massDOT
Massachusetts Department of Transportation

Research and
Technology Transfer

ANNUAL REPORT

FFY2022

Massachusetts Department of Transportation
Office of Transportation Planning

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Executive Summary

The Massachusetts Department of Transportation (MassDOT) is steadfast in meeting the Commonwealth's transportation needs and demands through a multifaceted approach of research, training initiatives, implementation, and innovation. Through the application of innovative computer information technology (e.g., cloud-based applications) and new objectives and methods that address unmet needs, MassDOT significantly increased outputs relating to transportation research and trainings. Research projects and trainings encompass a wide range of topics including safety, infrastructure condition, congestion reduction, highway system performance, and environmental sustainability. The ability to incorporate innovative technology into the methods and applications has allowed for an increase in efficiency, better decision-making opportunities, enhanced security, and improved customer service in project development, research, and training. For training, new software subscription packages such as Vyond have allowed the development of in-house animation for training and marketing applications. Research projects such as "Pavement Marking Inventory and Retroreflectivity Condition Assessment Method Using Mobile LiDAR" combined the necessary technology to perform efficient analysis with data collection while meeting a critical Highway Division need.

As Federal Fiscal Year 2022 (FFY22) began, MassDOT employed the aforementioned applications to provide training opportunities at a statewide level while also focusing on trainings with partners on the local and regional levels. MassDOT used technology to customize trainings and conferences and was able to offer options that allowed transportation professionals the choice to participate whether in-person, virtual or blended. The Research Roundtables continued virtually in FFY22 with three sessions and presentations from principal investigators on innovative research technology (e.g., obtaining critical data using LiDAR for bridge load rating procedures and using UAS to improve emergency response). Discussions held at these roundtables led to the formation of eight ideas that would each later receive research funding in FFY23. On the training side, both Baystate Roads and MassDOT Training Services (MTS) began to shift from virtual back to face-to-face (F2F) training, with F2F offerings initially focused on smaller groups, safety topics, and outdoor training. Despite the reemergence of F2F training, additional online and self-paced options increased this year, with a dramatic increase in classes available and in participation as compared to last year.

During FFY22, MassDOT continued its dedication to advancing transportation research with ten new projects launched. The latest information technology application is the centerpiece for a number of these projects—3D-Printed Lattice-Based Structures for Next-Generation Bridge Bearings & Bridge Isolation Bearings; Developing a Visualization, Sharing & Processing Platform for Large-Scale Highway Point Cloud Data; and Laboratory Information Materials Management System (LIMMS). These projects, along with others, tackled a range of important issues, including but not limited to sustainable transportation networks, accessible bus stop design, measuring fare payments, large point cloud data, 3D technology, and speed management.

A look back at FFY22 highlights many accomplishments:

- Initiating ten new research projects.
- Implementing research results from the seven projects completed at MassDOT during FFY21.
- Presenting the Moving Together Conference virtually to over 1,000 participants and the Transportation Innovation Conference in a hybrid format to 879 attendees in person and an additional 301 virtually.
- Delivering 116 Baystate Roads trainings to 2,491 participants and 84 MTS classes to 1,916 participants.

This report showcases MassDOT's commitment to using innovative applications to manage, process, and communicate information effectively and efficiently. By fully recognizing the benefits of computer hardware, software, and data management, MassDOT continues to enhance the transportation landscape in Massachusetts and beyond. Activities documented in this report are predominantly funded with State Planning and Research Funds (SP&R) Part II from the Federal Highway Administration (FHWA). Each year, MassDOT develops its SP&R Work Program to establish planning and research activities funded through the Federal Highway Administration SP&R funds as authorized by Title 23, US Code Section 505, and regulated by Title 23, Code of Federal Regulations (CFR), Part 420.

Overview

Mission & Vision

MassDOT provides research, training, and technology transfer services to a broad audience of municipal, state, and academic partners to support various statewide needs and initiatives. Research activities address key problems and issues in the areas of policy, management, safety, environment, planning, engineering, construction, operations, and maintenance as those areas relate to the Commonwealth's responsibilities for the state highway, public transportation, and inter-modal transportation systems. Activities can range from support services for technology transfer to large-scale multi-year research projects on complex problems that require technical assistance from outside resources.

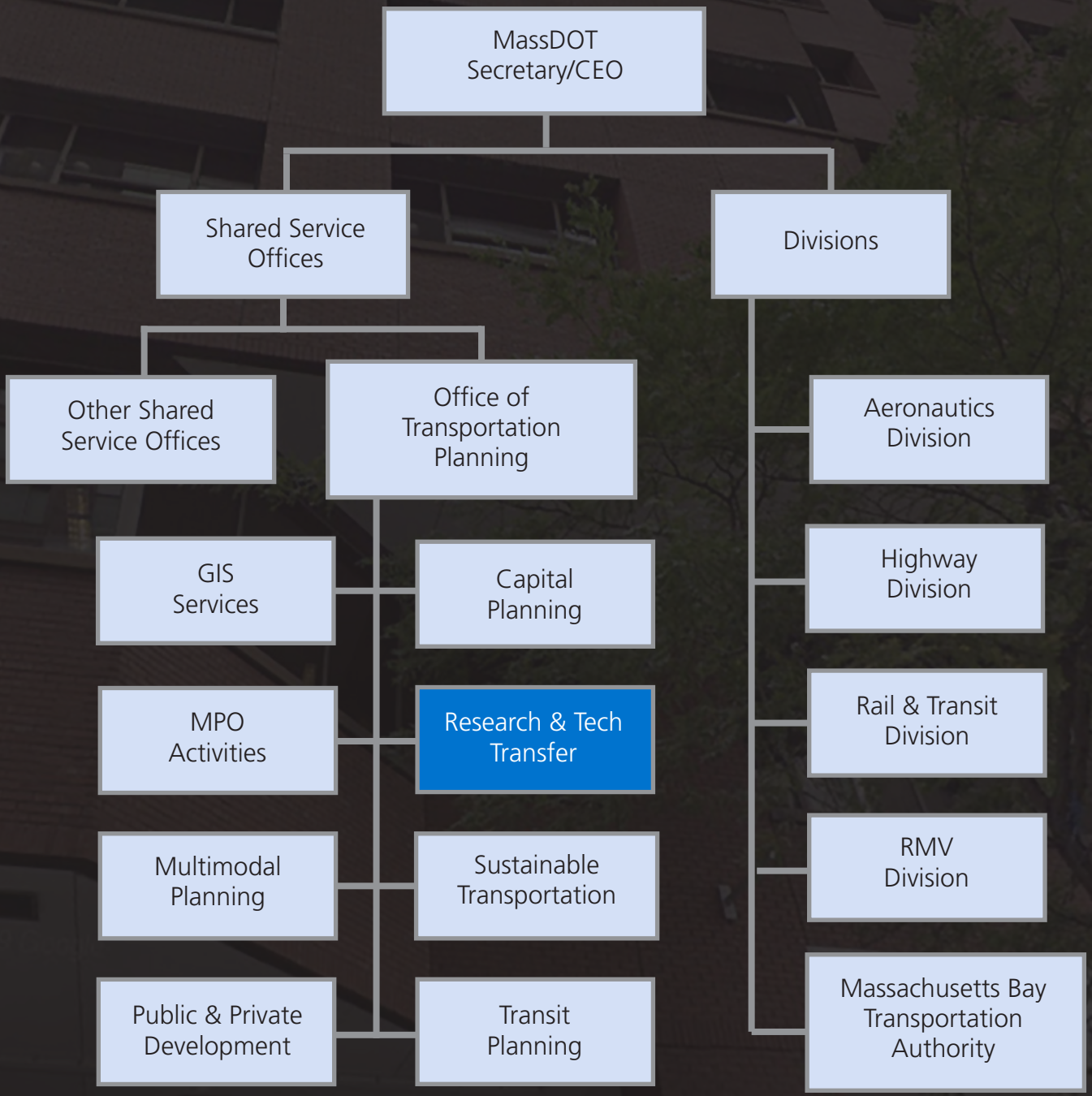
As transportation in Massachusetts is constantly evolving, the development of solutions through applied research and the dissemination of best practices and knowledge through training helps shape the changing transportation landscape. Collaborative efforts within these two platforms help the Commonwealth economize resources and funding as MassDOT considers the influence of the transportation systems for years to come.

Through an Interdepartmental Service Agreement (ISA), MassDOT partners with the University of Massachusetts Transportation Center (UMTC) to provide services in four areas:

- Massachusetts Cooperative Research Program (MCRP)
- Baystate Roads (the Massachusetts Local Technical Assistance Program otherwise referred to as LTAP)
- MassDOT Training Services (MTS, technical training for MassDOT Highway Division staff)

Our Team

MassDOT's Transportation Research and Technology Transfer Section (Research Section) is located within the Office of Transportation Planning (OTP) and oversees MassDOT's transportation research and technology transfer program, supported with the Federal Highway Administration's State Planning and Research (SP&R) Part II funds. As such, the Research Section organizes its core Research Technology and Transportation (RT&T) activities relating to highway, public transportation, and intermodal transportation systems in accordance with the provisions of 23 U.S.C. 505(b).



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mass.gov/orgs/massachusetts-department-of-transportation

Program Components and Funding

The Research Program is multifaceted, including three components: Innovative Research, Local Technical Assistance Program, and MassDOT Technical Training Services.

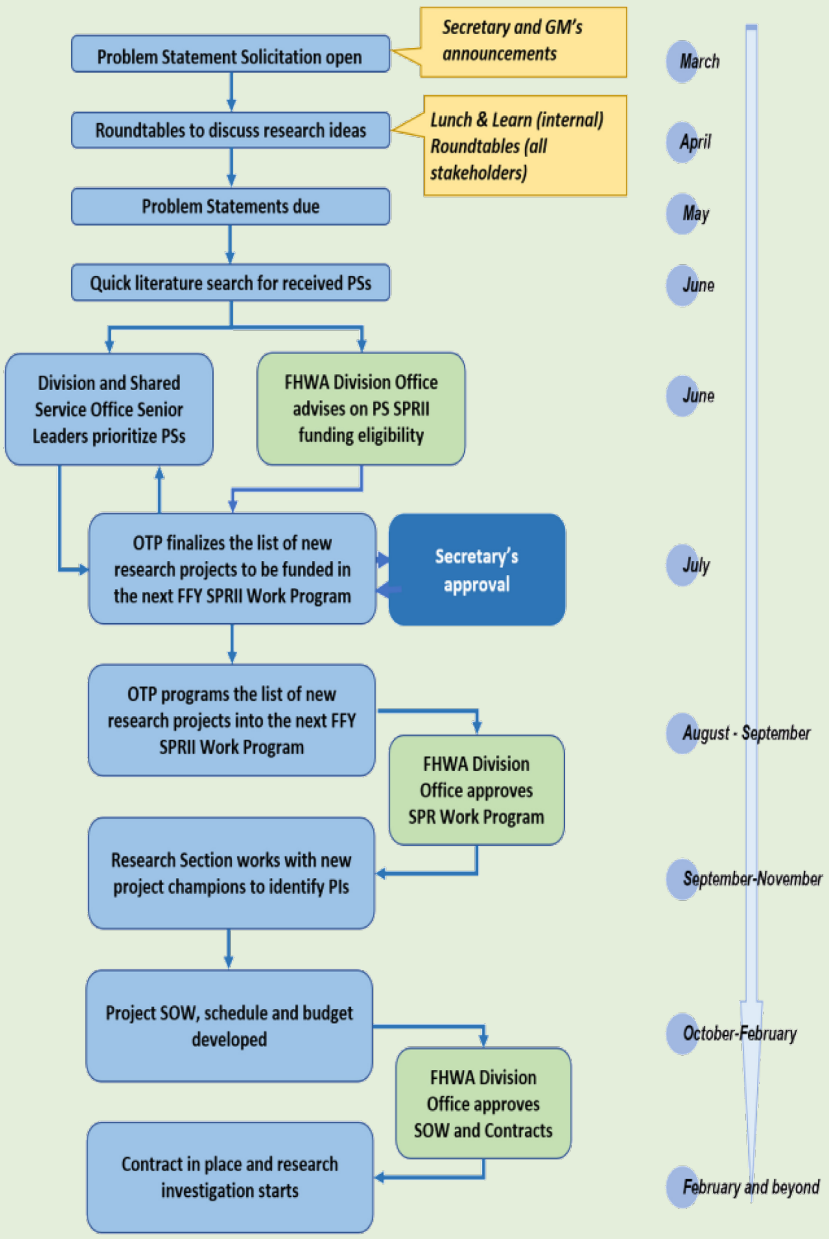
Research

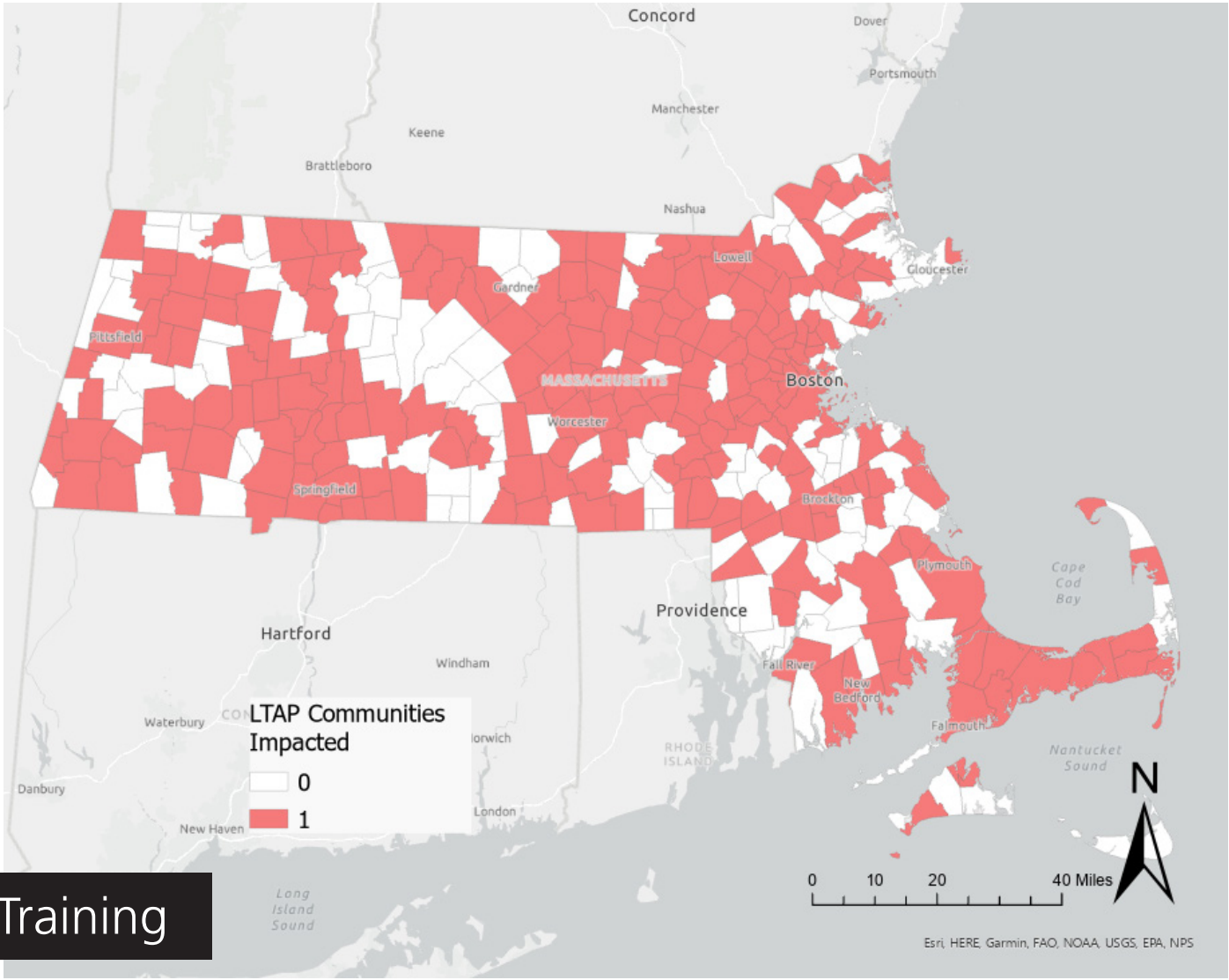
The purposes of the research program are to organize and manage the State Planning and Research (SP&R) Part II research program, conduct internal and external outreach activities, and administer associated contracts. The Research Section carries out its initiatives by soliciting and prioritizing MassDOT's research needs in collaboration with MassDOT Divisions and Shared-Service Offices, facilitating principal investigator identification, conducting research contracts, and tracking project performance and implementation efforts and impacts. Figure 1 shows the annual process of the Research Section to identify, select, and carry out new SPRII research projects.

Research activities address key concerns in the areas of policy, management, safety, environment, planning, engineering, construction, operations, and maintenance as those areas relate to the Commonwealth's responsibilities for the state highway, public transportation, and intermodal transportation systems. Activities can range from support services for quick literature searches and state-of-practice synthesis to large-scale multi-year research projects on complex problems requiring technical assistance from outside resources. In addition, the Research Section also coordinates and facilitates MassDOT's participation in national and regional research activities, such as National Cooperative Highway Research Program (NCHRP) and Transportation Pooled Fund (TPF) studies.

Research projects that are chosen from the MassDOT annual research solicitation process and the off-cycle special request process are assigned to one of the five categories, which include: (1) quick turnaround projects (<12 months) or time-sensitive (usually issued as research tasks under the multi-year UMTC services agreement between MassDOT and the University of Massachusetts Amherst, aka the Massachusetts Cooperative Research Program), (2) short-term projects (<15 months), (3) medium-term projects (15-21 months), (4) long-term projects (>21 months), and (5) projects suitable for national or regional cooperative research programs such as NCHRP and TPF.

MassDOT Annual Research Process





Training

MassDOT contracts with the UMTC to provide training services to both MassDOT and municipal audiences. Through Baystate Roads, the Massachusetts LTAP Center, and MassDOT Training Services, the UMTC assists MassDOT in developing and implementing annual training plans to provide essential and high-quality technical training to the MassDOT Highway Division, municipal and town departments of public works (DPWs), and Metropolitan Planning Organizations (MPOs) in Massachusetts. These events serve as conduits for the transfer of new technologies, assist transportation professionals with maintaining mandatory certifications for performing essential work, and share methodologies for operating, maintaining, and managing state and municipal highway departments throughout the Commonwealth. These programs also serve as communication platforms through which MassDOT shares new initiatives and changes related to policies, programs, and engineering directives in addition to providing updates on transportation research projects and results.

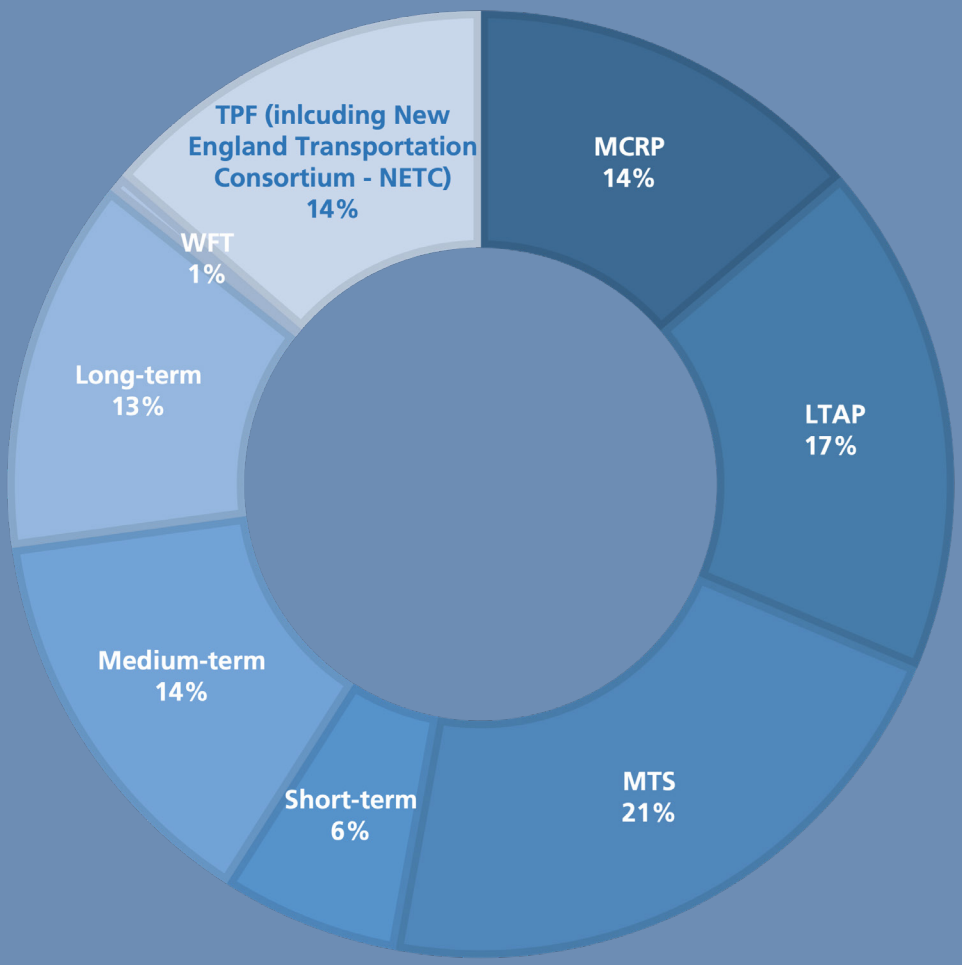
Whether participating via various remote options or face-to-face, it is important that training efforts connect with the municipal Bay State audience. In FFY22, Baystate Roads training participants represented 223 communities equating to 63 percent of the communities reached statewide.

FFY2022 Program Funding

Each year, MassDOT develops its SP&R Work Program to coordinate planning and research activities funded through the Federal Highway Administration SP&R funds as authorized by Title 23, US Code Section 505, and regulated by Title 23, Code of Federal Regulations (CFR) Part 420. Part II of the SP&R Program details how MassDOT will use these funds to conduct research and technology transfer activities in the next federal fiscal year.

Figure 2 shows the FFY2022 SPRII funding distribution. Research activities (short-term, medium term, long-term, Massachusetts Cooperative Research Programs [MCRP], and Transportation Pooled Funds [TPFs]) accounted for 61 percent of SPRII funds, while training activities (MTS, LTAP and MassDOT Workforce Training [WFT]) accounted for about 39 percent of SPRII funds. MassDOT Workforce Training distribution supports MassDOT University's activities that provide oversight and administration to the technical training, certification, and professional skills development for MassDOT employees.

Figure 2 – FFY22 State Planning and Research Program II



Research Highlights

Annual Research Solicitation Process and Research Roundtables

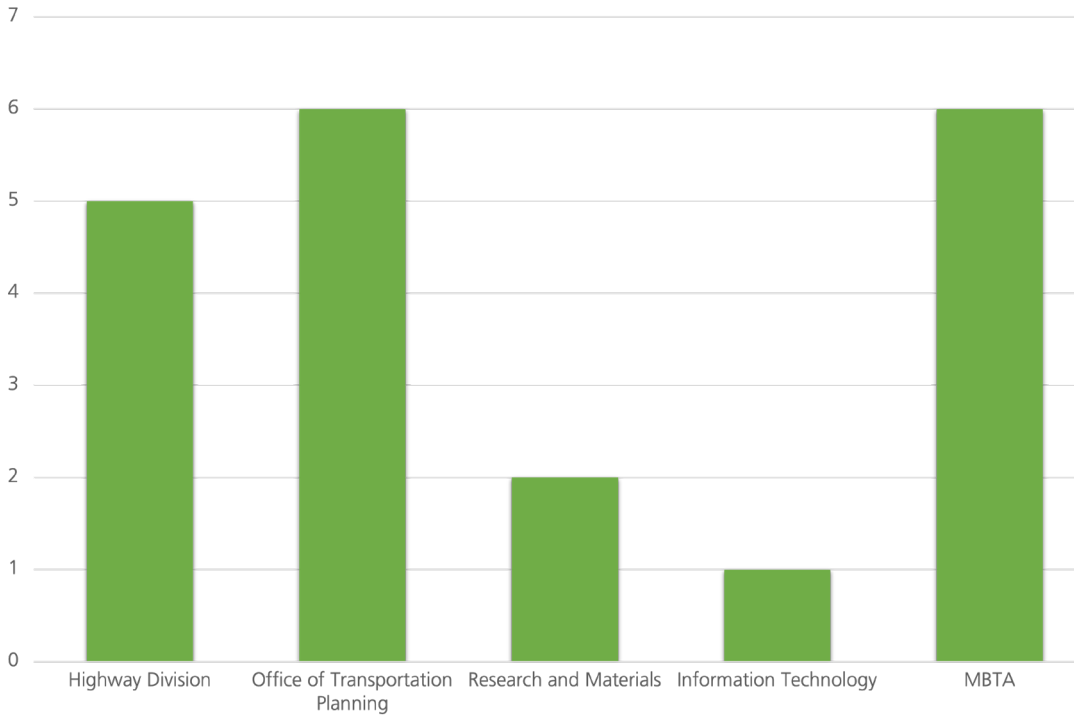
MassDOT's annual process of soliciting and selecting research projects for the coming fiscal year starts with a solicitation period to gather Research Problem Statements selected based upon current transportation needs and challenges. Each Research Problem Statement is submitted or sponsored for consideration by a MassDOT or MBTA colleague who, if the project advances to receive funding, then serves as Project Champion (PC). The project champion is to make sure the research project they sponsor addresses a critical agency need, produces implementable products, and the result implementation mechanism is in place. The annual process includes outreach to state transportation practitioners and academic researchers.

MassDOT began holding Research Roundtables during the solicitation period starting in 2019. Research Roundtables established a new way to connect state transportation practitioners with academic researchers, brainstorm research ideas to address practical problems, and foster future collaborations between academia and practitioners. At the Roundtables, MassDOT participants discuss their challenges, needs, and potential ideas for future research projects; researchers from various Massachusetts universities briefly present on their areas of expertise, their current and past transportation research, and facility capabilities. During the Spring 2022 solicitation period for FFY2023 Research Projects, MassDOT, together with the UMTC, hosted three virtual Research Roundtables on three combined topic areas:

- Roundtable #1: Safety, Roadway Engineering, and Design
- Roundtable #2: Active Transportation, Mobility, Policy, Planning, and Transit
- Roundtable #3: Asset Management, Materials, Maintenance, and Construction

The three interactive Roundtable sessions had a total of 42 individual attendees, including 20 individual MassDOT and MBTA staff, 18 researchers from academic institutions, and four UMTC personnel.

In addition, a Lunch and Learn session was provided for MassDOT and MBTA employees to inform and engage agency staff in the SP&RII research process and program as well as other available research resources and services. A total of 34 problem statements were submitted for FFY2022 research funding consideration. Of the ten high-priority projects that would receive funding in FFY2023, the original concepts of eight projects were proposed and discussed at the Research Roundtables.



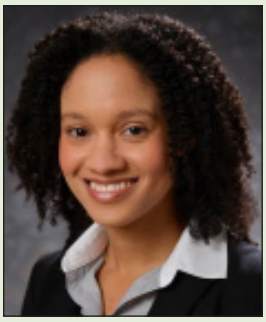
Research Recognition, Presentations, Publications

A research study titled "Evaluating the Safety Impacts of Flashing Yellow Permissive Left-Turn Indications in Massachusetts," championed by James Danila, MassDOT state traffic engineer, and conducted by UMass Amherst assistant research professors Francis Tainter (Principal Investigator) and Cole Fitzpatrick was selected as an American Association of State Highway and Transportation Officials (AASHTO) Sweet Sixteen High-Value Research Project for 2022. Dr. Tainter presented this research at the 2023 Transportation Research Board Annual Meeting. Dr. Tainter is currently conducting additional research to further explore the type of crashes avoided due to the flashing yellow permissive left-turn indication, along with Dr. Fitzpatrick.

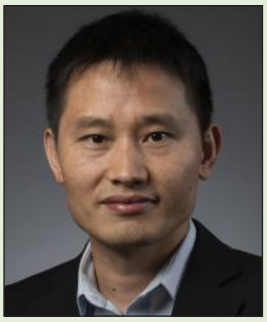
UMTC research affiliate UMass Amherst assistant professor Wen Chen, mechanical and industrial engineering, received two recent honors. Dr. Chen was awarded a CAREER grant from the National Science Foundation (NSF) Early Career Development Program. Dr. Chen will use the $550,000 award for his research on additive manufacturing, also known as 3D printing, to investigate and improve the understanding the microstructural origin and deformation mechanisms that govern the mechanical properties of 3D-printed high-entropy alloys. Dr. Chen's second honor was in recognition by SME (formerly the Society of Manufacturing Engineers) with a Sandra L. Bouckley Outstanding Young Manufacturing Engineers award for his exceptional contributions and accomplishments in manufacturing. Chen is one of the Principal Investigators (PIs), along with colleagues from UMass Amherst and the Massachusetts Institute of Technology, on a series of MassDOT research projects exploring metal 3D printing technology applications for transportation infrastructure repairs.

Three research affiliates from UMass Amherst recently received 2022-2023 ADVANCE Collaborative Research Seed Grant awards from the National Science Foundation. The ADVANCE program's mission is to enhance equity for women faculty, including women of color, in science and engineering. Assistant professor Jessica Boakye and research assistant professor Egemen Okte, both of the Civil and Environmental Engineering department, received a seed fund award for their project "Quantifying the Impact of Road Condition on Drivers and Residents in Vulnerable Communities." Assistant professor Shannon Roberts of mechanical and industrial engineering, along with colleague Lauren McCarthy from political science, were awarded a seed grant to support their project "Understanding Cybersecurity Risk and Resilience for Law Enforcement Vehicles." Dr. Roberts was a PI on a MassDOT study completed in 2021 on "Improving Future of the Commonwealth's Curb."

Francis Tainter



Shannon Roberts



Wen Chen

Jessica Boakye

Egemen Okte

Research Projects

During FFY22, each MassDOT research project followed the MassDOT research statement solicitation, review, and selection project process used in previous years. As shown in the table below and in the brief project descriptions later in this section, together these projects cover a broad range of topics of interest to MassDOT. Each of the short-term, medium-term, and long-term projects is conducted through a separate contractual agreement, while the cooperative research projects are issued as research tasks under a comprehensive Interdepartmental Service Agreement between MassDOT and the University of Massachusetts Amherst. The project status of the following projects reflects the completion of this report, February 2023.

Active MassDOT Research Projects, FFY 2022(Project Status is as of February 2023)

Short-Term Research Projects
1. Implementing the AASHTO Mechanistic-Empirical Pavement Design Guide Phase III (In Progress)
2. Methods to Identify Problematic Carriers and Prevent Infrastructure Damage (In Progress)
3. Feasibility of 3D Printing Applications for Bridge Element Repairs (In Progress)
4. Data-Driven Approach for Transit Capital Planning (In Progress)
5. BIM for Transit Infrastructure: A Feasibility and Gap Assessment with Current Practices and Systems at the MBTA (In Progress)
6. Using Traffic Signals to Limit Speeding Opportunities on Arterial Roads (In Progress)
7. Uncovering the Root Causes for Truck Rollover Crashes on Ramps (Completed)
8. Using Mycofiltration Treatment for Stormwater Management (In Progress)
Medium-Term Research Projects
1. Measuring Accessibility to Improve Public Health (In Progress)
2. A Pavement Marking Inventory and Retroreflectivity Condition Assessment Method Using Mobile LiDAR (Completed)
3. Feasibility of 3D Printing Applications for Highway Infrastructure Construction and Maintenance (Completed)
4. Development of a Salt Spreader Controller Program Using Machine-Sensed Roadway Weather Parameters (In Progress)
5. Use of UAS in Surface Transportation Emergency Incident Response (Completed)
6. Detecting Subsurface Void in Roadways Using UAS with Infrared Thermal Imaging (Completed)
7. Impact of Advanced Driver Assistance Systems (ADAS) on Road Safety and Implications for Education, Licensing, Registration, and Enforcement (Completed)
8. Smart Work Zone Control and Performance Evaluation Based on Trajectory Data (In Progress)
9. Developing Massachusetts-Specific Trip Generation Models for Land Use Projects (In Progress)
10. Multisource Data Fusion for Real-Time and Accurate Traffic Incident Detection (In Progress)
11. Post-Fire Damage Inspection of Concrete Structures in Tunnels Phase II (Completed)
12. Massachusetts Depth to Bedrock Project (In Progress)
13. Outdoor Information Panels to Convey Real-Time Travel Information for Ridership Recovery (In Progress)
14. Post-Fire Damage Inspection of Concrete Structures Field Verification Phase III (In Progress)
15. Implementing AASHTO M-E Pavement Design Guide Phase II (Completed)
16. Effectiveness of Two-Stage Turn Queue Boxes in Massachusetts: A Comparison with Bike Boxes (In Progress)

Long-Term Research Projects
1. Ultra-High-Performance Concrete Reinforced with Multi-Scale Hybrid Fibers and Its Durability-Related Properties (In Progress)
2. Complete Streets v.2: Respecting the Roots (In Progress)
3. Understanding Asset Management Systems Utilized by Municipalities in Massachusetts (Completed)
4. Revised Load Rating Procedures for Deteriorated Prestressed Concrete Beams (In Progress)
5. Field Study to Determine Salt Usage Efficiency on Two Pavement Types (In Progress)
6. Development of Comprehensive Inspection Protocols for Deteriorated Steel Beam Ends (Completed)
7. Optimization of MassDOT's High Performance Thin Lift Mixtures (In Progress)
8. Development of Improved Inspection Techniques Using LiDAR for Deteriorated Steel Beam Ends (In Progress)
Cooperative Research Program Projects
1. Construction & Materials Best Practice for Concrete Sidewalks Phase II (In Progress)
2. Evaluating the Safety Impacts of Flashing Yellow Permissive Left-Turn Indications in Massachusetts: Approach Level Analysis (In Progress)
3. Automated Guardrail Inventory and Condition Evaluation (Completed)

Short-Term Research Projects

1 Implementing the AASHTO Mechanistic-Empirical Pavement Design Guide Phase III

Principal Investigator: Dr. Walaa Mogawer, UMass Dartmouth
MassDOT Project Champion: Edmund Naras
Allocated Funding Amount: $400,000

Project Overview

This project builds upon the outputs of Phase I and Phase II, which developed an AASHTOWare® Pavement M-E user manual and a local experimental plan and sampling template for Massachusetts. For Phase III, the project team will collect relevant field data (distress data, falling weight deflectometer data, etc.) and laboratory data (mixture production data, mixture performance data, binder properties, etc.) that are needed for the local calibration of the AASHTO M-E Pavement Design prediction models.

Main Research Objectives:

- Review the previously developed local experimental plan and sampling template from Phase II.
- Evaluate the estimated sample size for bias and precision for each of the distress prediction models.
- Select roadway segments and plant-produced mixtures. Mixtures that represent the spectrum of mixtures produced in Massachusetts will be collected and tested in Phase III.
- Continued laboratory testing of mixtures to obtain data for Level 1 PMED implementation.
- Conduct field and forensic investigations.
- Establish a calibration database using Excel.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/implementing-the-aashto-mechanistic-empirical-pavement-design-guide-phase-iii/download

Timeframe: Expected Completion in May 2024.

2

Methods to Identify Problematic Carriers and Prevent Infrastructure Damage

Principal Investigator: Robin Riessman, UMass Amherst
MassDOT Project Champion: Makaela Niles
Allocated Funding Amount: $126,200

Project Overview:

This project aims to establish the current use and availability of datasets, methods of access, and integration nuances related to oversize/overweight trucking operations in Massachusetts, as well as violation types and rates for these vehicles.

Main Research Objectives:

This research will compile a comprehensive classification of relevant existing data sources, fields, and their framework of interoperability from state agencies and departments including but not limited to:

• MassDOT Registry of Motor Vehicles (RMV) division citation, licensed drivers, registered vehicles, and crash data, as well as Massachusetts State Police (MSP) SafetyNet Commercial Motor Vehicle (CMV) crash and inspection data. Furthermore, MassDOT datasets including (but not limited to) overweight/size permits, freight restrictions, roadway inventory, and toll records would be examined for potential inclusion.

• This research will also develop recommendations and procedures for the preferred use of shared datasets from multiple departments and agencies to enable MassDOT to identify and analyze height- and/or weight-restricted Massachusetts transportation infrastructure, and to prevent damage from problematic use by commercial carriers.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/methods-to-identify-problematic-carriers-and-prevent-infrastructure-damage-0/download

Timeframe: Expected Completion in November 2023.

Massachusetts State Police

3

Feasibility of 3D Printing Applications for Bridge Element Repair

Principal Investigators: Dr. Simos Gerasimidis and Dr. Wen Chen, UMass Amherst; and Dr. John Hart, Massachusetts Institute of Technology
MassDOT Project Champions: Paul Tykodi and Catherine H. Chen
Allocated Funding Amount: $150,000

▶ Project Overview:

In recent years, there has been a significant increase in additive manufacturing (AM), though AM is still largely unexplored for infrastructure projects. Following up on Phase 1, this study will explore more AM innovations, capabilities, and research, focusing on recommended methods for improving repair techniques of deteriorated transportation infrastructure elements, including deteriorated bridge ends, using 3D printing technologies related to addressing corroded steel beam ends and different techniques to repair them.

▶ Main Research Objectives:

• Explore the feasibility of additive repair technologies for real corroded steel beam ends. Different additive manufacturing solutions and repair technologies will be examined in the lab and on-site. Repaired beams will be tested for their strength, fatigue, and corrosion resistance.

• Research the key factors related to the different repair technologies and equipment investigated that can impact the success of an attempted repair (for example, velocity of material being deposited).

• Develop a list of suggested options for equipment and facilities that seem well suited for handling 3D printing applications and the associated qualifications testing of 3D printing repairs to steel bridge beams.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/feasibility-of-3d-printing-applications-for-highway-infrastructure-construction-and-maintenance-phase-ii-research-need/download

Timeframe: Expected Completion in November 2023.

Data-Driven Approach for Transit Capital Planning

Principal Investigator: Dr. Eric Gonzales, UMass Amherst
MBTA Project Champion: Elizabeth McCarthy
Allocated Funding Amount: $100,000

Project Overview:

Existing processes for data collection and analysis are susceptible to discrepancies due to different data definitions and interpretations across users. Transparent and repeatable processes for data aggregation and analysis are necessary to support decision-making through the Capital Investment Plan. This project will coordinate with 15 Regional Transit Authorities (RTAs) in Massachusetts to improve the current data collection method and prioritization approach for Capital Investment Plans.

Main Research Objectives:

• To identify and prioritize the data requirements, aggregation methods, and analysis techniques to forecast needs for transit capital investment decisions that align with the Commonwealth

• To identify software tools and workflows that make data aggregation and analysis processes more transparent, consistent, and repeatable for prioritizing capital investments.

• To create an implementation plan so that proposed processes are adopted consistently across RTAs and are repeatable over time.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/data-driven-approaches-for-transit-capital-planning/download

Timeframe: Expected Completion in December 2023.

BIM for Transit Infrastructure: A Feasibility and Gap Assessment with Current Practices and Systems at the MBTA

Principal Investigators: Dr. Simos Gerasimidis and Dr. Scott Civjan, UMass Amherst
MassDOT Project Champion: Loay Abdelkarim
Allocated Funding Amount: $100,000

▶ Project Overview:

Managing new and ongoing projects at the MBTA is a critical component to efficiency and cost savings. It is important that the MBTA is able to have a data governance system in place to integrate these projects. The management of ongoing operations can be improved by implementing the Building Information Modeling (BIM) delivery methodology in the Capital Delivery department. BIM integrates many different concepts and models into a single platform, including the coordination of information between trades, contractors, and designers during the design and constriction processes.

▶ Main Research Objectives:

• Collect and present information on effective BIM strategies based on practices of comparable agencies and a literature review.

• Provide recommendations on where BIM has the most promise for effective integration into MBTA practice.

• Highlight pitfalls to avoid when implementing BIM.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/bim-for-transit-infrastructure-a-feasibility-and-gap-assessment-with-current-practices-and-systems-at-the-mbta/download

Timeframe: Expected Completion in August 2023.

Using Traffic Signals to Limit Speeding Opportunities on Arterial Roads

Principal Investigator: Dr. Peter Furth, Northeastern University
MassDOT Project Champion: James Danila
Allocated Funding Amount: $140,000

▶ Project Overview:

Traffic signal timing may be able to reduce incidences of dangerous speeding by removing opportunities to drive at high speeds through multiple intersections. This project is focused on preventing speeding on multi-lane arterials while still providing good traffic flow at a safe speed. Preliminary studies suggest that compared to conventional arterial signal timing, traffic signal timing can reduce "speeding opportunities"—the number of cars arriving at an intersection on a stale green and with no vehicle ahead of them—by up to 50% with little or no change in average traffic delay.

▶ Main Research Objectives:

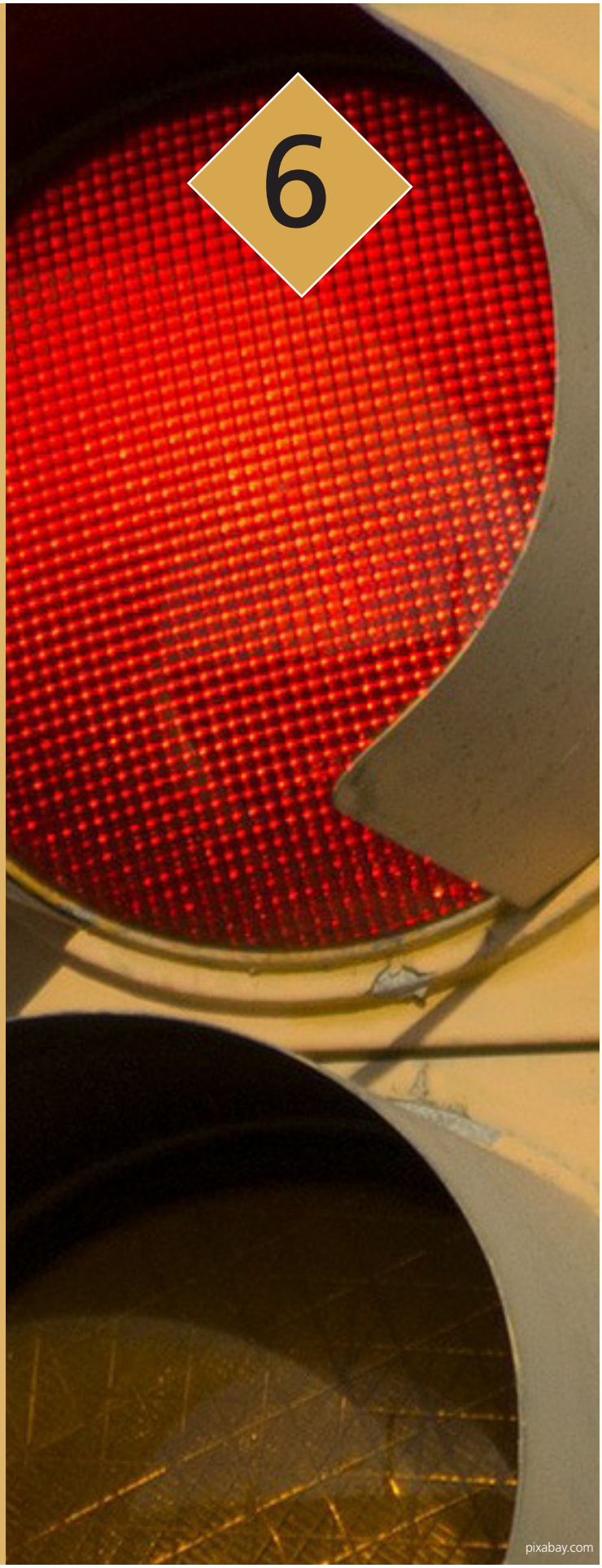
• To do field tests to confirm this theory, measuring changes in speeding, speeding opportunities, traffic delay, and stops.

• To develop a software tool that enables traffic engineers to estimate the number of speeding opportunities that a traffic signal timing plan produces. This will allow engineers to develop and choose timing plans that improve safety while still supporting traffic flow.

• To produce a guidebook on timing traffic signals in a way that reduces speeding opportunities.

Web link to Research Cut Sheet: https://www.mass.gov/doc/using-traffic-signals-to-reduce-speeding-opportunities/download

Timeframe: Expected Completion in November 2023.



Uncovering the Root Causes for Truck Rollover Crashes on Ramps

Principal Investigators: Dr. Yuanchang Xie and Dr. Benyuan Liu, UMass Lowell and Dr. Chengbo Ai, UMass Amherst
MassDOT Project Champions: Bonnie Polin and Dr. Jeffrey DeCarlo
Allocated Funding Amount: $120,000

▶ Project Overview:

The sharp horizontal curves of highway ramps make them hotspots of truck rollover crashes. Such crashes can block the entire ramp and cause severe congestion. Understanding the major causes of ramp truck rollover crashes is important for developing effective crash risk mitigation strategies and improving highway safety and traffic operational reliability.

▶ Main Research Objectives:

- Review literature and best practices on reducing highway ramp truck rollovers.
- Analyze historical ramp truck rollover data in Massachusetts.
- Focus on using traffic cameras and advanced video analytics tools to uncover the causes of truck rollovers on highway ramps and derive surrogate safety performance measures.
- Establish correlations between truck rollovers and ITS devices, signage and markings, and roadway design practices.

Web link to the Research Cut-Sheet: https://www.mass.gov/doc/uncovering-the-root-causes-to-truck-rollover-crashes-on-ramps/download

Timeframe: Expected Completion in March 2023.

8

Using Mycofiltration Treatment for Stormwater Management

Principal Investigator: Kate Kennen, Offshoots, Inc
MassDOT Project Champions: Robbin Bergfors and Hung Pham
Allocated Funding Amount: $40,000

▶ Project Overview:

Mycofiltration is a nascent stormwater management technology that uses mycelium or fungal webs as biological filters within organic matter and soil substrates. This low-cost and low-tech solution could be a beneficial addition to MassDOT's typical Best Management Practices (BMPs) for stormwater management and improve water quality within transportation projects, such as through sediment control barriers, bioswales, tree trenches, and compost slope blankets. Research is needed to define mycofiltration treatment design and operating parameters and to ensure that mycofiltration systems meet the needs of MassDOT project types and personnel.

▶ Main Research Objectives:

• Identify MassDOT project types for which mycofiltration systems could be appropriate and detail implementation requirements for each type.

• Draft of construction specifications and typical details needed to implement the recommended mycofiltration systems.

• Develop a cost analysis of materials, installation, and operation and maintenance for mycofiltration systems, and identify potential vendors of fungal inoculants.

• Identify research that can support water quality credit permitting, and identify the need for additional research such as field trials in conditions typical of MassDOT transportation projects.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/using-mycofiltration-treatment-for-stormwater-management/download

Timeframe: Expected Completion in April 2023.

realmushrooms.com

Medium-Term Research Projects

Principal Investigators: Dr. Eleni Christofa and Dr. Eric Gonzales, UMass Amherst
Project Champion: Derek Krevat
Allocated Funding Amount: $150,000

▶ Project Overview:

This project aims to develop a methodology to identify and classify gaps in accessibility to jobs, health care, and food across time, demographic groups, and locations, which impact the public health of the populations affected; and to provide a set of recommendations for actions to address the specific types of identified accessibility gaps to reduce inequities. These methods could support MassDOT's existing accessibility data dashboard to continuously monitor accessibility gaps and inequities that affect public health.

▶ Main Research Objectives:

• Link metrics of access to social determinants of health, such as access to health care, open space for physical activity, educational opportunities, housing, and food, with demographic and socioeconomic data to identify the most critical accessibility gaps.

• Recommend targeted actions that can be made by public officials to address inequities. The main outcome of this research will be a methodology for identifying accessibility gaps and a set of recommendations for various stakeholders (e.g., transportation and health agencies) that can be used to address accessibility-induced transportation inequities. These products should support MassDOT's existing accessibility initiatives and data dashboards to continuously monitor accessibility gaps and inequities that affect public health.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/measuring-accessibility-to-improve-public-health/download

Timeframe: Expected Completion in July 2023.

2

A Pavement Marking Inventory and Retroreflectivity Condition Assessment Method Using Mobile LiDAR

Principal Investigator: Dr. Chengbo Ai, UMass Amherst
MassDOT Project Champion: Neil Boudreau
Allocated Funding Amount: $200,000

▶ Project Overview:

The FHWA is proposing regulations to guide minimum pavement marking retroreflectivity levels. This study seeks to help MassDOT prepare for these regulations by developing an automated method for locating pavement markings, assessing their retroreflectivity, and testing it on a discrete sample of road segments. This method employs mobile LiDAR and automated LiDAR processing algorithms.

▶ Key Findings:

• The research team has developed a complete methodology for automatically inventorying pavement markings and evaluating the corresponding retroreflectivity condition and binding material loss, using mobile LiDAR and video log images.

• The deliverables include a complete georeferenced pavement marking inventory with retroreflectivity condition measurements for selected road sections.

• The georeferenced inventory database includes the detailed retroreflectivity deterioration trends covering three observation timestamps (i.e., six-month intervals) within the duration of this study.

• This study demonstrated that the mobile LiDAR-based method is a feasible and reliable option for state transportation agencies to implement in their pavement marking inventory and retroreflectivity condition evaluation programs.

Web link to the Final Report: https://www.mass.gov/doc/a-pavement-marking-inventory-and-retroreflectivity-condition-assessment-method-using-mobile-lidar-final-report/download

Timeframe: Completed in June 2022.

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Feasibility of 3D Printing Applications for Highway Infrastructure Construction and Maintenance

3

Principal Investigators: Dr. Simos Gerasimidis and Dr. Wen Chen, UMass Amherst; and Dr. John Hart, Massachusetts Institute of Technology
MassDOT Project Champions: Paul Tykodi and Catherine H. Chen
Allocated Funding Amount: $175,000

▶ Project Overview:

In recent years, there has been a significant increase in additive manufacturing (AM), though AM is still largely unexplored for infrastructure projects. The study explored AM innovations and capabilities related to transportation infrastructure and as a potential future resource to assist MassDOT with construction and maintenance activities for highways, bridges, and tunnels.

▶ Key Findings:

This project demonstrated the new opportunities that have opened up for the usage of AM in the transportation and infrastructure sector in general. This project concluded that there is a future where AM can play a significant role in improving the construction and maintenance of our transportation infrastructure. MassDOT could benefit from participation in standardization bodies and professional associations focused on standardization in AM.

• One of the immediate next steps in this research effort may focus on additive repair of deteriorated steel bridges.

• An initial framework of standard operating procedures for AM within MassDOT was provided.

Web link to the Final Report: https://www.mass.gov/doc/feasibility-of-3d-printing-applications-for-highway-infrastructure-construction-and-maintenance-final-report/download

Timeframe: Completed in May 2022.

4

Development of a Salt Spreader Controller Program Using Machine-Sensed Roadway Weather Parameters

Principal Investigators: Dr. Chengbo Ai and Dr. Russell Tessier, UMass Amherst
MassDOT Project Champion: Mark Goldstein
Allocated Funding Amount: $150,000

Project Overview:

Massachusetts treats more than 15,000 lane miles during winter. While treating these lane miles with de-ice and anti-ice materials, it is critical that the distribution is done efficiently and effectively. Only when snow-fighting material use is optimized can transportation agencies maintain desirable levels of roadway operations and safety in winter while reducing potential environmental impacts of these materials.

Main Research Objectives:

• To develop and validate an automated system that can automatically adjust the spreader controller based on the acquired mobile Road Weather Information System (RWIS) sensor data, such as road temperature, grip level, and surface state.

• The products include a hardware/software program that enables automated roadway treatment with minimum supervisor/plow driver intervention.

• The program will consist of essential hardware, RWIS data acquisition software, and the spreader controlling algorithm.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/development-of-a-salt-spreader-controller-program-using-machine-sensed-roadway-weather-parameters/download

Timeframe: Expected Completion in April 2024

5

Use of UAS in Surface Transportation Emergency Incident Response

Principal Investigators: Dr. Danjue Chen and Dr. Yuanchang Xie, UMass Lowell
MassDOT Project Champions: Dr. Jeffrey DeCarlo and Chester Osborne
Allocated Funding Amount: $60,000

▶ Project Overview:

This study builds on research conducted by the same Principal Investigators in an earlier project, "The Application of Unmanned Aerial Systems in Surface Transportation," which developed a conceptual UAS emergency response network for emergency highway incident and natural disasters. This subsequent project investigates the deployment of the UAS emergency response network and how UAS can best be integrated into existing highway emergency response practices. The study includes details such as creating a proposed decision-making protocol, new data collected from an emergency response pilot exercise, and analyzing historic incident data to identify incident responses that can benefit most from UAS.

▶ Key Findings:

• UAS can be very advantageous to complement existing CCTV cameras for incident response.

• Establishing a small-scale UAS network using four super stations and gradually extending to the key stations. The network will serve multiple purposes (e.g., regular roadway traffic surveillance, MBTA incidents, and extreme weather). The stations of the UAS network can change based on incident frequency and needs.

• Equipping the UAS stations with different types of sensors (e.g., infrared, thermal sensors, LiDAR) that drones could use to serve different types of incidents.

• Implementing a few mobile UAS platforms (e.g., placing drone-in-a-box on a truck) to serve the on-demand needs, such as response to severe traffic incidents on roads without CCTV cameras.

• Conducting outreach to local communities (e.g., emergency managers of towns) to demonstrate the capabilities of UAS and the utility of a UAS network and air operation plan.

Web link to the Final Report: https://www.mass.gov/doc/use-of-uas-for-surface-transportation-emergency-response-final-report/download

Timeframe: Completed in July 2022.

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6

Detecting Subsurface Voids in Roadways Using UAS with Infrared Thermal Imaging

Principal Investigator: Dr. Alessandro Sabato, UMass Lowell
MassDOT Project Champions: Dr. Jeffrey DeCarlo and Jason L. Benoit
Allocated Funding Amount: $60,000

▶ Project Overview:

Soil voids beneath roadways can create a safety hazard. These voids can result from the failure of culverts and drainage piping. This project focused on reducing such failures through better inspections. The project explored the use of UAS and rapid aerial infrared thermography to detect soil voids and assess the conditions of culverts and drainage piping beneath public roadways.

▶ Key Findings:

• Validation of a new nondestructive method to detect and assess roadway subsurface voids based on IR imaging combined with UAS surveying.

• Development of advanced image post-processing techniques to improve the detection accuracy of IR imaging.

• Recommendations based on laboratory experiments and field testing for best practices during future real-world operations using IRT to detect and assess subsurface voids.

Web link to the Final Report: https://www.mass.gov/doc/detecting-subsurface-voids-in-roadways-using-uas-with-infrared-thermal-imaging-final-report/download

Timeframe: Completed in February 2022.

Impact of Advanced Driver Assistance Systems (ADAS) on Road Safety and Implications for Education, Licensing, Registration, and Enforcement

Principal Investigator: Dr. Anuj K. Pradhan, UMass Amherst
MassDOT Project Champion: Daniel A. Sullivan
Allocated Funding Amount: $120,000

▶ Project Overview:

Drivers often do not fully understand the capabilities and limitations of ADAS technologies, which can then lead to their misuse of these systems and potential transportation safety issues, especially as ADAS becomes more common. The study will gather information to investigate this topic, and then propose strategies to address current driver knowledge gaps and safety concerns.

▶ Key Findings:

• Determined that drivers of new vehicles with ADAS are not supported in their understanding of the technology, with many drivers experimenting with systems during driving.

• This research showed that targeted training improved drivers' understanding of these systems, with some indication of improved safety behaviors as well.

• This research underlines the complexity and burden of trying to gather this data. This finding thus spotlights a critical need to ease data collection about ADAS systems in vehicles, potentially at the registration level.

Web link to the Final Report: https://www.mass.gov/doc/impact-of-advanced-driver-assistance-systems-adas-on-road-safety-and-implications-for-education-licensing-registration-and-enforcement-final-report/download

Timeframe: Completed in March 2022

Smart Work Zone Control and Performance Evaluation Based on Trajectory Data

Principal Investigators: Dr. Yuanchang Xie, Dr. Danjue Chen, and Dr. Benyuan Liu, UMass Lowell
MassDOT Project Champion: Carrie McInerney
Allocated Funding Amount: $150,000

Project Overview:

MassDOT strives to keep all roads safe, and this includes all active work zones on these roads. Many strategies can potentially affect work zone safety and traffic operations, including taper length and rumble strips. The performance of these strategies is often evaluated based on traffic throughput, speed, etc., measured at selected locations. Such metrics do not provide sufficient detail regarding individual drivers' speed choices and lane-changing behaviors over the course of the entire work zone, which are critical for understanding work zone safety and traffic operations under different traffic, control, and layout conditions. This project will evaluate how selected work zone traffic control methods affect driver behavior using vehicle speed and trajectory data.

Main Research Objectives:

- Develop methods to extract vehicle trajectories.
- Use the trajectories to analyze driver behavior, particularly lane-changing behavior, under different traffic conditions.
- Use the trajectories to quantify the effects of various merging taper lengths and rumble strip configurations on vehicle speed and lane-changing behavior.
- Use the analysis results to identify safety hazards and opportunities to improve work zone safety and operations.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/smart-work-zone-control-and-performance-evaluation-based-on-trajectory-data/download

Timeframe: Expected Completion in September 2023.

9

Developing Massachusetts-Specific Trip Generation Models for Land Use Projects

Principal Investigators: Dr. Danjue Chen, Dr. Yuanchang Xie, and Dr. Benyuan Liu, UMass Lowell
MassDOT Project Champion: J. Lionel Lucien
Allocated Funding Amount: $150,000

▶ Project Overview:

Vehicle trip generation is used to identify potential transportation impacts associated with new development projects, to provide a substantive basis for determining appropriate impact mitigations, and to inform transportation infrastructure management, planning, and public involvement. In the US, trip generation estimation typically relies on the Trip Generation Manual published by the Institute of Transportation Engineers (ITE). The ITE trip generation rates have been found to overestimate trips for sites that benefit from their proximity to public transportation and accessibility by walking and bicycling, and do not accurately reflect the current trip generation trends in Massachusetts. Over- and underestimation of trip generation may result in either significant waste and unfair financial burden on developers or inadequate infrastructure to support the state's economic activities. Accurate trip generation models and automated data collection tools will significantly benefit transportation impact analysis and mitigation for economic development projects.

▶ Main Research Objectives:

• Develop an algorithm-based model for deriving accurate trip generation rates for development projects located in Massachusetts.

• Identify and study available innovative technologies such as machine learning models and video analytics that can be used to assist MassDOT's efforts to collect vehicular and multimodal trip generation data.

• The study outcome can improve the current methods used by MassDOT for projecting trip generation rates resulting from new, large urban development projects.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/developing-massachusetts-specific-trip-generation-models-for-land-use-projects/download

Timeframe: Expected Completion in September 2023.

Multisource Data Fusion for Real-Time and Accurate Traffic Incident Detection via Predictive Analytics

Principal Investigators: Dr. Chronis Stamatiadis, Dr. Yuanchang Xie, and Dr. Nathan H. Gartner, UMass Lowell
MassDOT Project Champion: Chester Osborne
Allocated Funding Amount: $150,000

▶ Project Overview:

This research will investigate how data from the various traffic data sources that MassDOT owns or has access to can be merged for accurate, real-time traffic incident detection, which can lead to more prompt incident responses and ultimately improved travel time reliability. The study will assess the current traffic incident detection methods employed by MassDOT and develop new tools for improved traffic incident detection based on available traffic data. It will address the fusion of information from multiple sources of different temporal and spatial scales, such as traffic data collected from loop detectors, information from the MassDOT Real Time Traffic Management system, and information available through third-party vendors (e.g., Waze, Google, INRIX). The fusion of data from these sources will be accomplished through evaluating the reliability of the various data sources and deploying advanced data analytical methods such as deep neural networks.

▶ Main Research Objectives:

• Identify datasets owned by MassDOT as well as by other sources that can be harvested to support real-time incident detection.

• Investigate how data from multiple sources can be integrated to add confidence to incident detection and improve travel time reliability.

• Develop guidance for the setting of "trigger points" to alert Highway Operations Center operators about incidents on the roads.

• Perform a field test of the "trigger points

Web link to the Research Cut Sheet: https://www.mass.gov/doc/multisource-data-fusion-for-real-time-and-accurate-traffic-incident-detection-via-predictive-analytics/download

Timeframe: Expected Completion in April 2023.

Post-Fire Damage Inspection of Concrete Structures in Tunnels Phase II

Principal Investigators: Dr. Simos Gerasimidis and Dr. Scott Civjan, UMass Amherst
MassDOT Project Champion: John Czach
Allocated Funding Amount: $160,000

▶ Project Overview:

The second phase of this research focuses on physical testing of critical components of tunnels after being exposed to high combustion temperature. Key activities in this phase include identification of critical tunnel components for testing, physical testing of the components in a structural testing facility for their post-fire residual capacity, evaluating the nondestructive test devices and methods identified in the Phase I literature review and owned by MassDOT, and adding new information resulting from lab testing to the inspection protocol checklist developed in Phase I to assist field inspections.

▶ Main Research Objectives:

• Report experimental results of heating structural and nonstructural elements using the new heating setup at the Brack Structural Testing Facility at UMass Amherst.

• Conduct residual strength tests of structural components.

• Provide an updated, improved flow chart/checklist that will be used as a tool for post-fire inspection protocols specific to MassDOT tunnel materials and components. It will also contain photos of actual fire damage.

• Further investigate the efficiency of nondestructive testing techniques.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/post-fire-damage-inspection-of-concrete-structures-phase-ii-experimental-phase/download

Timeframe: Completed in February 2023.

Massachusetts Depth to Bedrock Project

Principal Investigators: Dr. Stephen Mabee and Dr. Bill Clement, UMass Amherst
MassDOT Project Champion: Jennifer Rauch
Allocated Funding Amount: $115,000

▶ Project Overview:

Fundamental to any transportation planning and engineering activity is having a reasonable estimate of the thickness of the overburden. Knowing the overburden thickness not only influences cost but may also affect selection of the appropriate foundation system for a particular structure and selection of a suitable subsurface investigation method. The overall goal is to help reduce the uncertainty in highway projects by providing a rational approach to clarifying overburden thickness during project planning and design development.

▶ Main Research Objectives:

• Identify, collect, assemble, and apply necessary data validation, quality control, attribution, and processing to each of the existing geoformation data sources to unify the information for modeling soil thickness.

• Combine soil thickness values with the constraints in the recently completed statewide surficial materials map (of outcrops and shallow bedrock areas), LiDAR data (surface elevation), and other sources to model a continuous soil thickness raster along with a data quality confidence raster using appropriate geostatistical or other methods.

• Use the soil thickness raster along with existing shear wave velocity data to generate a National Earthquake Hazards Reduction Program soil classification map for Massachusetts.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/massachusetts-depth-to-bedrock-project/download

Timeframe: Expected Completion in May 2022.

Outdoor Information Panels to Convey Real-Time Travel Information for Ridership Recovery

13

Principal Investigators: Dr. Song Gao and Dr. Eleni Christofa, UMass Amherst
MassDOT Project Champion: Elizabeth Winters Ronaldson
Allocated Funding Amount: $125,000

▶ Project Overview:

The MBTA has launched an Outdoor Information Panels (OIP) program, where 25% of the playlists will be dedicated "set asides" for MBTA purposes. As all locations eligible for digital upgrade will be near decision-making points for people in vehicles, optimizing MBTA set-aside time with Real Time Travel Information (RTTI) (e.g., train departures, parking availability) will be critical information delivery to users of transit and to nonusers to "nudge" them toward behavior change at that point or in the future. This research aims to provide a better understanding of which RTTI meets the needs of current ridership connecting to transit by vehicle, how RTTI can be used to incentivize off-peak travel, and how RTTI may lead to mode-shifting based on the value propositions of information presented.

▶ Main Research Objectives:

• Develop guidelines for determining locations and contents of RTTI with high potential for incentivizing off-peak travel, recovering ridership loss due to COVID-19 and mode shift, and building rider trust post-COVID-19.

• Understand transit user and nonuser preferences on types of RTTI and the value users and nonusers place on the information, before and after the implementation of OIPs.

• Estimate the potential of OIPs in reducing greenhouse gas emissions.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/outdoor-information-panels-to-convey-real-time-travel-information-for-ridership-recovery/download

Timeframe: Expected Completion in July 2023

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Post-Fire Damage Inspection of Concrete Structures in Tunnels Phase III: In-Situ Experimental Phase

Principal Investigators: Dr. Simos Gerasimidis and Dr. Scott Civjan, UMass Amherst
MassDOT Project Champion: John Czach, PE
Allocated Funding Amount: $180,000

▶ Project Overview:

The third phase of this research focuses on physical testing of critical components of tunnels after being exposed to high combustion temperatures. Key activities in this phase includes identification of critical tunnel components for testing, physical testing of the components in a structural testing facility for their post-fire residual capacity, evaluating the nondestructive test methods identified in the Phase I literature review and owned by MassDOT based on the testing results, and adding new information resulting from lab testing to the inspection protocol checklist to assist field inspections.

▶ Main Research Objectives:

• Report experimental results of heating structural and nonstructural elements using the new heating setup at the Brack Structural Testing Facility at UMass Amherst.

• Conduct residual strength tests of structural components.

• Provide an updated, improved flow chart/checklist that will be used as a tool for post-fire inspection protocols specific to MassDOT tunnel materials and components. It will also contain photos of actual fire damage.

• Further investigate the efficiency of nondestructive testing techniques.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/post-fire-damage-inspection-of-concrete-structures-phase-iii-in-situ-experimental-phase-research-need/download

Timeframe: Expected Completion in February 2024.

15

Implementing AASHTO M-E Pavement Design Guide Phase II

Principal Investigator: Dr. Walaa Mogawer, UMass Dartmouth
MassDOT Project Champion: Edmund Naras
Allocated Funding Amount: $200,000

▶ Project Overview:

Building upon the outputs of Phase I, Phase II developed an AASHTOWare® Pavement M-E user manual and developed a local experimental plan and sampling template for Massachusetts. The standalone manual shows a user a thorough step-by-step procedure on how to use the AASHTOWare Pavement M-E Design software. The manual guides users on how to generate data, in particular, materials properties and climatic and traffic data as they relate to local locations within the state of Massachusetts. A statistical plan or sampling template to refine the calibration of the M-E distress and International Roughness Index prediction models based on local conditions, policies, and materials was also developed. The primary tier parameters in the sampling template include distress dependent, surface layer type and thickness, and subgrade soil type. This experimental and sampling plan will provide the foundation for Phase III efforts.

▶ Key Findings:

• Developed an AASHTOWare® Pavement M-E user manual & local experimental plan and sampling template.

• A preliminary experimental and sampling plan for local verification and calibration of the distress functions and smoothness regression equations in the AASHTOWare® Pavement M-E Design was developed.

• Several plant-produced mixtures were tested in this study to generate the inputs necessary to run designs using the AASHTOWare® Pavement M-E Design software.

• Continued to conduct testing of already sampled mixtures to accelerate future phases of this research.

Web link to the Final Report: www.mass.gov/doc/improving-the-long-term-condition-of-pavements-in-massachusetts-and-determining-return-on-investment-implementing-the-aashto-mechanistic-empirical-pavement-design-guide-phase-ii/download

Timeframe: Completed in September 2022.

Effectiveness of Two-Stage Turn Queue Boxes in Massachusetts: A Comparison with Bike Boxes

Principal Investigators: Dr. Eleni Christofa, Dr. Chengbo Ai, and Dr. Francis Tainter, UMass Amherst
MassDOT Project Champion: Violet Wilkins
Allocated Funding Amount: $150,000

▶ Project Overview:

Existing research has investigated motorist and bicyclist behavior at bike boxes and has assessed the bike boxes effectiveness in improving safety. However, studies on the effectiveness of two-stage turn queue boxes have been limited. Most importantly, a comprehensive comparison of the effectiveness of the two treatments in the Commonwealth that can guide future implementations is missing.

▶ Main Research Objectives:

- Create an inventory of two-stage turn queue boxes and update the existing bike box inventory for Massachusetts.

- Characterize bicyclist and motorist behaviors at intersections with two-stage queue turn boxes and compare them with those at bike boxes.

- Provide guidelines on the design and implementation of two-stage turn queue boxes and bike boxes to promote safety.

Web link to the Final Report: https://www.mass.gov/doc/effectiveness-of-two-stage-turn-queue-boxes-in-massachusetts-a-comparison-with-bike-boxes/download

Timeframe: Completed in February 2024.

Long-Term Research Projects

1 Ultra-High-Performance Concrete Reinforced with Multi-Scale Hybrid Fibers and Its Durability-Related Properties

Principal Investigators: Dr. Jianqiang Wei, UMass Lowell, and Dr. Sergio Brena, UMass Amherst
MassDOT Project Champion: Richard Mulcahy
Allocated Funding Amount: $200,000

▶ Project Overview:

Ultra-high-performance concrete (UHPC) is a cementitious composite material composed of an optimized gradation of granular constituents, a low water-to-cementitious materials ratio, and a high percentage of discontinuous internal fiber reinforcement. Due to its excellent mechanical properties, ease of placement, and volume stability, UHPC is often used in transportation infrastructures including roads, underground structures, and bridges. The study is to develop a novel UHPC reinforced with Multi-Scale Hybrid Fibers (MSHF) and nano-scale additives with enhancements in both early-age properties and long-term performance such as high early-age strength, low volume change, low permeability, and extended service life in the presence of environmental stresses in Massachusetts. The project will also develop a comprehensive understanding of the roles of MSHF, additives, and cement chemistry in improving durability-related properties of UHPC.

▶ Main Research Objectives:

• Develop novel nonproprietary Fiber Reinforced Concrete (FRC) and UHPC mixtures.

• Identify and maximize the roles of fibers and additives in enhancing mechanical and durability-related properties in UHPC.

• Promote the widespread use of FRC and UHPC in transportation infrastructure.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/ultra-high-performance-concrete-reinforced-with-multi-scale-hybrid-fibers-and-its-durability-related-properties/download

Timeframe: Expected Completion in October 2023.

2

Complete Streets v.2: Respecting the Roots

Principal Investigator: Dr. Brian Kane, UMass Amherst
MassDOT Project Champions: George Batchelor and Andrew Schlenker
Allocated Funding Amount: $90,000

▶ Project Overview:

This research project focuses on the preservation of large trees in high-density areas during infrastructure projects to enhance their value to the community. Trees contribute to the quality of life in our communities, as do infrastructure improvement projects to promote walking and cycling. However, infrastructure projects that do not adequately accommodate trees' natural needs can harm trees' health and reduce their value to a community. Preventing harm to trees preconstruction and during construction and restoring habitat conditions post-construction can be beneficial to trees and the community.

▶ Main Research Objectives:

• Complete a state-of-practice synthesis including a literature review.

• Conduct an online survey of practicing professionals responsible for health of the urban forest at select DOTs and cities.

• Gather feedback and facilitate consensus-building from a multidisciplinary panel of experts.

• Develop a preliminary corridor tree-health evaluation and general impact analysis method.

• Provide guidance for soil area planting requirements for new trees, as well as best management practices for soil protection during construction.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/tree-preservation-and-planting-for-complete-streets-development/download

Timeframe: Expected Completion in August 2024.

Understanding Asset Management Systems Utilized by Municipalities in Massachusetts

3

Principal Investigator: Dr. Walaa Mogawer, UMass Dartmouth
MassDOT Project Champions: Edmund Naras, Derek Krevat, and John Moran
Allocated Funding Amount: $200,500

▶ Project Overview:

Massachusetts has about 3,000 centerline miles of roadways under its jurisdiction and 33,700 miles under municipal or other jurisdictions. Conditions on MassDOT's 3,000 miles are reported annually to the legislature, and 3,361 miles of national highway roadways are reported through the Highway Performance Monitoring System (HPMS). Condition data on the remaining mileage remains unreported. Many cities and towns have implemented asset management systems using differing approaches. To harmonize pavement condition assessment by different entities across the Commonwealth, there is a need to identify what type of pavement asset data is being collected by these municipalities, who collects the data, and what these organizations then do with the data.

▶ Key Findings:

• A 35-question internet-based survey was developed and administered to a list of 2,000 contacts representing 320 municipalities and 14 Metropolitan Planning Organizations (or Regional Planning Agencies) in Massachusetts. Findings from the internet survey included:

- There are 13 different PMS software programs being used in Massachusetts.

- Many different procedures are used to collect condition data.

- Seven different condition rating systems (indices) are being used.

• Representatives of six municipalities and nine MPOs/RPAs were interviewed. Findings from the interviews included:

- Little information was available/known on exactly how condition indices were calculated. These calculations were generally made by the PMS software.

- PMS software selection was based on different factors for municipalities versus MPOs.

- Municipal investment decisions made with PMS data included recommendations of repair methods, cost-benefit analyses, planning decisions, and development of capital plans. MPOs generally did not make investment decisions.

• The potential of using a unified PMS software for MPOs/RPAs in Massachusetts was explored. After multiple rounds of discussions, it was determined that a group purchase would best be feasible at a regional rather than statewide level. A simplified standardized methodology for pavement condition based on submissions from MPOs may be used to create a unified pavement condition data layer for the whole state road network.

Web link to Final Report: https://www.mass.gov/doc/understanding-asset-management-systems-utilized-by-municipalities-in-massachusetts-final-report/download

Timeframe: Completed in September 2022.

4

Revised Load Rating Procedures for Deteriorated Prestressed Concrete

Principal Investigators: Dr. Sergio Brena, Dr. Simos Gerasimidis, Dr. Scott Civjan, and Dr. Jessica Boakye, UMass Amherst
MassDOT Project Champion: Matthew Weideler
Allocated Funding Amount: $200,000

▶ Project Overview:

MassDOT has a substantial inventory of deteriorating precast, prestressed concrete structures, many of which have exposed and broken stirrups and strands. This project will develop an approach to realistically and reliably determine a safe working capacity for existing precast, prestressed concrete bridges that exhibit deterioration to avoid unnecessary bridge closures while also keeping the public safe. This project is being carried out through a combination of computer model simulations and full-scale laboratory testing of actual deteriorated beams.

▶ Main Research Objectives:

• Categorize the severity of deterioration of precast, prestressed concrete bridges as it relates to their safety.

• Develop engineering procedures to estimate the remaining capacity of deteriorated precast, prestressed concrete beams based on severity of the deterioration encountered. These procedures will be based on solid engineering principles verified by calibrated finite element analyses using laboratory testing of existing deteriorated components extracted from bridges scheduled for replacement.

• Develop a reliable rating methodology that results in safe predictions of working capacity applicable to the range of deterioration encountered in existing precast, prestressed concrete bridges in Massachusetts.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/revised-load-rating-procedures-for-deteriorated-prestressed-concrete-beams/download

Timeframe: Expected Completion in November 2023.

Field Study to Determine Salt Usage Efficiency on Two Pavement Types

Principal Investigators: Dr. Walaa Mogawer, UMass Dartmouth, and Kirk Smith, USGS New England Water Science Center
MassDOT Project Champion: Mark Goldstein
Allocated Funding Amount: $450,000

▶ Project Overview:

MassDOT has concerns that certain pavement surface types have been being overtreated during winter maintenance. This is because one specific type of pavement surface, Open-Graded Friction Course (OGFC), will appear visually "white" even after treatment. This could lead to a situation where the road is treated again when it is not necessary. OGFC pavement sections typically adjoin dense-graded (DG) pavement sections. Thus, when the OGFC section is treated, the adjoining DG section is also typically treated, which can lead to excessive treatment application. This study is to collect and analyze salt application, the two types of road surface conditions, and runoff properties data in the field during winter maintenance season to investigate the efficiency of winter maintenance treatment on OGFC and DG pavement surfaces.

▶ Main Research Objectives:

• Compare OGFC and DG pavement response to identical winter maintenance (salt) applications in terms of reflected physical parameters.

• Investigate the safety implications related to winter maintenance activities for both OGFC and DG pavement types.

• Evaluate whether either pavement type requires a greater or lower application rate to achieve desired results.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/field-study-to-determine-salt-usage-efficiency-and-transport-to-the-surrounding-environment-on-two-pavement-types/download

Timeframe: Expected Completion in September 2025.

6

Development of Comprehensive Inspection Protocols for Deteriorated Steel Beam Ends

Principal Investigators: Dr. Simos Gerasimidis and Dr. Sergio Brena, UMass Amherst
MassDOT Project Champions: Alexander Bardow
Allocated Funding Amount: $150,000

▶ Project Overview:

Recently completed MassDOT research projects have found new parameters that are extremely important for assessing the residual capacity of deteriorated bridge steel beams for the load rating procedure and proposed the new load rating procedures. This project develops a comprehensive inspection and documentation protocol to implement these new procedures, and explores innovative techniques to collect necessary information for the new procedure during bridge inspection. It documents the current state of practice of beam-end inspections, explores the utilities of new technological solutions such as ground LiDAR and unmanned aircraft systems for bridge inspection, and performs computerized bridge beam-end deterioration measurements and condition assessment using LiDAR data collected in the lab environment.

▶ Key Findings:

• Developed effective and consistent procedures for collecting important data from deteriorated steel beam ends and provided a clear list of measurements and tasks for inspectors to follow during inspections.

• Explored new practical inspection techniques and provided inspection solutions using new technology such as LiDAR scanning and drone technology to obtain the critical measurements.

• Developed a comprehensive inspection and documentation protocol that will be used along with the new load rating procedures for more accurate and effective load rating of steel bridge beam ends.

• Identified and classified unique cases that would require future research or advanced modeling that cannot be described by the new load rating procedures.

Web link to the Final Report: https://www.mass.gov/doc/development-of-comprehensive-inspection-protocols-for-deteriorated-steel-beam-ends-final-report/download

Timeframe: Completed in March 2022

Optimization of MassDOT's High-Performance Thin Lift Mixtures

Principal Investigator: Dr. Walaa Mogawer, UMass Dartmouth
MassDOT Project Champions: Edmund Naras and Mark Brum
Allocated Funding Amount: $250,000

▶ Project Overview:

MassDOT and municipalities in the Commonwealth have used high-performance thin asphalt overlays (HPThinOL) as a pavement preservation strategy. MassDOT has been piloting a special provision that allows contractors to choose between placing HPThinOLs either as an asphalt rubber gap-graded (ARGG) or a polymer modified asphalt (PMA) dense-graded mixture, with the condition that any chosen material must meet identical performance targets using Beam Fatigue, Semi-Circular Bend (SCB), and Hamburg Wheel Tracking tests. This research project will investigate if using a dense-graded polymer modified high-performance thin overlay mixture provides the same or better performance and lifecycle costs compared to the asphalt rubber gap-graded mixtures with which MassDOT has more experience.

▶ Main Research Objectives:

• Evaluate the ARGG and PMA HPThinOL specifications and performance characteristics as they currently stand.

• Test current MassDOT ARGG and PMA HPThinOL mixes and benchmark their performance and construction costs while determining if it is possible to optimize materials or design parameters to improve on the current specifications.

• Perform a lifecycle cost analysis for the optimized mixture types.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/optimizing-of-massdots-high-performance-asphalt-overlay-hpol-mixtures/download

Timeframe: Expected Completion in September 2023

Development of Improved Inspection Techniques Using LiDAR for Deteriorated Steel Beam Ends

8

Principal Investigators: Dr. Simos Gerasimidis, Dr. Chengbo Ai, and Dr. Sergio Brena, UMass Amherst
MassDOT Project Champion: Jean Markowski
Allocated Funding Amount: $200,000

▶ Project Overview:

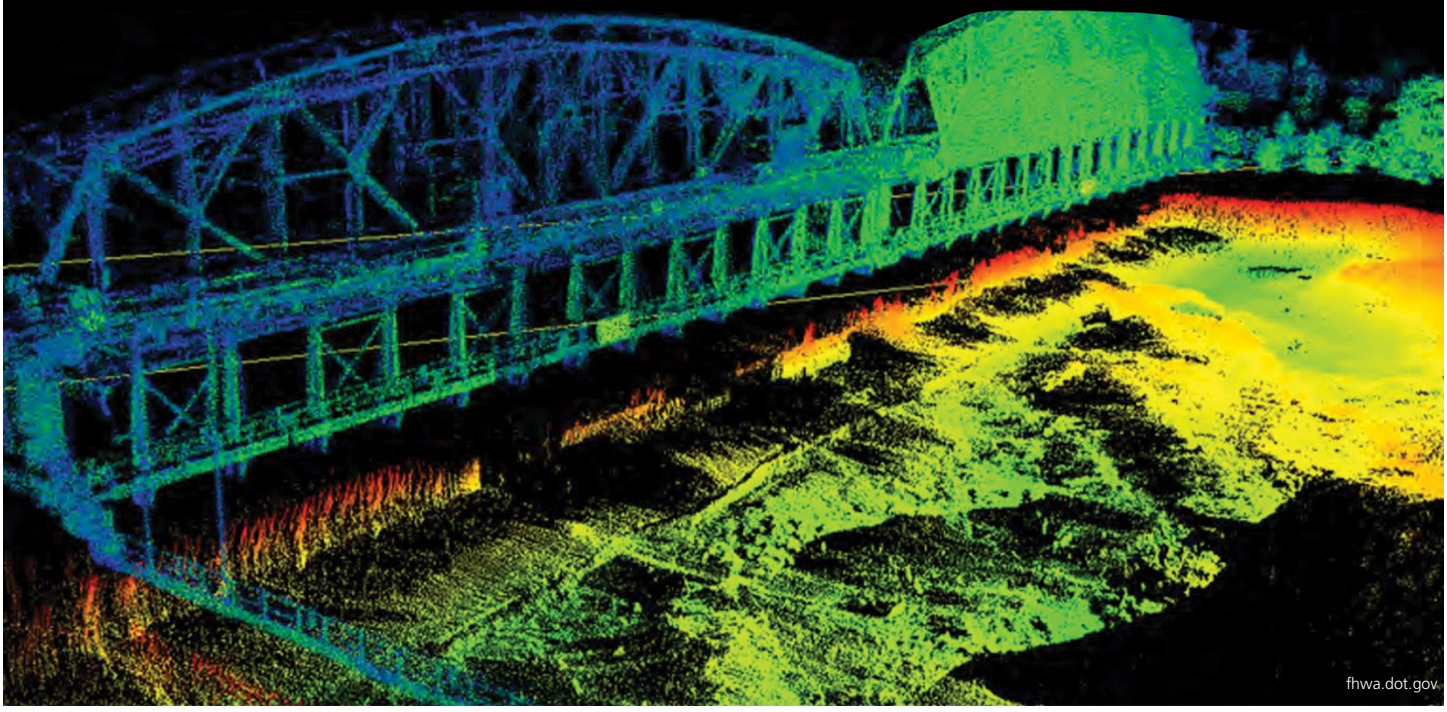
There is an emerging need for MassDOT to leverage the strength of LiDAR point cloud data and incorporate such a promising technology into their bridge inspection practices if it is deemed feasible.

▶ Main Research Objectives:

- Review of LiDAR-based bridge inspection methods and practices.
- Lab experiments for residual loading capacity estimation.
- Field experiments for residual loading capacity estimation.
- Develop and validate the automated or semiautomated LiDAR point cloud extraction method.
- Develop a new protocol for LiDAR-enriched bridge inspection.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/development-of-improved-inspection-techniques-using-lidar-for-deteriorated-steel-beam-ends/download

Timeframe: Expected Completion in November 2023



Cooperative Research Program Projects

Construction & Materials Best Practice for Concrete Sidewalks Phase II

Principal Investigators: Dr. Sergio Breña and Dr. Kara Peterman, UMass Amherst
MassDOT Project Champion: Richard Mulcahy
Allocated Funding Amount: $250,000

▶ Project Overview:

Deterioration, such as scaling of concrete sidewalks, is one of the most urgent challenges that need to be tackled. MassDOT is seeking to improve the quality and durability of concrete to address the statewide deterioration challenges of the currently used concrete sidewalks under the extreme weather conditions of Massachusetts with an objective to reduce the significant maintenance and reconstruction costs. This project represents a collaboration between industry, contractors, and research agencies to provide resolution to this complex problem. The first phase of this project investigated various aspects affecting concrete scaling while concrete was placed in cold weather conditions. The second phase investigates performance of concrete placed in warm weather conditions while continuing to monitor concrete panels placed in Phase I.

▶ Main Research Objectives:

• Research proper concrete sidewalk workmanship for sidewalks placed under hot weather conditions.

• Determine whether curing/sealing compounds can replace moist curing to enable faster placement and return to use.

• Determine if penetrating sealers are effective at limiting chloride penetration from commercially available chemical deicers.

• Perform extensive testing on fresh and hardened concrete to identify processes responsible for concrete deterioration.

• Document the performance of sidewalks through detailed visual and photographic inspection to support lab testing.

• Perform hardened concrete testing using petrographic methods and chloride ingress testing to identify conditions that may lead to observed degradation in the field.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/construction-materials-best-practices-for-concrete-sidewalks-phase-2/download

Timeframe: Expected Completion in March 2023.

2

Evaluating the Safety Impacts of Flashing Yellow Permissive Left-Turn Indications in Massachusetts: Approach Level Analysis

Principal Investigators: Dr. Francis Tainter and Dr. Cole Fitzpatrick, UMass Amherst
MassDOT Project Champion: Jim Danila
Allocated Funding Amount: $126,000

▶ Project Overview:

Building upon a recently completed research project that used high-level crash data to investigate the crash reduction effects and benefit-cost ratio of the novelty traffic control device Flashing Yellow Arrows (FYA), this follow-up study provides MassDOT with a greater understanding of these signals' safety impacts from an approach-level perspective. Using collision diagrams at each of the FYA intersections, this study provides MassDOT with a holistic overview of infrastructure and operational impacts at each of these intersections, ultimately leading to an improved understanding of future design characteristics.

▶ Main Research Objectives:

- Stratify before & after crash information from collision diagrams using FYA location database.
- Develop and disseminate survey to MassDOT district traffic engineers to obtain design specs for each FYA intersection in Massachusetts.
- Analyze safety impacts with left-turn FYA-related infrastructure (post-installation).
- Develop guidance and recommendations for left-turn FYAs.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/evaluating-the-safety-impacts-of-flashing-yellow-permissive-left-turn-indications-in-massachusetts-approach-level-analysis-phase-ii/download

Timeframe: Expected Completion in March 2023.

3

Automated Guardrail Inventory and Condition Evaluation

Principal Investigator: Dr. Chengbo Ai, UMass Amherst
MassDOT Project Champion: Neil Boudreau
Allocated Funding Amount: $250,000

▶ Project Overview:

Guardrails are an important piece of infrastructure that provide effective prevention for vehicles running out of the road and that protect critical roadside properties from consequential collisions. MassDOT actively works with FHWA on the Manual for Assessing Safety Hardware (MASH) implementation. It is critical to plan and manage MASH upgrades and integrate the guardrail asset within its asset management plan with a complete guardrail inventory.

▶ Key Findings:

• The research team developed and validated a comprehensive methodology for automatically inventorying guardrails and extracting the corresponding properties and conditions of the guardrails.

• The results have shown that mobile LiDAR is an effective and efficient technology for network-level guardrail inventory with detailed property and condition information.

Web link to the Final Report: https://www.mass.gov/doc/automated-guardrail-inventory-and-condition-evaluation-final-report/download

Timeframe: Completed in May 2022.

Research Impacts and Outcomes

Using Research Findings at MassDOT (Project Champion Survey Results)

MassDOT is committed to tracking the implementation and impacts of research. To help with this goal, the MassDOT Research Section sent a Project Completion Survey to the MassDOT Project Champions (PCs), Principal Investigators (PI), and Project Managers (PM) for research projects completed during FFY22, and a follow-up survey to the PCs and PIs for research projects completed in FFY20-21.

These surveys collect important information on how research study findings are used by MassDOT and help to inform revisions to agency procedures and policies to improve efficiency and outcomes. The survey results also show how research findings are disseminated through journal publications, conferences, and otherwise, aiding knowledge transfer and future workforce development by sharing the state of research and best practices.

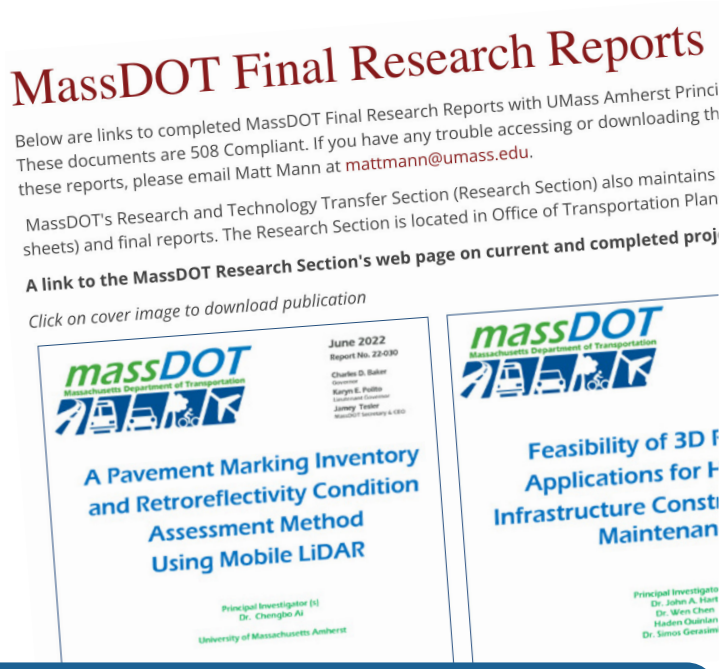
Survey responses from the PCs and PMs demonstrate a range of potential implementation techniques within MassDOT. In the most successful cases, research findings and results have already been incorporated into the agency's Standard Operating Procedures (SOPs) and technical specifications, and/or have facilitated a phased approach to long-term implementation. For example, the results from "Improved Load Rating Procedures for Deteriorated Steel Beam Ends with Deteriorated Stiffeners" (i.e., revised load rating equations based on prediction modeling verified by real beam testing results) are being incorporated into the updated version of the MassDOT Bridge Manual.

One common theme in PC and PM responses to the surveys' questions on technology transfer and implementation of findings was that the research results had been shared with other MassDOT personnel who may play a crucial role in MassDOT using the findings and implementing recommendations. Another common theme in the PC and PM responses was that further study was needed before implementation. Of the eight research projects that finished in FFY22, MassDOT is now funding additional phases for four of them. Two of the other projects were themselves later phases of earlier studies. One of the key takeaways shared by the PC for one project, "Automated Guardrail Inventory and Condition Evaluation," was that the current technology could not provide all the answers needed on its own, and therefore implementation was feasible as part of the solution, not the whole or only solution.

Some information and findings from MassDOT research are also disseminated directly to private firms (working with MassDOT) as well as local, regional, and federal agencies (e.g., municipal governments, MPOs, Regional Transit Agencies, and FHWA). Sharing this information across different transportation spectra allows key stakeholders to be involved and provide feedback. One example of this is provided with the "Exploring Short-Sea Shipping as an Alternative to Non-Bulk Freight Trucking in Southeast Massachusetts" project. After the study was completed, the results were shared with the Steamship Authority, the Town of Falmouth, and the City of New Bedford. This level of public–private collaboration exponentially increases the potential for implementation.

Disseminating Research Results through Digital Publication

All final MassDOT research reports are publicly accessible online along with their compliancy with accessibility requirements. MassDOT, Federal Highway (FHWA), and UMTC work together to finalize each report, including 508 compliant measures. Once a report is 508 compliant, the report is published on the MassDOT Research and Technology transfer webpage alongside the Project Summary cut sheet. The Final Report is also submitted to the FHWA Research Library; the FHWA Office of Corporate Research, Technology, and Innovation Management; the National Transportation Library; National Technical Information Service; Transportation Research Board Library; and the Transportation Library for their records and collections.



Sharing Research Internationally, Nationally, and In-State

During 2022, MassDOT research projects and findings were shared at international, national, and in-state conference settings. Studies and their key findings and data were presented at the 2022 Transportation Board Annual Meeting held in Washington, DC, and at the American Society of Civil Engineers International Conference on Transportation and Development in Seattle.

2022 TRB Annual Meeting

The 2022 Transportation Research Board (TRB) Annual Meeting was held in person for the first time since 2019. There were approximately 7,000 attendees, and MassDOT was well represented at the poster sessions and the lectern sessions. MassDOT-funded projects and sessions where MassDOT staff presented covered a wide range of transportation projects, including but not limited to:

- Making Safe Systems a Reality: Planning to Implementation
- Legal Considerations of Renewable Energy Production in State Right-of-Way
- Safety of Motorcyclists and Active Transportation Modes
- High-Value Research at State DOTs: Sweet 16
- Transit Signal Priority Innovation, Research, and Performance Measurement
- Poster Session: Emerging Research on Shared Micromobility
- Poster Session: Managing the Response of Transportation Agencies to Disruption
- Poster Session: Advances in Understanding About Bicycle Safety, Modeling, and Behavior

Research & Innovation Webinar Series, October 2021–September 2022

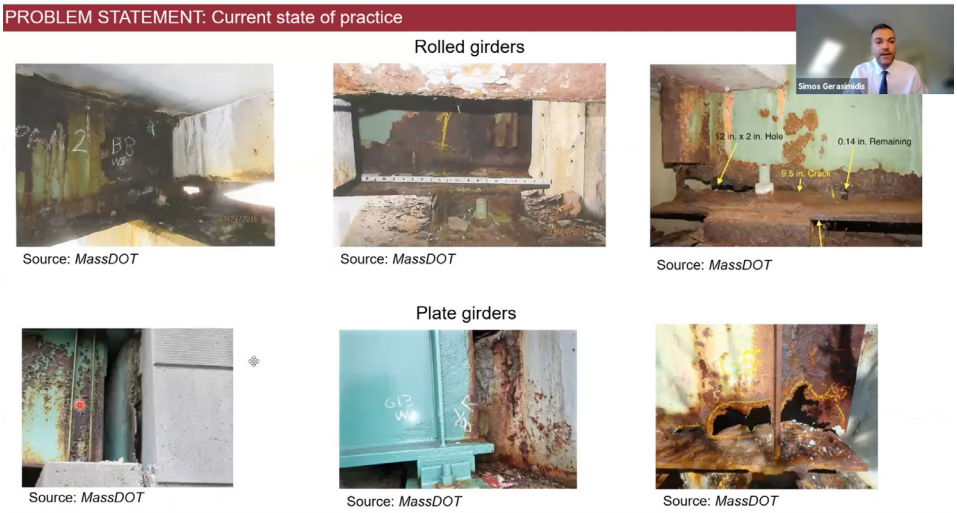
The Innovation Webinar series started in 2020 to share information on important innovative transportation initiatives, technologies, and projects to a local and national audience. In 2020, abstracts from the postponed in-person Innovation Conference were used to create an eight-webinar series. In FFY22, the Innovation Webinar series continued with a greater focus on MassDOT-funded research. Three webinars were held during the year:

- Developing Improved Load Rating Procedures for Deteriorated Steel Bridge Beam Ends

- Tools for Crash Data Analyses and Developing the Massachusetts Strategic Highway Safety Plan

- Evaluating the Safety Impacts of Flashing Yellow Permissive Left-Turn Indications in Massachusetts

The webinar series had a total of 711 attendees across the three webinars, with attendees representing MassDOT, FHWA, municipalities, regional agencies, the private sector, academia, and at least 12 other state DOTs. Feedback received from attendees was very favorable.



"The information presented here is very practical to the work we perform on a regular basis."

"Important research topic."

— Developing Improved Load Rating Procedures for Deteriorated Steel Bridge Beam Ends

"The webinar was very helpful and informative."

"This webinar showed concrete evidence that safety has been improved by comparing the number/types of crashes and injuries before and after FYA implementation at various intersections."

— Safety Impacts of Flashing Yellow Permissive Left Turn Indications

Training the Next Generation of Transportation Professionals (PI Survey Results)

All MassDOT-sponsored research projects, when performed by universities, have involved graduate students, the next generation of transportation professionals on one level or another. Through hands-on activities such as data gathering, literature review, lab testing, field research, data analysis, and developing and calibrating computational models, they are continuously exposed to designing research, choosing methodologies, conducting research investigations, drawing conclusions, and presenting results effectively. With this hands-on experience and having some of the PIs incorporate their research project objectives, data, and key findings into their curriculum, the groundwork continues to be laid for developing qualified new transportation professionals.

Identifying Additional Research Efforts

Over 40 percent of the PIs for the research studies completed in 2021 reported that the findings of those projects then led to additional research efforts. Research activities, by their very nature, are to explore the unknowns. The initial investigation of a posed problem often leads to the identification of an empirical knowledge and tool gap to address the problem and the careful mapping of necessary next steps to arrive at an implementable solution. As such, the results of some of the preliminary research projects became the foundations for subsequent research efforts. The collaborative relationship, client-centered mentality, and solution-driven outlook all made it possible to merge practitioners' perspectives and real-world experiences with academic researchers' expertise and knowledge into multi-phased research efforts that lead to ultimate adoption and deployment of research results.

Relatedly, several MassDOT research projects presented in this report share a common technology theme: using LiDAR and computer vision technology to automate network-level transportation asset data collection and processing. Following the successful pilot study of automating the sidewalk and curb ramp inventories and condition evaluation on the 218-mile Massachusetts State Route 9, this technology was subsequently applied in other research projects to explore the feasibility of automating the gathering and analyzing of crucial location and condition data for other types of assets such as guardrails and pavement markings, and for analyzing design and safety characteristics for horizontal curves and bike boxes. Armed by the research results, MassDOT is in the process of purchasing its own LiDAR equipment to mount to its pavement condition monitoring truck for creating and updating comprehensive state-wide asset inventories and condition assessments.

Technology Transfer and Training Services

In FFY22, MassDOT State Planning and Research Funds Part II were used to fund training activities delivered through both the Massachusetts Local Technical Assistance Program (LTAP, branded as Baystate Roads) and MassDOT Training Services (MTS, technical training services to MassDOT Highway Division).

FFY22 was another year of transition within the Technology Transfer and Training Services. Initial COVID-19 restrictions continued to challenge training options with a variety of training formats and support materials provided, including virtual classrooms, blended learning, online training, and webinars. This was followed in the last five months by a gradual return to face-to-face training, an option that had not been provided for over two years.

In addition to pandemic social restrictions, having a variety of learning options provides learning opportunities for a variety of learning preferences and schedules. Face-to-face (F2F) training works best for some; others prefer the convenience of a live virtual class. A self-paced approach provides the most flexibility, whether working through a structured online course, linking to reading, watching videos, or listening to related podcasts. While classroom training was limited until the third FFY quarter for LTAP participants, various training approaches continued to allow access for a variety of learning styles and needs, with ongoing public safety efforts in mind.

The remote training formats referenced above can be defined as:

Virtual classroom: Live training via an online platform (e.g., Zoom). Classes may be condensed or broken into several presentation dates to complete.

Online: Self-paced modules completed independently online.

Blended learning: A combination of approaches such as completion of online modules followed by a classroom or virtual class.

Webinar: A one-hour presentation conducted on a virtual platform (e.g., Zoom).

Overview

During FFY22, Baystate Roads (BSR) provided 116 training sessions on 79 topics to cities and towns across the Commonwealth. Overall, the number of BSR classes reduced slightly this year (-3%) from the FFY21 total of 120.

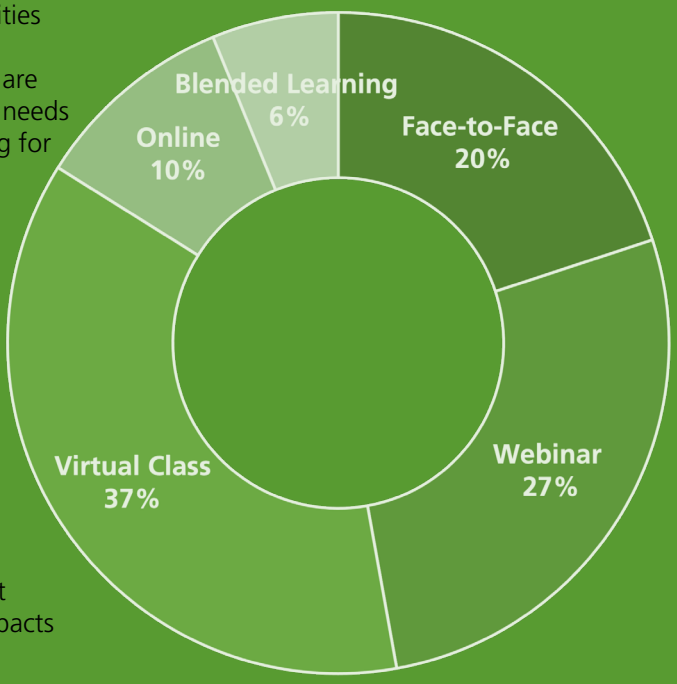
The technical training needs of the MassDOT Highway Division personnel continued being addressed through MassDOT Training Services (MTS). A total of 83 classes were conducted in FFY22, reflecting an increase of 8 percent (six classes) over FFY21 numbers

Baystate Roads and LTAP

The Massachusetts Local Technical Assistance Program (LTAP) provides training and technical resources to the 351 municipalities across the Commonwealth. Through the development and implementation of annual and quarterly training plans, classes are offered to municipal personnel and contractors based on local needs and MassDOT priorities. Statewide training and specific training for individual municipal groups is provided by a technical training specialist and a variety of additional professional instructors.

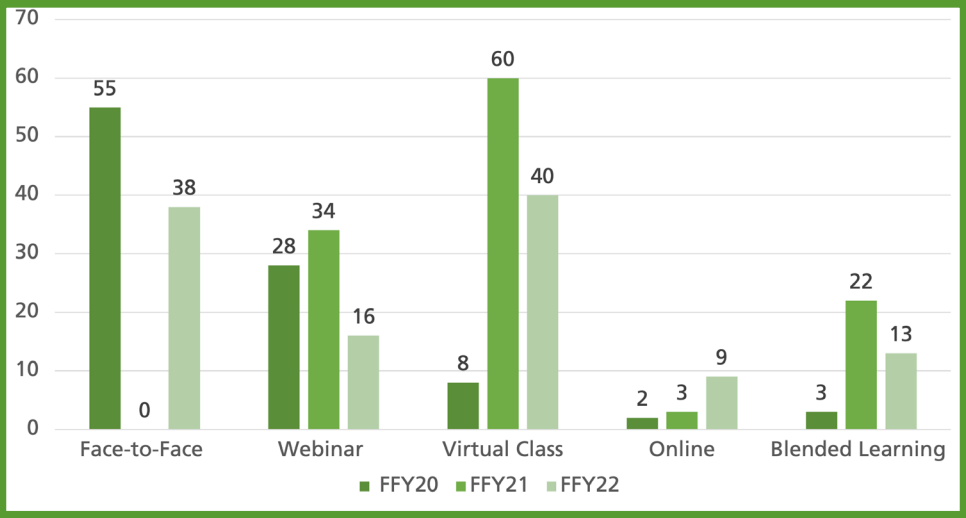
The gradual process of adding F2F training during the FFY22 fourth quarter also included a gradual return on the part of the training audience. Many prior participants had become accustomed to virtual training. Smaller F2F classes this year resulted from providing training to individual communities, due to ongoing pandemic conditions, and because fewer people were traveling to statewide classes. The pie chart below shows the percentage distribution of the five training formats for 116 LTAP classes:

LTAP FFY22
Participants By Format



The bar graph below shows the LTAP individual training format changes over the past three years, reflecting the COVID-19 impacts on training, Massachusetts LTAP's response, and the gradual recovery.
The pre-pandemic focus was on F2F training, with a quick change to (Stump the Instructor) webinars in the spring/summer of 2020. F2F training dropped to zero in FFY21, and then reemerged in FFY22. Virtual, online, and blended remote options were small components of the FFY20 schedule but were the primary training approaches during the pandemic. Returning to F2F training in FFY22, some remote option class numbers were reduced while online training showed slow continuing growth as more options were added to the learning management system.

LTAP Training Format Change Over Time

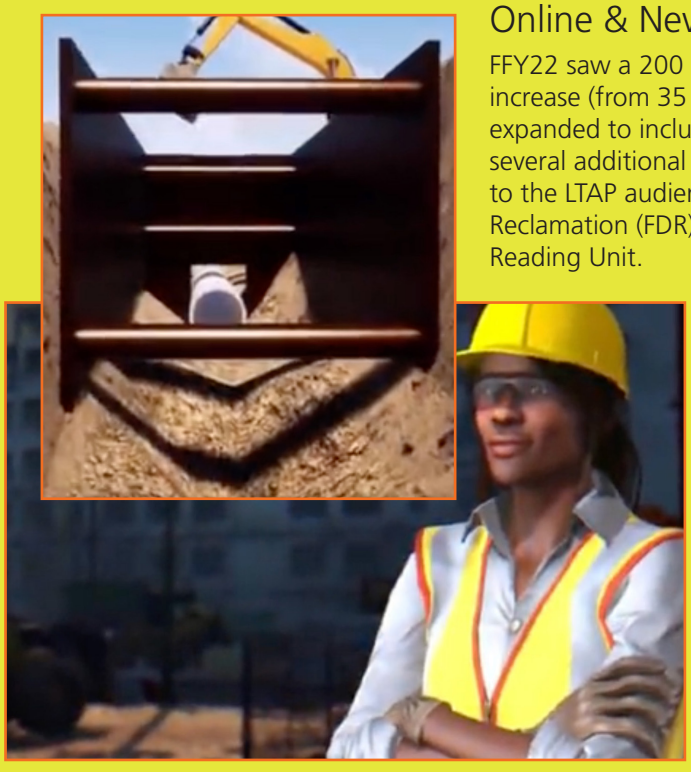


Baystate Roads—Hot Topics, Formats, Resources & Highlights

During FFY22, 79 training topics were presented, some in multiple formats (e.g., virtual, F2F, and blended training versions of a pavement preservation or grader training topic). Of these, 35 (44%) were new topics or sub-topics addressing local roadway safety, construction, design, maintenance and operations, and workforce development. A complete list of training subjects and formats is included in the report appendix.

Face-to-Face (F2F) Training Highlights

F2F training initially focused on smaller groups, safety topics, and outdoor training options, including various classes on Chainsaw, Bucket Truck Safety & Operation, Wood-Chipper Operation & Safety, Work Zone Safety, Class 2A and 4G Hoisting, and Concrete Sidewalk Construction. Thirty-eight classes were provided this year, attended by 497 people for an average of 13 participants per class.



Online & New On-Demand Highlights

FFY22 saw a 200 percent increase in classes available and a 606 percent increase (from 35 to 247) in participation. Online multi-module training expanded to include resources provided by other educational groups. This year, several additional self-paced AASHTO TC3 courses were also made available to the LTAP audience, including Cold In-Place Recycling (CIR), Full-Depth Reclamation (FDR), Hot In-Place Recycling, Intro to GIS Mapping, and a TC3 Plan Reading Unit.

Eighty-one people registered for the Traffic Signal Warrants: How to Perform, Assess, and Satisfy the Requirements of Each and FAA Drone Pilot Exam Prep courses.

SafetySkills

Accruing a shorter time demand, new online resources also included contracting with SafetySkills to provide 13 micro-training interactive graphic video segments. Partnering with the UMass Blackboard learning management system allowed viewing of this SCORM-compliant content. Topics this year included a variety of chainsaw, excavation, and hot box welding topics, a subscription that continues through part of FFY23.

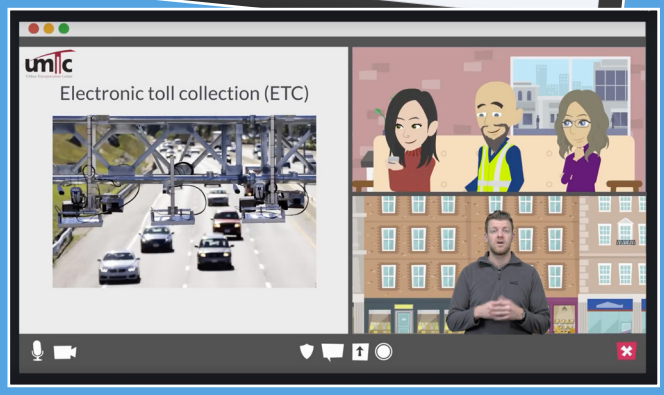
Additional Resources

The development of additional resources continued this year, providing material for other information needs and learning preferences. The Transportation Take-Away series evolved to become the shorter (micro-training) Transportation Terminology series, providing an entertaining animated format to educate viewers about transportation engineering and planning terms and concepts. New FFY22 topics covered included:

- Mobility as a Service (MaaS)
- Transportation on Demand (ToD)
- Complete Streets
- Congestion Pricing
- Bus on Shoulder (BoS)
- Intelligent Transportation Systems (ITS)
- Transportation Demand Management (TDM)
- Accelerated Bridge Construction (ABC) Include links to Complete Streets and ITS segments

Resource Sheets developed or updated in FFY22 included:
- Funding Resources Funding Resource Sheet.pdf
- MS4 Resources MS4 Resource Sheet_0922.pdf

The ongoing development of various training and support options continues to expand the Baystate Roads toolbox as in-person training resumes.



Virtual Classroom Highlights

Complete Streets

The MassDOT Complete Streets initiative continued this year with the provision of nine virtual classroom sessions attended by 189 participants. The series included the required 201: Designing Your Streets for People class, as well as six of the 300-level classes:

- 301: Transit Street Design
- 302: Safety Countermeasures
- 303: Bicycle/Pedestrian Network Planning
- 304: Traffic Calming Design
- 305: Workshop Design
- 306: Public Engagement

While geared toward municipal staff, local officials and private consultants working closely with Complete Streets found the courses helpful as well. Participant breakdown this year identified attendance as 66 percent public, 30 percent private sector and 4 percent MassDOT personnel.

Blended Learning Highlights

Grader Operator Training

With the availability of F2F training this year, we were also able to provide all three portions of a new blended Grader Operator class, including: two online modules, a virtual meeting with the instructor, and hands-on training. This tri-blended option was completed by 13 participants in FFY22 and an additional eight who began the process in FFY21 but had been unable to meet for the hands-on portion. Responding to whether they had any comments or suggestions to improve the training, participant feedback included, "No, it was everything I felt I needed to help me maintain our dirt roads and keep them safe for travel."

See the Gauging the Impact of Training section for additional series evaluation information.

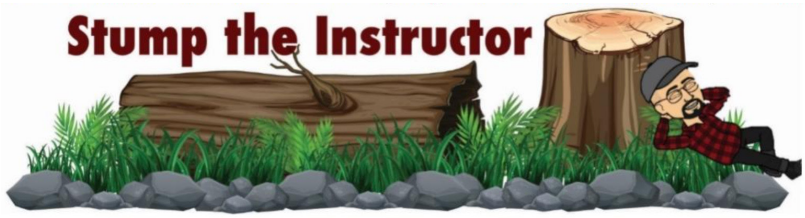
Flagger/First Aid Certification

Most blended learning classes continued to be for the combined Flagger & First Aid certification training, redesigned in FFY21, in which training is provided virtually followed by an online certification test on the UMTC learning management system. Ten of these blended Flagger/First Aid Certification courses were presented this year and attended by 129 participants. An additional three classroom versions brought total attendance to 167, with a passing exam rate of 99 percent (165).

Webinar Highlights

Stump the Instructor

During FFY22, Baystate Roads presented 16 Stump the Instructor (STI) episodes, attended by 678 participants. Kicking off shortly after the pandemic started, the series provided the public works audience a means to connect with Baystate Roads personnel, subject matter experts, MassDOT representatives, and each other. Although presentation numbers decreased this year as F2F and additional remote options grew, the series continues as another outreach method and quick-hit training tool.



"I love the Stump the Instructor topics—not time-consuming yet extremely helpful."

"Great refresher and there was a ton of conversation during this Stump … Nice job, Brenda and Mike."

"The forum is very open and responsive. I believe everyone is being heard."

FFY 2022 Training Topics Provided

Face-to-Face (21/1*)

Bucket Truck Safety & Operation
Chainsaw Maintenance
*Chainsaw Safety and Storm Damage Awareness Training
Chainsaw Skills & Safety
Chainsaw Storm Debris Cleanup
Class 2A and 4G Hoisting CEU
Class A CDL Program
Class B CDL Program
Concrete Sidewalk Construction
Confined Space
Flagger/First Aid Certification
Maintaining Your Roadways with Pavement Preservation
Municipal Culvert Assessment
NHI-135027 Urban Drainage Design
OSHA 10
Snow and Ice Operations for Front-Line Employees
Street Tree Essentials
Trenching & Excavating Safety: Competent Person
Welding Safety and Operation
Wood Chipper Operation & Safety
Work Zone Safety

Virtual Classroom (27/7*)

Capital Budgeting
Class 2A and 4G Hoisting CEU
Complete Streets 201: Designing Your Streets for People
Complete Streets 301: Transit Street Design
Complete Streets 302: Safety Countermeasures
Complete Streets 303: Bicycle/Pedestrian Network Planning
Complete Streets 304: Traffic Calming
Complete Streets 305: Workshop Design
Complete Streets 306: Public Engagement
Design of ADA Curb Ramps and Pedestrian Access Routes
Drainage—Roadway Maintenance and Reconstruction
Effective Beaver Management
*Erosion Prevention and Sediment Control Best Management Practices
*Illicit Discharge Detection & Elimination (IDDE) Training for MS4 Permitting
Maintaining Your Roadways with Pavement Preservation (Two-Part)
MaPIT 3.0
Municipal Operating Budget
OSHA 10
Roundabouts Series:
- *Roundabouts #11—Multilane Roundabouts and Special Considerations
- *Roundabouts #12—Signage & Markings
- *Roundabouts #13—Construction & Operations
- *Roundabouts #14—Simulation

Snow and Ice Operations for Supervisors
Snow and Ice Operations for Front-Line Employees
*Structural Stormwater BMP Operations and Maintenance under MA MS4 General Permit—Virtual
Trenching & Excavation Safety: Competent Person
Wood Chipper Operation & Safety

**Indicates new topic or training redesigned for a new presentation format*

Webinars

Stump the Instructor

*Been There and Bid That!
*Best Practices for Cement Concrete Sidewalk Materials and Construction
Calibration is Key!
*CDL Entry-Level Driver Training Requirements: Are You Ready?
*Cops, Contracts, and Contractors
*Equipment Inspection and Operation
From Brine to Beet Juice and Everything in Between
*Future of Commonwealth's Curbs
Grader Operations
Gravel Roads 101
Gravel Roads 201
Snow and Ice Jam Session
*So, You Had a … Flood, Major Snow Event, Windstorm. Now What?
*Public Works Mutual Aid
Trench Safety Month Kick-Off
Spring is in the Air and Mud is Coming for Your Roads

Blended Learning (3/1*)

Confined Space Training
Flagger/First Aid Certification
*Grader Operator

Online/On-Demand (21/18*)

*AASHTO TC3 Cold In-Place Recycling (CIR)
*AASHTO TC3 Full-Depth Reclamation (FDR)
*AASHTO TC3 Hot In-Place Recycling
*AASHTO TC3 Intro to GIS Mapping
*AASHTO TC3 Plan Reading Unit
Traffic Signal Warrants: How to Perform, Assess, and Satisfy the Requirements of Each
FAA Remote Pilot Exam Prep
Rigging and Load Securement
* SafetySkills—Chainsaw Safety
*SafetySkills—Chainsaw Safety: Safe Operations
*SafetySkills—Excavation and Trenching: Hazards
*SafetySkills—Excavation and Trenching: Requirements
*SafetySkills—Excavation and Trenching: Hazard Controls
*SafetySkills—Excavation and Trenching: Roles and Responsibilities
*SafetySkills—Excavation and Trenching Competent Person: Excavation Hazards
*SafetySkills—Excavation and Trenching Competent Person: Preplanning Excavations
*SafetySkills—Excavation and Trenching Competent Person: Protective Systems
*SafetySkills—Excavation and Trenching Competent Person: Roles and Responsibilities
*SafetySkills—Excavation and Trenching Competent Person: Soil Classification
*SafetySkills—Hot Arc Welding: Employee Responsibilities
*SafetySkills—Hot Arc Welding: Hot Work Hazard Controls

**Indicates new topic or training redesigned for a new presentation format*

MassDOT Training Services (MTS)

Massachusetts Department of Transportation Highway Division personnel training needs were addressed by the MassDOT Training Services (MTS) to a greater extent in FFY22. A total of 84 classes were conducted, an increase of 9 percent over FFY 2021 numbers. Participant numbers grew from 1,609 to 1,916 (19%).

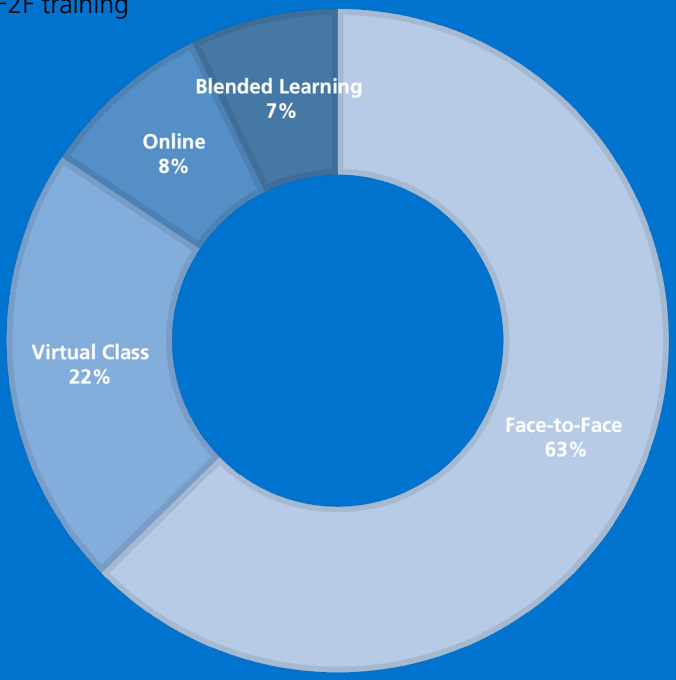
MTS continued to offer a variety of training approaches in FFY22, including virtual classroom and blended learning classes, online self-paced courses, and a return to face-to-face (F2F) training. The number of both blended classes and virtual classes decreased in FFY22 as more resources went into F2F training

New Topics, Formats, and Resource

During FFY22, MTS presented 37 unique training topics, of which 22 (59%) were new topics, including bridge software and inspection, GIS, GPS, highway and bridge construction specifications, intersection design and operation, and professional accreditation and refresher courses. A complete list of training subjects is included in the report appendix.

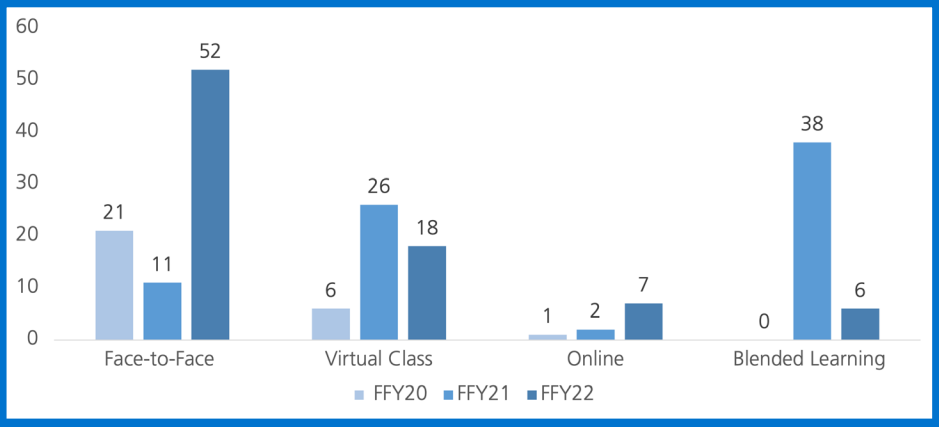
The chart identifies FFY22 session and participant numbers for each training format, FFY21 data (in blue), and the annual percentage changes.

In FFY21, there were few F2F courses because of the COVID-19 pandemic. In FY22, as COVID-related restrictions diminished, F2F courses returned, with F2F training constituting 63 percent (52) of MTS classes and 53 percent (1,019) of MTS course participants for the year overall. Virtual classroom training remained a highly employed option as well, with 18 classes, a total participation of 623 (33 percent of the FFY22 total), and an average of 35 participants per class.



MTS FFY22 Participants by Format

Training Approach	# Trainings Provided FFY2022 [FFY2021]	# Participants FY2022 [FFY2021]	% Change # Trainings FFY2021-22	% Change # Participants FFY2021-22
Face-to-Face	52 [11]	1019 [157]	373%	549%
Virtual Classroom	18 [26]	623 [816]	-31%	-24%
Blended Learning	6 [38]	118 [623]	-84%	-81%
Online	7 [2]	146 [13]	250%	1023%
TOTAL	84 [77]	1906 [1609]	8%	18%



MTS Training Format Change Over Time

Several substantial new efforts were added to the MTS training arsenal, including:

- New England Transportation Training Certification (NETTP) training courses
- Northern New England Concrete Association/American Concrete Institute certification training
- A variety of railroad right-of-way safety training

Personnel requiring these materials and safety certifications are not tracked individually, so are not included in the above chart, but represented 50 percent of MTS spending this federal fiscal year.

FFY22 MTS Highlights

Highlights this year included a new Project Manager training certification course to promote management efficiencies and to ensure a solid base of knowledge on MassDOT processes and procedures (especially among less experienced Project Managers). Another highlight was the return to face-to-face classes for safety training needs.

Virtual Classroom Highlights

Project Manager Certification Training

The MassDOT Project Manager Certification training series was offered for the first time in the spring of 2022. The virtual classroom series consisted of 17 total training hours over seven days. The series included 44 presenters covering a variety of topics important for Project Managers to be familiar with. Among these topics were: MassDOT's organizational structure; project initiation, advertising, and funding; consultant selection and contracts; bid and construction phases of projects and the use of design-build; state right-of-way, interagency coordination, reference documents, and public outreach. A total of 109 people participated in at least one of the training sessions, and 55 percent (61 people) completed all the training hours. All sessions were recorded and made available to all MassDOT employees through the MassDOT Learning Hub. Makeup sessions of the training will be offered in Fall 2022.

Face-to-Face Highlights

Safety Training

Returning to F2F training (as public health conditions allowed) enabled MTS to assist with a backlog of new employee safety training and seasoned personnel refresher topics, including Bucket Truck Operation & Safety, Large Mower Operation & Safety, Woodchipper Operation & Safety, Load Securement & Rigging, Work Zone Safety, Chainsaw Safety (three different training courses offered), and OSHA10 training. In FFY2022, these F2F safety classes had a combined total of 708 participants.

Training Topics

Topics presented this year included numerous safety, construction, maintenance, and design options. Listed by presentation approach (some were available in more than one format), * indicates new FFY2022 topics.

Virtual Classroom (11/8)

*BSCES Professional Engineer Refresher Course-MTS
Design of ADA Curb Ramps & Pedestrian Access Routes
*Drainage Design—Roadside Maintenance & Reconstruction
*FE Exam Prep Course
*Introduction to SIDRA (Intersection Software Program)
*MassDOT Project Manager Certification Training
*NHI-131139V—Constructing and Inspecting Asphalt Paving Projects
OSHA 10
*Safety Awareness Training (OSHA 10 Awareness Level)
*SIDRA Fundamentals (Awareness Level)
Trenching & Excavation Safety

Online/OnDemand (7/7)

*AASHTO TC3 Aggregate Sampling Basics
*AASHTO TC3 Erosion and Sediment Control for Construction
*AASHTO TC3 Global Positioning Systems (GPS)
*AASHTO TC3 Introduction to GIS
*AASHTO TC3 Micropile
*Asphalt 101
*WPS/PQR (Welding Procedure Specifications/Procedure Qualification Record) Explained

Blended Learning (4/1)

Work Zone Safety for Construction Field Personnel
Work Zone Safety for Construction Supervisors & Foremen
*MA Construction Supervisor License CEUs
Work Zone Safety for Maintenance Supervisors & Foremen

F2F Training (22/6)

*ATSSA Guardrail Installation Training
Bucket Truck Operation & Safety
Chainsaw Maintenance
Chainsaw Safety & Storm Damage Awareness
Chainsaw Skills & Safety
Highway/Construction Survey
Large Mower Operation & Safety
NHI-130055—Safety Inspection of In-Service Bridges
NHI-130091—Underwater Bridge Inspection
NHI-130081A—LRFD for Highway Bridge Superstructures
NHI-130108—Bridge Maintenance

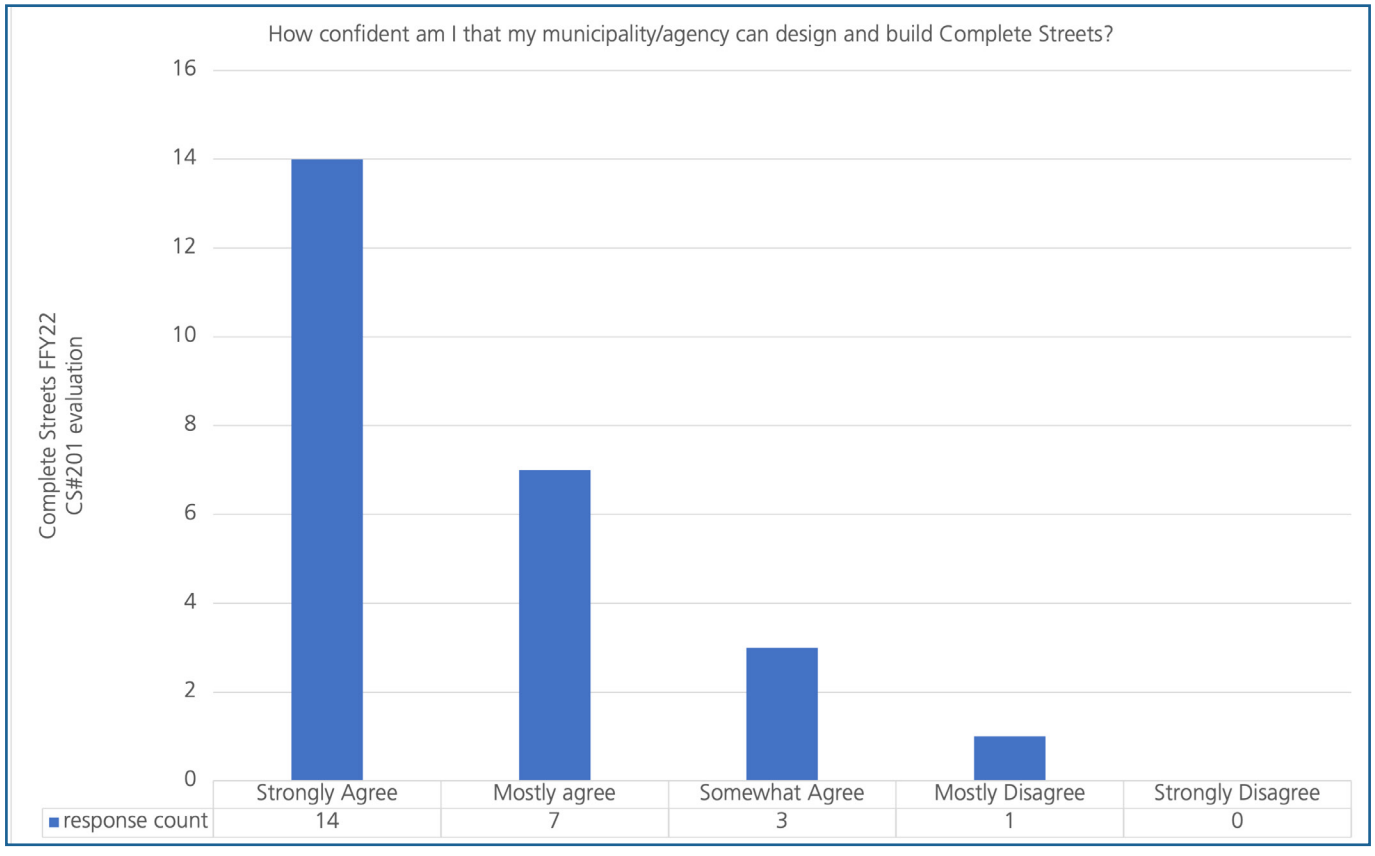
F2F Training (22/6) *(continued)*

*NHI-131141—Quality Assurance for Construction Projects
*NHI-132042—Design of Mechanically Stabilized Earth Walls & Reinforced Soil Slopes
*NHI-132078—Micropile Design & Construction
*NHI-134067—Construction Inspection of Bridge Rehabilitation Projects
*NHI-135082—Highways in the Coastal Environment
NHI-135056—Culvert Design
OSHA 10
Rigging & Load Securement
Wood-Chipper Operation & Safety
Work Zone Safety for Maintenance Field Personnel
Work Zone Safety for Maintenance Supervisors & Foremen

Gauging the Impact of Training

To assess training applications on the job, the Training Program and LTAP conducted an Annual Needs Survey. Results showed that of the 102 responses, 70 percent of attendees participated in training or received other resources provided by the LTAP center. Of these responses, 90 percent affirmed information/skills application. LTAP—Complete Streets Training.

In FFY22, Complete Streets training topics were attended by 189 people and included seven virtual classes and six topics. The first of these is a required class before communities can apply for Complete Streets state funding. Application starts with confidence, a characteristic that Complete Streets 201 evaluations ask participants to rank: I am confident that my municipality/agency can design and build Complete Streets. Twenty-five participants attended the Complete Streets 201 class, with the following Level 1 evaluation response.



MTS—Project Manager Certification

A post-training survey was sent out three months after the completion of the spring Project Manager Certification training series. It went to all participants who had attended at least six of the eight session series. Of the responses received answering the question "How valuable was the information you learned during the Project Manager series," 90 percent reported that the training was either "Extremely valuable" (50%) or "Very valuable" (40%). Additionally, 95 percent of respondents said that they would recommend the training series. Comments from individuals included:

"It overall improved my knowledge of the whole project development process."

"Knowing where to look for information is extremely valuable. Being able to quickly identify the next step in the process is helpful so that I can find the appropriate SOP and prepare for next steps."

"I reference Larry Cash's presentation about preparing a project for advertisement all of the time."

LTAP—Grader Operator Training

Six months after completing the Grader Operator class, a three-question Level 3 evaluation (application) was developed and distributed to the 21 participants. Of the 21, nine replied, for a response rate of 43 percent. The survey focused on participant self-assessment of skill levels for three key grader operator training objectives:

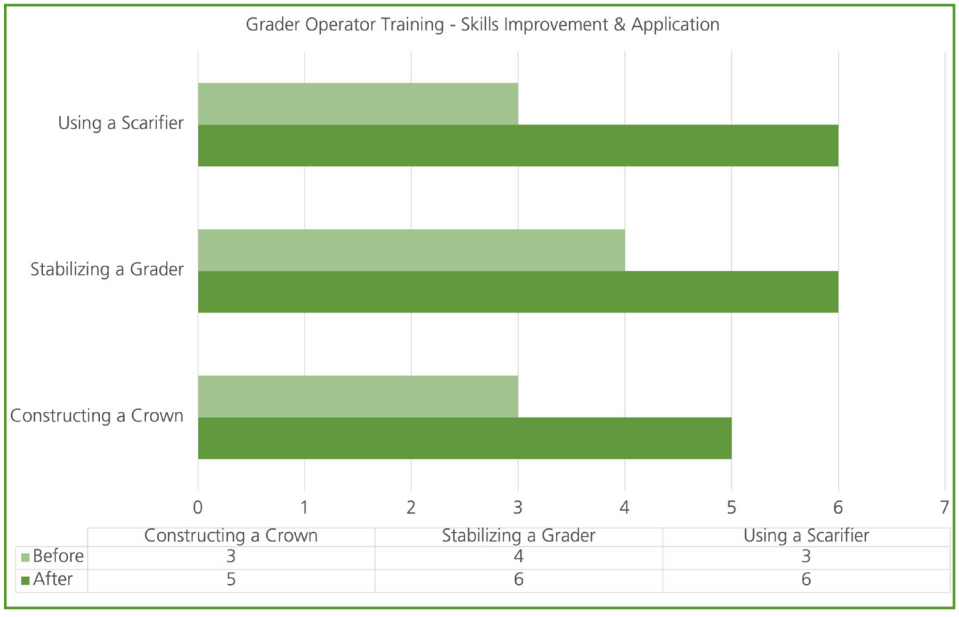
1. Construction of a tangential crown on a road.

2. Application of grader stabilization techniques.

3. Ability to use a scarifier to prepare gravel surfaces prior to grading.

On a scale of 0-7, prior training mean skill levels were assessed at a Level 3 for construction of a tangential crown and use of a scarifier, and 4 for the application of grader stabilization techniques.

After completing the class and applying the class information and skills learned on the job, their self-assessed mean skill levels improved by 40 percent in the construction of tangential crowns, 33 percent in application of grader stabilization techniques, and 50 percent in the ability to effectively use a scarifier.



	Constructing a Crown	Stabilizing a Grader	Using a Scarifier
Before	3	4	3
After	5	6	6

Public Outreach: Providing Assistance and Identifying Needs

LTAP center impact includes not only training participation, but the variety of outreach opportunities provided. Baystate Roads fosters connections with municipal peers and organizations, allowing opportunities for public input and training needs identification. Several approaches provided these opportunities in FFY2022, including continued participation at a variety of local and regional meetings and events such as the New England Public Works Exposition, New England APWA Snowplow Roadeo, MassHighway Association Driver Skills & Backhoe Competition, and local county association meetings. All afford the opportunity to share information on new training and resources, LTAP marketing materials (image of new Baystate Roads brochure), and identification of performance gaps for future assistance. More formal needs identification approaches include information gathered from Advisory Committee meetings, class evaluations, annual needs surveys, and MassDOT initiatives.

Technical assistance is the heart of any LTAP center. In FFY22, Baystate Roads responded to over 50 direct requests. Phone calls and email were primary communication methods previously—and still viable options—but the Baystate Roads listserv has become a preferred technical assistance approach for many. Providing feedback and problem-solving input from both peers and LTAP specialists, the FFY2022 listserv conversations and informational posts covered a wealth of topics, including multiple employment posts, information on funding opportunities, human resources and contracting questions, material specs and applications, and additional learning opportunities. A complete list follows this section.

The M3 newsletter provides another opportunity to connect with and engage the municipal audience. Content this year included information on Complete Streets awards, CDL applicant requirements, the $1.2 trillion federal highway bill, Baystate Roads courses and resources, the FHWA Rural Roadway Departure Countermeasure Pocket Guide, best practices for concrete sidewalk construction and materials, other MassDOT initiatives, upcoming conferences and events, new Baystate Roads Scholars, transportation research, and specific topics of interest to the DPW community. M3_Quarterly_Summer2022V4.pdf; M3 Quarterly_Winter2021_V2wLinks.pdf Newsletters.

Continued participation in National Local Technical Assistance Program Association (NLTAPA) and industry training events allows sharing of products, services, and new instructor identification. FFY2022 events were attended remotely as well as in-person, including the NLTAPA virtual winter business meeting, regional meeting, and annual conference in Seattle.

FFY22 ListServ Posts

- Employment Postings—19 communities advertised here this year, some multiple times
- Funding information and opportunities:
  - Hazard Mitigation Assistance Grant Programs (FEMA)
  - Culvert Replacement Municipal Assistance Grant Program
  - Baker-Polito Administration's "HireNow" Hiring and Training Employer Grant Program
  - Upcoming USDOT Funding Opportunity
- Hiring, contracting, and HR questions:
  - New position job description assistance
  - Sick days
  - Hired contract rates and incentives
  - Sample performance reviews & comparison wages for superintendents
  - Snowplow Operator Staffing Survey request
  - Help compiling a list of firms
  - Purchasing page snow contracts link
  - Snow and ice contracts
  - Template for memorandum of understanding
  - Spec for "day rate"
  - LED streetlight maintenance contract
- Materials, Specs, & Procedures:
  - Road opening and trench patch requirements
  - PFAS and secondary water supply
  - Procedures for establishing speed limits on town owned roads
  - Flowable fill on road opening permits
  - Street sweeping/catch basin cleaning removal
  - Chip seal pricing
  - Integral curb and gutter
  - Road opening permits
  - Reclaiming and paving
  - Seal coating of asphalt surfaces
  - Pavement management policy
  - Dry hydrant installation guidelines
  - 2020 MassDOT concrete sidewalk specifications
  - Leachate removal services—RFP
  - Generic DPW ConCom order of conditions
  - Plowing—"black pavement"?
  - Project management software
  - Parking kiosks
  - Beaver trappers
  - DCR salt brine video
  - Weather service
  - 25 mph safety/speed zones—modernization act
- Additional Learning Opportunities:
  - Upcoming UMTC conferences and events
  - FY22 local hazard mitigation planning pilot program
  - NEAPWA call for presentations—2022 educational sessions
  - New asphalt academy program
  - DigSafe training
  - Internship position
  - Entry-level CDL training

MassDOT Conferences

In FFY22, MassDOT hosted its two annual transportation conferences, Moving Together and the Transportation Innovation Conference. The Moving Together Conference was held virtually; the Innovation Conference returned to an in-person format for the first time since 2019 and offered a virtual attendance option as well.

The virtual and hybrid conference formats used during FFY22 helped attract a wider geographic distribution of attendees from outside of Massachusetts and New England. The virtual and hybrid formats also promoted equity and inclusion by making the conferences accessible to people for whom attending in person would be a challenge for logistical or health reasons. After each conference, the recordings of the keynote and presentation sessions were shared initially with conference attendees and then later were made publicly available.

Moving Together - December 7-9, 2021

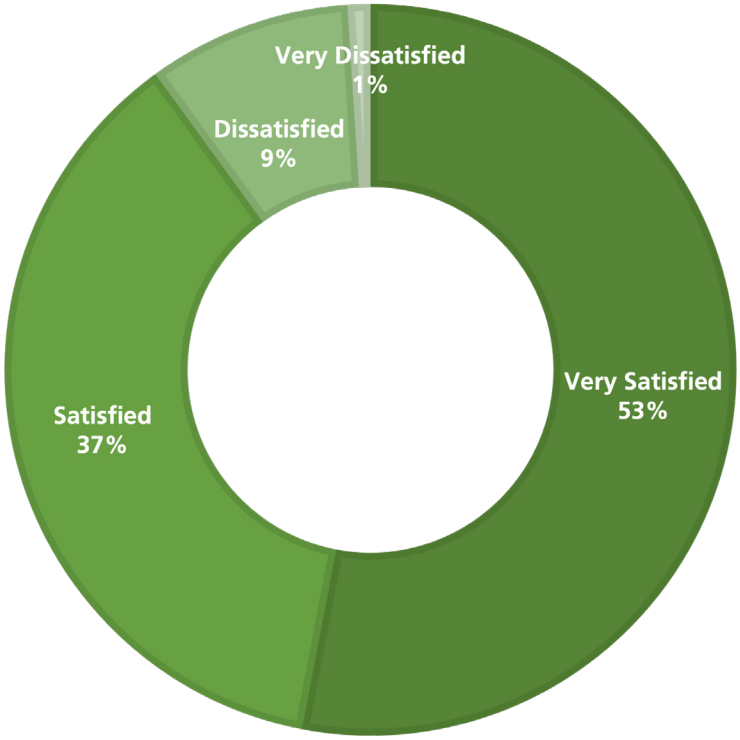
The 21st Annual Moving Together Conference was held virtually on December 7-9, 2021. Each year, Moving Together highlights current walking, bicycling, and public transportation topics and projects. Just over 1,000 people registered for the conference, including from Massachusetts, 23 other US states, the District of Columbia, Canada, and the Netherlands. The conference had keynote speakers each day, 24 panel sessions, virtual site visits to six trail projects in Massachusetts, and 31 sponsors with booths in the virtual exhibit hall.

As has been the tradition at past Moving Together Conferences, the Massachusetts Secretary of Transportation and MassDOT chief executive officer provided the keynote address and granted awards to recognize the best entries in the annual Safe Streets Smart Trips High School Video Contest. Besides Massachusetts secretary of transportation Jamey Tesler, other keynote speakers included Jonathan Gulliver, MassDOT Highway Administrator; Todd Litman, Victoria Transport Policy Institute (Victoria, British Columbia); Sara Studdard, People for Bikes (Boulder, Colorado); Jennifer Dill, Portland State University (Portland, Oregon); and Jeff Speck, Speck & Associates. There were still many presenters highlighting projects from Massachusetts and New England. However, the virtual format supported a number of projects from further away being featured as well, including from the Netherlands, Toronto, Montreal, Los Angeles, Jackson Hole, Minneapolis, Fort Lauderdale, Raleigh, and Washington, DC. In the post-conference survey, 53 percent of respondents indicated that they were "Very Satisfied" with their experience at the conference; 37 percent were "Satisfied." The full conference program is provided in the appendix of this report

Total Registrations.. 1,002

112 attendees responded to the conference evaluation

Overall how would you rate your experience at this conference?



Transportation Innovation Conference, May 24-25, 2022

The Transportation Innovation Conference took place on May 24-25, 2022, at the DCU Center in Worcester, Massachusetts. The annual Innovation Conference provides a forum for sharing knowledge and ideas on innovative transportation initiatives, technologies, and systems. There were 1,180 people who registered for the conference, with 879 signing up to attend in person and 301 attending virtually. Conference attendees came from Massachusetts, 23 other US states, the District of Columbia, and Canada. In-person attendance was capped below its normal level due to public health reasons. This was the first in-person Innovation Conference since 2019, and the first time MassDOT offered virtual access to attend in-person sessions in real-time.

The conference had 33 panel sessions and 62 sponsors/exhibitors. Two highlights of the conference were the opening plenary talks by Massachusetts governor Charlie Baker and lieutenant governor Karyn Polito. Other keynote speakers included Massachusetts secretary of transportation Jamey Tesler, MassDOT highway administrator Jonathan Gulliver, and MassDOT Highway Division chief engineer Carrie Lavallee. In the post-conference survey, over 70 percent of respondents indicated that they attended both days, and 83 percent said that overall, they had a favorable—either "Good" or "Excellent"—experience at the conference. From the survey comments, it was clear both that many attendees were happy that the conference was back in-person, and that other attendees were grateful that a virtual attendance option was offered as well. A number of the virtual attendees noted that it would not have been possible for them to have attended in person. The conference program is provided in the appendix of this report.

Total Registrations.. 1,180

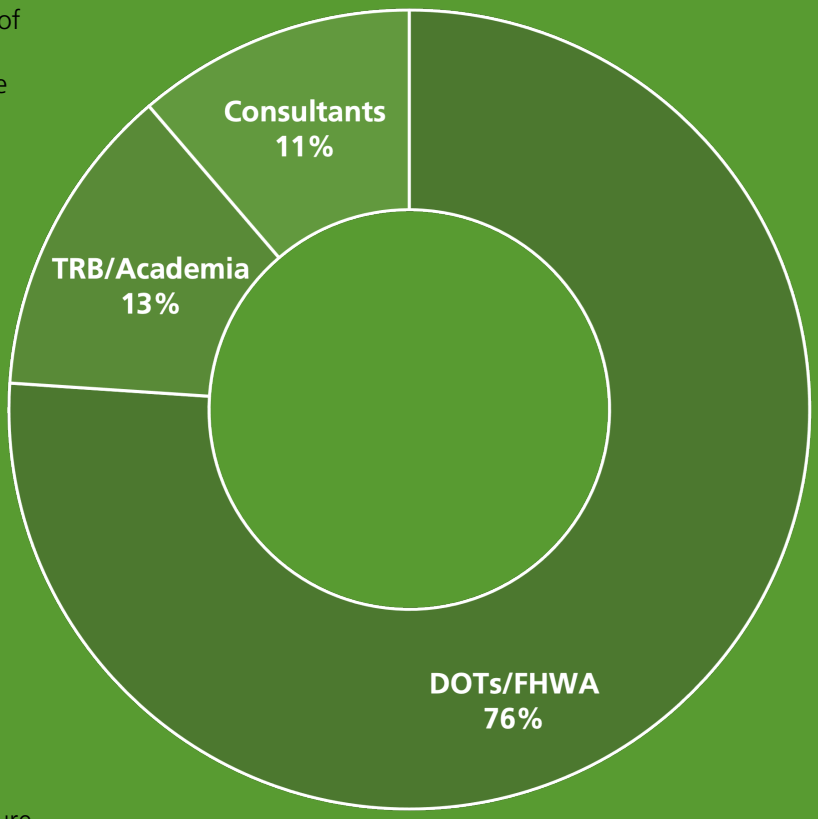
219 attendees responded to the conference evaluation

Overall conference experience

National and Regional Research Collaboration

AASHTO Research Advisory Committee & Transportation Research Board Representatives Annual Meeting

MassDOT hosted the 2022 Research Advisory Committee (RAC) annual meeting in Newton, MA. RAC is the AASHTO Special Committee on Research and Innovation (R&I) that supports the activities of R&I and is committed to being a proactive committee promoting quality and excellence in research and in the application of research findings to improve state transportation systems.



Over four and half days, there were many high-quality presentations, poster sessions, and discussions on the current and future outlook of transportation research. The presentations and discussions included promoting practices that enhance identifying quality indicators, developing methods, practices, and tools that allow for better coordination, and collaboration of research efforts to improve information exchange. The meeting agenda included sessions topics on:

- TRB Research Innovation Implementation Management (RIIM)
- The Transportation Knowledge Infrastructure
- FHWA Accelerating Innovation Programs—What's in it for Your Agency?
- CUTC—Introduction and Successful Technology Transfer Stories
- TRID and Research in Progress (RIP) Update for Research Managers
- High-Value Research
- How to Build an Innovation
- Tour of the US DOT Volpe Center

In total, over 70 people registered for the RAC meeting, with 70 percent of the attendees coming from DOTs.

Transportation Research Board (TRB)

MassDOT staff members participate on a number of Transportation Research Board (TRB) committees to share knowledge of best practices across many different transportation platforms. Many MassDOT employees also serve on TRB-administered research project technical panels, such as National Cooperative Highway Research Program (NCHRP) projects. NCHRP is driven by state DOT research programs addressing common transportation needs. These panels are made up of experienced practitioners and research specialists from across the country, providing technical guidance on transportation research projects selected annually by the American Association State Highway and Transportation Officials (AASHTO) Research & Innovation (R&I) committee. The following two tables summarize the TRB committees and NCHRP project panels on which MassDOT employees currently participate as members

TRB Standing Committees
Standing Committee on Hydrology, Hydraulics, and Stormwater
Standing Committee on Seismic Design and Performance of Bridges
Standing Committee on Quality Assurance Management
Standing Committee on Asphalt Materials Selection and Mix Design
Standing Committee on Contract Law
Standing Committee on Workforce Development and Organizational Excellence
Standing Committee on Performance Effects of Geometric Design
Standing Committee on Aviation Administration and Policy
Standing Committee on Research Innovation Implementation Management
Standing Committee on Data for Decision-Making
Standing Committee on Bus Transit Systems
Standing Committee on Economic Development and Land Use
Standing Committee on Access Management
Standing Committee on Critical Transportation Infrastructure Protection
Standing Committee on Rural, Intercity Bus, and Specialized Transportation
Standing Committee on Alternative Fuels and Technologies
Standing Committee on Safety Performance and Analysis
Standing Committee on Transportation Safety Management Systems
Standing Committee on Airport Terminals and Ground Access
Standing Committee on Economic Development and Land Use
Standing Committee on Community Resources and Impacts
Standing Committee on Strategic Management
Research Advisory Committee (RAC)

NCHRP Project Representation
A Guidebook for Emergency Contracting Procedures for Administration
Access to Jobs, Economic Opportunities, and Education in Rural Areas
ACRP Project Panel on Airfield Pavement Markings—Effective Removal and Temporary Application Techniques
Alternative Technologies for Mitigating the Risk of Injuries and Deaths in the Work Zone
Application of Federal Funding Flexibility at the State DOTs
Assessing the Impacts of Connected, Automated, and Autonomous Vehicles on the Future of Transportation Safety
Bridge Deck Overhangs with MASH-Compliant Railings
BTSCRP Project Panel on the Influence of Infrastructure Design on Distracted Driving
Catastrophic Transportation Emergency Management Guidebook
Development of Guidance for Nonstandard Roadside Hardware Installations
Effective Use of Duplex Coating Systems to Improve Steel Bridge Structure Durability
Emerging Challenges to Priced Managed Lanes
Emerging LED Technologies and Their Spectrum of Use within Tunnels
Ensuring Essential Capability for the Future Transportation Agency
Estimating Effectiveness of Safety Treatments in the Absence of Crash Data
Evaluation of Bridge Rail Systems to Confirm AASHTO MASH Compliance
Flood Cast: A Framework for Enhanced Flood Event Decision-Making for Transportation Resilience—Phase IV
Guidance for Agencies to Incorporate Uncertainty into Long-Range Transportation Planning
Guidance for Improving Outcomes and Implementing Equitable Transportation Decision-Making
Guidelines for Selecting Ramp Design Speeds
IDEA (Innovations Deserving Exploratory Analysis)
Identify Emerging Approaches for Public Engagement to Meaningfully Involve Minorities, Low-Income, and Other Vulnerable Populations
Implementation and Training Materials for the Highway Safety Manual, Second Edition
Improvement and Reorganization of Section 13 of the AASHTO LRFD Bridge Design Specifications to Address MASH Loading
Incorporating Driver Behavior Considerations in Safety Performance Estimates on Infrastructure Improvements
Incorporating New Mobility Options into Travel Demand Forecasting and Modeling
Identifying Influences on and Minimizing the Variability of Ignition Furnace Correction Factors
Integrating Effective Transportation Performance, Risk, and Asset Management Practices
Integrating Freight Movement into 21st Century Communities' Land Use Design and Transportation Systems
Leveraging Big Data and Artificial Intelligence to Streamline Safety Data Analyses

Local Calibration of LRFD Geotechnical Resistance Factors
Mechanical Properties of Laboratory-Produced Recycled Plastic Modified (RPM) Asphalt Binders and Mixtures
Methods of Short-Term Crash Prediction
Mitigation of Weldment Cracking of Highway Steel Structures Due to the Galvanizing Process
NCHRP Project Panel for the Protection of Transportation Infrastructure from Cyber Attacks
NCHRP Project Panel of Synthesis of Leveraging Private Capital for Infrastructure Renewal
NCHRP Topic Panel on Measuring Investments in Active Transportation When Accomplished as Part of Other Transportation Projects
NCHRP Topic Panel on Micromobility Policies, Permits, and Practices
Operational Standards for Highway Infrastructure
Practices for Adding Bicycle and Pedestrian Access on Existing Vehicle Bridges
Practices to Motivate Safe Behaviors with Highway Construction and Maintenance Crews
Proposed AASHTO Guideline for Load Rating of Segmental Bridges
Proposed AASHTO Guidelines for Adjacent Precast Concrete Box Beam Bridge Systems
Proposed AASHTO Guidelines for Use of Stainless Steel in Bridge Girders
Proposed AASHTO Highway Safety Manual, Second Edition
Recommended Guidelines for Prefabricated Bridge Elements and Systems Tolerances and Dynamic Effects of Bridge Moves
Reducing Risks to Worker Safety in Work Zones Due to Distracted Drivers
Research for AASHTO Standing Committee on Planning: Support for Improved Transportation Planning and Project Development
Research Roadmap for Knowledge Management
Roadwide Design for Conflicts in Proximity to Bridge Ends and Intersection Roadways
Safe Systems in the US—Developing a Roadmap for Transportation Road Designers, Planners, and Engineers
Safety Performance for Active Transportation Modes Using Exposure Models
Safety Performance of LED and Variable Lighting Systems
Safety Performance of Part-Time Shoulder Use on Freeways
Scoping Supply Chain Challenges and Solutions amid COVID-19
State DOT Contributions to the Study, Investigation, and Interdiction of Human Trafficking
State DOT Usage of Bicycle and Pedestrian Data: Practices, Sources, Needs, and Gaps/Practices and
Recommendations in Reporting and Integrating Nonfatal Injury Data for Active Travel Modes
Strategic Plan and Research Roadmap for AASHTO Committee on Planning
Strategies and Programs for Electric Vehicle Charging
Support for Critical Issues in Transportation and Commitment to the Future HIS

Support for State DOT Transportation Systems Resilience and All-Hazards Programs
Surface Transportation Security Research
Synthesis of the Performance of Portable Concrete Barrier Systems
TCRP Project Panel on Command-Level Decision-Making for Transit Emergency Managers
TCRP Project Panel on Mobility Inclusion for Un(der)served Populations with Emerging Technologies
TCRP Synthesis Panel on Assessing Equity and Identifying Impacts Associated with Bus Network Redesigns
Temporary Pavement Markings Placement and Removal Practices in Work Zones
Toolbox for Navigating the Land Use Impacts of the Automated Vehicle Ecosystem
Understand How Accessibility to Employment, Health Care, Education, and Other Vital Needs Varies for Different Population Groups in Different Settings, and Methods for Effectively Assessing Mobility and Accessibility Needs
Understand the Role of Transportation Infrastructure Investment in Gentrification and Displacement
and Identify Effective Policies and Strategies to Address These Effects
Update of Security 101: A Physical Security Primer for Transportation Agencies
Updates to the Digital Edition of the AASHTO Transportation Asset Management Guide
Updating Safety Performance Functions for Data-Driven Safety Analysis

Transportation Pooled Fund Projects (TPFs)

The Transportation Pooled Fund (TPF) Program is a popular means for the State Department of Transportation (DOT), Federal Highway Administration (FHWA) program offices, and commercial entities to combine resources and achieve common research goals. Pooling resources reduces marginal costs and provides efficient use of taxpayer dollars. It also provides greater benefits to participating interests as compared to individual entities conducting or contracting for research on their own. MassDOT continues to collaborate and contribute with FHWA and other state DOTs to a certain number of transportation-related studies pertinent to the Commonwealth now and in years to come.

FFY2022 TPF Projects MassDOT Participated In

Project Number	Title	Lead Agency	MassDOT annual contribution ($)
TPF-5(343)	Roadside Safety Research for MASH Implementation	Washington State DOT	$50,000
TPF-5(370)	Fostering Innovation in Pedestrian and Bicycle Transportation Pooled Fund Study	FHWA	$25,000
TPF-5(373)	New England Transportation Consortium	Maine DOT	$137,461
TPF-5(422)	National Cooperative Highway Research Program	FHWA	$826,802
TPF-5(431)	Application of Enterprise GIS for Transportation, Guidance for a National Transportation Framework (AEGIST)	FHWA	$100,000 (100% federal fund waiver is for SPRI)
TPF-5(437)	Technology Transfer Concrete Consortium	Iowa DOT	$12,000
TPF-5(447)	Traffic Control Device (TCD) Consortium	FHWA	$10,000
TPF-5(455)	National Accessibility Evaluation Phase II	Minnesota DOT	$38,000
TPF-5(456)	Econworks	Arkansas DOT	$4,000 (100% federal fund waiver is for SPRI)
TPF-5(464)	H&H Software Updates	FHWA	$10,000
TPF-5(479)	Clear Roads Phase III	Minnesota DOT	$25,000
TPF-5(481)	In-Service Performance Evaluation (ISPE) of Roadway Safety Features	Arizona DOT	$30,000
TPF-5(482)	Development and Evaluation of Roadside Safety Systems for Motorcyclists	Texas DOT	$40,000

Over the years, one of the consistent project highlights of the TPF has been the continued involvement and success of the New England Transportation Consortium (NETC). NETC is a cooperative research effort that includes the state DOTs from Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. The NETC is a valuable regional partnership for the identification and dissemination of shared transportation research initiatives.

NETC Advisory Committee

The NETC Advisory Committee includes representatives from the state DOTs, FHWA, and New England state universities (including the University of Massachusetts, represented by the UMTC). MassDOT's involvement in NETC includes an annual financial contribution for research projects, collaboration on annual project solicitation and prioritization, participation on project technical committees, and in monthly meetings and annual events.

Active NETC research projects in 2022 included:

- 19-1: Curved Integral Abutment Bridge Design
- 19-2: Multi-Scale Multi-Season Land-Based Erosion Modeling and Monitoring for Infrastructure Management
- 19-3: Experimental Validation of New Improved Load Rating Procedures for Deteriorated Steel Beam Ends
- 20-1: In-Service Performance Evaluation of NETC Bridge Railings
- 20-2: Current Status of Transportation Data Analytics and a Pilot Case Study Using Artificial Intelligence (AI)
- 20-3: Investigating Thermal Imaging Technologies and Unmanned Aerial Vehicles to Improve Bridge Inspections
- 20-4: New England Connected and Automated Vehicle Legal and Regulatory Assessment
- 21-1: Quality Review and Assessment of Pavement Condition Survey Vehicle Data across New England
- 21-2: Sustainable Biomass Based Sealant for Service Life Extension of Concrete Structures and Pavements
- 21-3: Initiating Seed Production for Effective Establishment of Native Plants on Roadsides in New England

NEW ENGLAND TRANSPORTATION CONSORTIUM

Appendix

FFY 2022 SPR Annual Spending Report (10/1/2021–09/30/2022)
Office of Transportation Planning Research Activities / SPR II

Project Title	*Contract Number*	*Total Amount*	*FFY22 Spending*
A. Research Program Administration	**N/A**		
B. Massachusetts Cooperative Research Program (MCRP)	**109600**		
1 Concrete Sidewalk II		$250,000	$183,430
2 Cost Recovery		$37,686	$7,730
3. Guardrail Inventory and Condition Assessment		$95,678	$61,113
4. YFA II		$115,000	$100,842
C. Local Technical Assistance Program (LTAP)	**109600**		
D. MassDOT Training Services	**109600**		
Short-Term Research Projects			
1. Implementing the AASHTO Mechanistic-Empirical Pavement Design Guide Phase III (FFY22 New Project, Continuation of Phase II Effort in Subtask F.15)	**120714**	$400,000	$0
2. Methods to Identify Problematic Carriers and Prevent Infrastructure Damage (FFY22 New Project)	**117649**	$126,220	$1,541
3. Feasibility Study of 3D Printing Applications for Bridge Elements in MA (FFY22 New Project)	**117646**	$150,000	$0
4. Data-Driven Approach for Transit Capital Planning (FFY22 New Project)	**119829**	$100,000	$0
5. BIM for Transit Infrastructure: A Feasibility and Gap Assessment with Current Practices and Systems at the MBTA (FFY22 New Project)	**117455**	$100,000	$36,293
6. Using Traffic Signals to Limit Speeding Opportunities on Arterial Roads (Continuing Project)	**114372**	$140,000	$45,450
7. Uncovering the Root Causes for Truck Rollover Crashes on Ramps (Continuing Project)	**113772**	$120,000	$55,694
8. Synthesis Study: Mycofiltration Treatment and Design Options (Continuing Project)	**114903**	$40,000	$28,990
Medium-Term Research Projects			
1. Measuring Accessibility to Improve Public Health (Continuing Project)	**114069**	$149,999	$95,845
2. A Method for Pavement Marking Inventory and Retroreflectivity Condition Assessment Using Mobile LiDAR (Continuing Project)	**110352**	$200,000	$1,969
3. Feasibility of the 3D Printing Application for Highway Infrastructure Construction and Maintenance (Continuing Project)	**110756**	$175,000	$59,301
4.Using Grip Sensors to Control a Salt Spreader Application Rate (FFY22 New Project)	**117740**	$125,000	$15,673
5. UAS for Surface Transportation Emergency Response (Continuing Project)	**113771**	$60,000	$33,793.61
6. Detecting Subsurface Voids Using UAS with Infrared Thermal Imaging (Continuing Project)	**112754**	$60,000	$22,325.57
7. Impact of Advanced Driver Assistance Systems (ADAS) on Road Safety and Implications for Education, Licensing, Registration, and Enforcement (Continuing Project)	**110757**	$120,000	$30,484
8. Smart Work Zone Control and Performance Evaluation Based on Trajectory Data (FFY22 New Project)	**117478**	$150,000	$6,605.21
9. Developing Massachusetts-Specific Trip Generation Rates for Land Use Projects (Continuing Project)	**113773**	$150,000	$66,718.19
10. Multisource Data Fusion for Real-Time and Accurate Traffic Incident Detection (Continuing Project)	**113774**	$150,000	$96,012.04
11. Post-Fire Damage Inspection of Concrete Structures in Tunnels Phase II (Continuing Project)	**114201**	$160,000	$126,315
12.Massachusetts Depth to Bedrock Project (Continuing Project)	**113776**	$114,675	$78,850
13.Outdoor Information Panels to Convey Real-Time Travel Information for Ridership Recovery (Continuing Project)	**114217**	$124,999	$51,389
14. Post-Fire Damage Inspection of Concrete Structures Phase III Field Verification Phase (FFY22 New Project)	**117741**	$180,000	$12,269
15.Implementing AASHTO M-E Pavement Design Guide Phase II (Continuing Project)	**114775**	$200,630	$134,589.88
16.Effectiveness of Two-Stage Turn Queue Boxes in Massachusetts: A Comparison with Bike Boxes (FFY22 New Project)	**118671**	$150,000	$0

Long-Term Research Projects			
1. Ultra-High Performance Concrete Reinforced with Multi-Scale Hybrid Fibers and Its Durability-Related Properties (Continuing Project)	**115287**	$206,538	$37,030.13
2. Complete Streets v.2: Respecting the Roots (FFY22 New Project)	**117524**	$90,000	$9,680
3. Asset Management Systems at Municipalities (Continuing Project)	**110556**	$200,497	$109,687.86
4. Revised Load Rating Procedures for Deteriorated Prestressed Concrete Beams (Continuing Project)	**114071**	$199,955	$90,842
5. Field Study to Determine Salt Usage Efficiency on Two Pavement Types (FFY22 New Project)	**119609**	$450,000	0
6. Development of Comprehensive Inspection Protocols for Deteriorated Steel Beam Ends (Continuing Project)	**110354**	$149,998	$10,393
7. Optimization of MassDOT's High-Performance Thin Lift Mixtures (Continuing Project)	**114557**	$249,997	$71,689.25
8. Development of Improved Inspection Techniques Using LiDAR for Deteriorated Steel Beam Ends (FFY22 New Project)	**117416**	$199,998	$40,501
9. Accessibility-Focused User Research (FFY22 New Project)	**removed**		