Congestion Management Technologies Deployment **Initiative** (*San Francisco Municipal Transportation Agency: San Francisco, CA*)

- 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: New highway HOV lanes for transit/carpools; transit signal priority and emergency vehicle preemption; electronic, autonomous shuttles; curb space for pickup/dropoff by carpools and ride-sourcing services; multimodal intelligent traffic signal systems located roadside and in-vehicle; and a connected, electronic toll system for the congestion pricing program.

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

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

A Connected Region: Moving Technological Innovations Forward in the Niagara International Transportation Technology Coalition **(NITTEC) Region** (*Niagara Frontier Transportation Authority: Erie and Niagara Counties, NY*)

- 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: CV applications supporting in-vehicle dissemination of alerts, advisories, parking, traffic, and weather information, improved traffic signal system, parking management analytics engine, and DSS.

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

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

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

- 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 project will improve real-time information access and optimize transit operations.
- Technologies Being Deployed: Conversion of nearly 40,000 City of Pittsburgh streetlights to LED 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 Transportation Systems Management and Operations (TSMO) and Active Demand Management (ADM) (*TxDOT: Houston, TX*)

- 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: Various regional advanced traveler information systems and data sources for predictive multi-/intermodal travel time, cost, and reliability information in an application.

APPENDIX C. SUMMARY OF CHALLENGES AND LESSONS LEARNED IN 2021 PROGRAM REPORT

CHALLENGES

This appendix presents detailed information on grantees' reported challenges and lessons learned. The specific challenges referenced in chapter 4 are listed in table 6.

Table 6. Grantee challenges and subthemes in 2021 Program Report.

Challenge	Subthemes[1]
Technology/ equipment/data	• Additional testing/data validation needed (*n*=2) • National events related (*n*=2) • Data integration issues (*n*=2) • Technology integration issues (*n*=2) • Equipment-related delays • Equipment testing and selection • Limited equipment capability • Security challenges • Technology unavailable early in the scheduled time frame • Equipment underperforming
Project costs	• Procurement costs different than expected (*n*=3) • Budget limitations led to reduced scope (*n*=2) • Budget update/redistribution (*n*=2) • National events related • Funding approval • Potential inability to meet in-kind contributions • Potential loss of Federal funds • Request for obligation • Underspending due to plan for rebid

[1] If multiple grantees mentioned a challenge, the number of grantees is noted in parentheses, e.g., (*n*=3).

Table 7. Grantee challenges and subthemes in 2021 Program Report (continuation).

Challenge	Subthemes
Internal project coordination	• Construction delay impacts (*n*=2) • Coordination with other projects causing delay (*n*=2) • Additional time needed for planning details and developing documentation • Challenges in conducting work during the national event • Delays due to splitting the project into planning and execution phases • Installation delays • Hybrid setup challenging to work with, considering needed technology resources • Program planning activities have taken longer than anticipated, and the team requested a project extension • Restrictions on in-person meetings • Restrictions on traveling to the project site
Staffing	• Staff turnover (*n*=4) • National event related: key staff diverted to national event priorities (*n*=3) • Staff limited/unavailable (*n*=2) • National event related: termination of unvaccinated employees and a concrete workers' strike • Difficulties training staff virtually
Vendors/contracts	• Vendor company transitions (*n*=2) • Awaiting Federal Highway Administration (FHWA) amendment for change in vendor and errors with invoice documents • Choosing multiple vendors for pedestrian detection • Expiring contracts causing delays • Loss of original contractor • Need for further understanding of procurement processes/proactive coordination • Negotiations taking longer than anticipated due to intellectual property issues • Nonresponsive vendors
Stakeholder coordination	• Keeping all participants informed (*n*=3) • National event related meeting problems (*n*=2) • Changing scope to coordinate with multiple stakeholders • Coordinating funding and space for equipment • Geographic scope expanded • Increasing input from users • Uncertainty around stakeholder interest levels • Vehicle fleet operators not participating

Table 8. Grantee challenges and subthemes in 2021 Program Report (continuation).

Challenge	Subthemes
Federal Communications Commission ruling	• Project risk uncertainty (*n*=3) • Timeframe uncertainty (*n*=2) • Schedule delays • Changes to permits/technology contracts • Reduction of the geographic scope
National event related	• National event related schedule delays (*n*=5) • Impacts on commuters' behavior might impact project outcome
Supply chain	• National event related delays (*n*=2) • Disruptions in the global supply chain • General supply chain issues • Minor procurement delays • Supply chain issues resulting in contractor extension
Document revisions/review	• FHWA review of concept of operations document delayed • Environmental document approval delays • Error in the period of performance component of the project agreement • Concept of operations revisions
Evaluation challenges	• Differing mile points analyzed between consultant and main analysis • Difficulty defining how systems identify incidents • Decreasing opportunities for data collection due to changes in train schedule
Schedule/project delays	• General delays (*n*=3)
External/local factors	• Working around utility repair work • Peak season-high volumes delayed implementation of port manager
Administration	• Technical difficulties with Web conferencing
State and Federal requirements	• Clarification of State and Federal requirements needed

LESSONS LEARNED

Several of the lessons learned included in this report were repeated from previous reports that covered the period (April 2019–March 2021). Those lessons are listed in Table 9.

Table 9. Grantees' lessons learned repeated from previous reports (April 2019-March 2022).

Category	Grantees' Previously Reported Lessons Learned[2]
Staffing	Agility related to team resources and skills allows for diversification and quick response when situations, such as changes in travel patterns, arise.
Project management	• Identify all external and third-party data sources, as well as necessary data flows, connections, and/or application programming interfaces for software development early in the project. Contact data information providers to see data availability and cost (*n*=2). • Identify tasks early in the deployment process that can start quickly or need additional dedicated resources. This step 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. • Use proof-of-concept strategies or pilots to establish a higher comfort level with technologies before a larger scale deployment.
Cost	Before letting and including funds in a request for proposal, AV deployers should ensure they have provided enough funding to accommodate necessary infrastructure, such as signing and markings, electrical charging stations, conduit, boxes, and wiring.
Industry partners/third-party vendors	• Work closely with vendors of existing infrastructure to troubleshoot compatibility issues and ensure smooth integration of newer technologies and devices (*n*=2). • Provide minimum insurance requirements to prospective vendors ahead of the advertisement to vet prospective bidders appropriately.

[2] If multiple grantees mentioned a lesson learned, the number of grantees is noted in parentheses, e.g., (*n*=3).

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