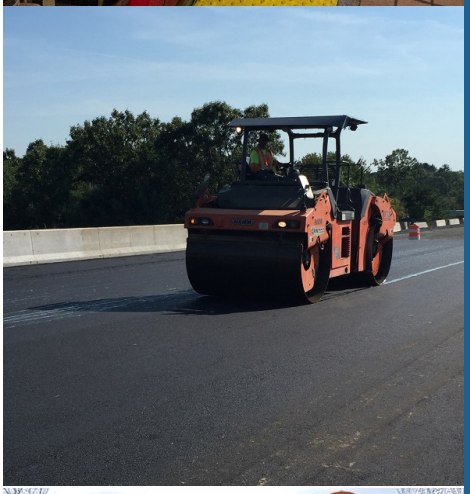
massDOT
Massachusetts Department of Transportation

Research and
Technology Transfer

ANNUAL REPORT

FFY2021

Massachusetts Department of Transportation
Office of Transportation Planning



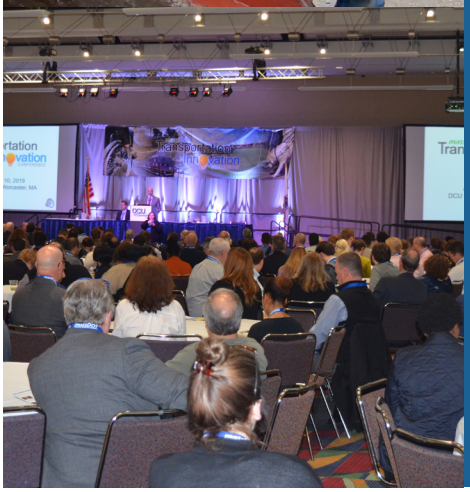


TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Massachusetts Department of Transportation (MassDOT) is committed to addressing, maintaining, and evolving the transportation needs of the Commonwealth through a wide range of research and training programs. This commitment relies on the development and fulfillment of established and creative solutions that address critical current and emerging transportation factors such as data management, implementation, and innovation. With the COVID-19 pandemic consuming much of Federal Fiscal Year 2021 (FFY21), MassDOT operated under mostly remote conditions, while continuing to expand and enhance conducting business at an optimal level. MassDOT continued to exceed expectations at improving alternative program delivery and exploring ways to integrate transportation professionals from outside of Massachusetts. This provided MassDOT with an opportunity to not only take an alternative approach with programs and projects, but to also look through a different lens regarding the current and future landscape of the transportation industry. Through hosting virtual outreach meetings and training sessions, MassDOT maintained a steady route of communication, both internally as well as in public and private partnerships. This emerging shift to virtual program delivery included methods in which research, trainings and the transfer of knowledge were conducted throughout the statewide transportation industry and beyond state lines.

The delivery of trainings, conferences, and other relevant and instructive information were conducted in a virtual manner for the majority of FFY21. While the Research Roundtable connected MassDOT personnel with researchers through a virtual format, the Local Technical Assistance Program (LTAP) Advisory Board meeting in June 2021 explored the hybrid meeting format, with some folks gathering at the new MassDOT District 3 Office and others participating online. With growing adaptation towards technology, normal business continued as usual.

FFY21 saw an increase in MassDOT transportation research projects with 14 new projects taking form. The new transportation research topics ranged from uncovering the root causes of truck rollover crashes and developing trip generation rates for Massachusetts specific land uses, to understanding loading procedures for deteriorated prestressed concrete beams for bridges. These new projects, coupled with the continuation of MassDOT's technical training programs, highlighted MassDOT's commitment to formalizing innovative transportation initiatives and methods to better the future of transportation infrastructure in the Commonwealth.

A look back at FFY21 showcases many milestones including:

- Initiating 14 new research projects
- Implementing research results from the 11 projects completed during FFY21 at MassDOT
- Presenting two annual statewide transportation conferences through a virtual platform
- Delivering 120 Baystate Roads classes to 3,072 Massachusetts municipal employees, and
- Providing 77 MassDOT Training Service classes to 1,609 MassDOT participants

While highlighting research and training milestones, this report also showcases the collaborative techniques used to create and share transportation research and trainings throughout Massachusetts and across the country. The report illustrates MassDOT's continuing commitment to the improvement of the Commonwealth's multimodal infrastructure, transit mobility services, and transportation safety.

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, U.S. Code, Section 505, and regulated by Title 23, Code of Federal Regulations (CFR), Part 420.

The contents do not necessarily reflect the official views or policies of the Massachusetts Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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, mostly driven by internal needs, 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.

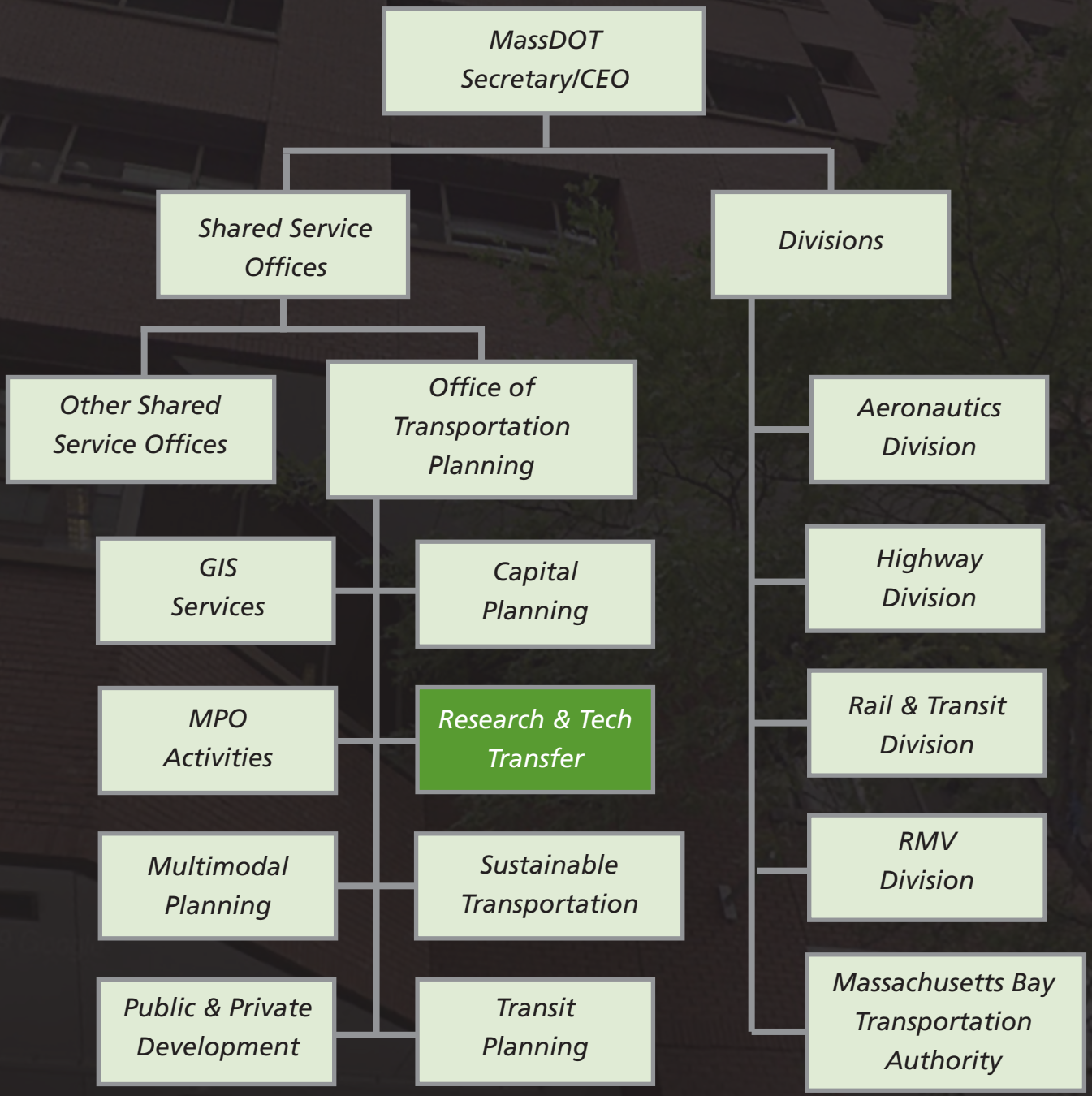
As transportation in Massachusetts is constantly evolving, the development of solutions through applied research and the dissemination of best practices and knowledge through training helps shape the changing transportation landscape. Collaborative efforts within these two platforms help the Commonwealth economize resources and funding as MassDOT looks towards influencing 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 three areas:

- Massachusetts Cooperative Research Program (MCRP)
- Baystate Roads (the Massachusetts Local Technical Assistance Program)
- MassDOT Training Services (MTS, technical trainings 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).



10 Park Plaza, Suite 4160, Boston, MA 02116
mass.gov/orgs/massachusetts-department-of-transportation

Program Components and Funding

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

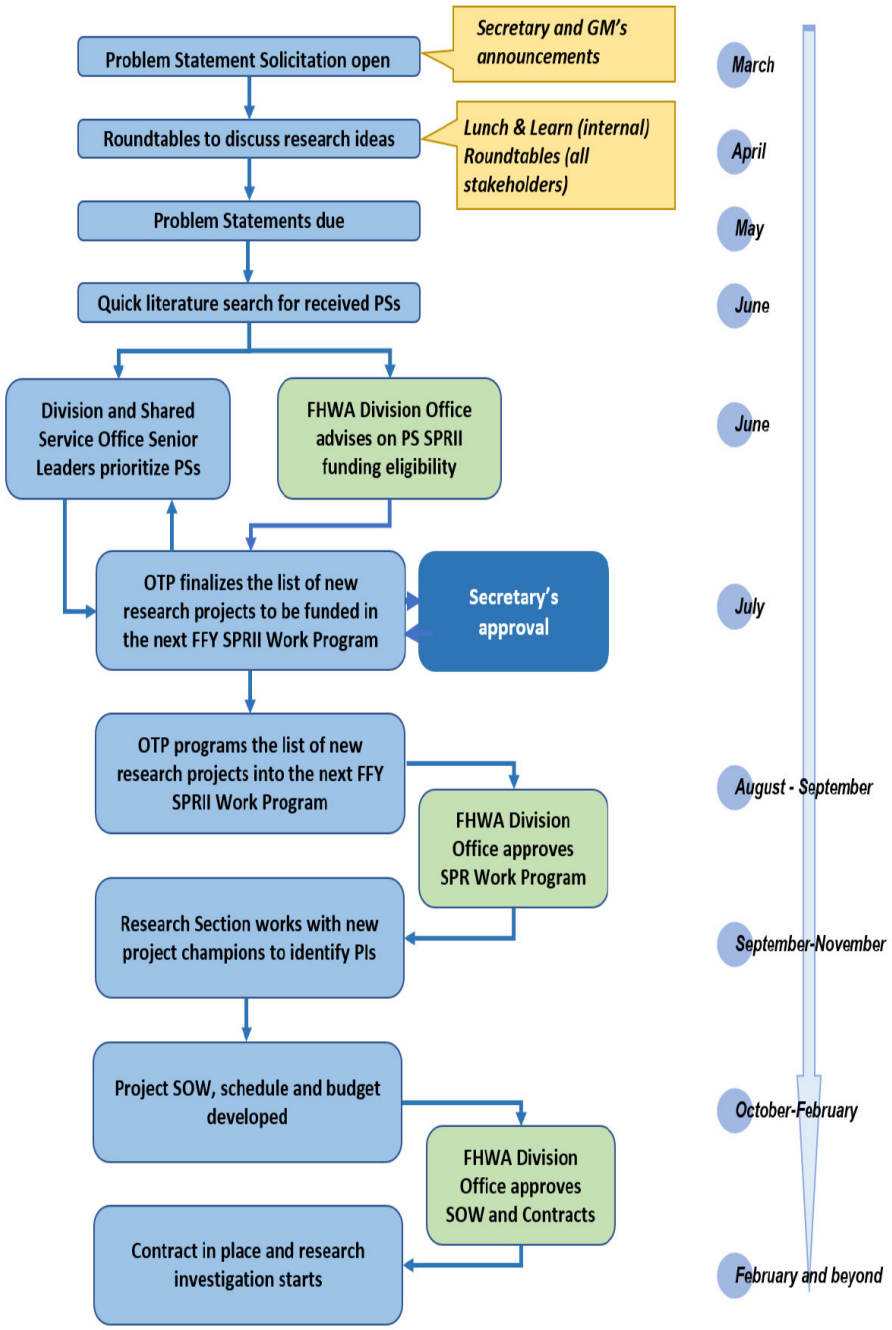
Research

The purposes of the research component 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 at Research Section to identify, select and carry out new SPRII research projects.

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 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, 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 come out of the MassDOT annual research solicitation process and the off-cycle special request process are assigned to one of the five categories: quick turn-around (<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, a.k.a., Massachusetts Cooperative Research Program), short-term (<15 months), medium-term (15-21 months), long-term (>21 months), and the ones suitable for national or regional cooperative research programs such as NCHRP and TPF.

Figure 1: MassDOT Annual Research Process



Training

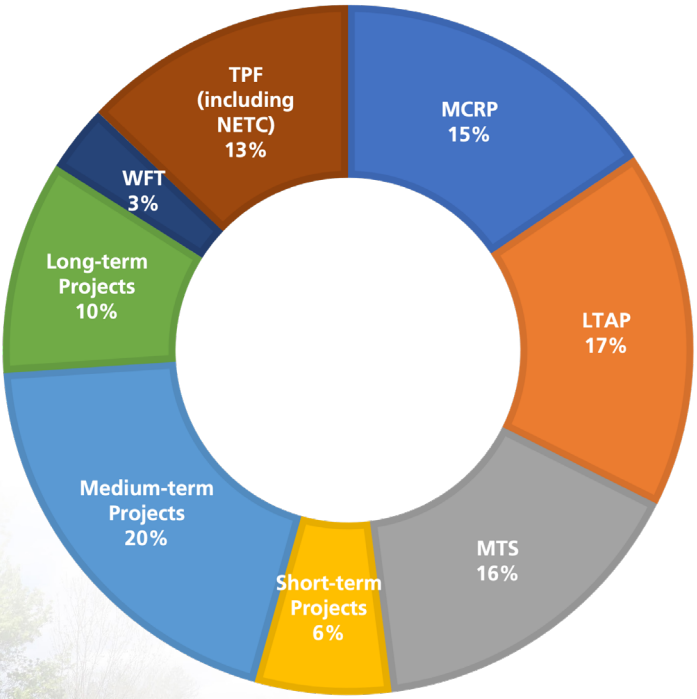
MassDOT contracts with the UMTC to provide training services to both MassDOT and municipal audiences. Through Baystate Roads, the Massachusetts LTAP Center, and MassDOT Training Services, the UMTC assists MassDOT in developing and implementing annual training plans to provide essential and high-quality 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 and assist staff 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, engineering directives, provides updates on transportation research projects and results, and other essential developments.

FFY2021 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, U.S. 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 FFY2021 SPRII funding distribution. Research activities (Short-term, Medium term, Long-term, MCRP, and TPFs) accounted for about 64% of SPRII funds while training activities (MTS, LTAP and MassDOT Work Force Training) accounted for about 36% of the SPRII funds. MassDOT Work Force Training

Figure 2: FFY21 State Planning and Research Program II



- MA Cooperative Research Program (MCRP)
- Local Technical Assistance Program (LTAP)
- MassDOT Training Services (MTS)
- Short-term Research Projects
- Medium-term Research Projects
- Long-term Research Projects
- Work Force Training (WFT)
- Transportation Pooled Funds (TPF) (inlcuding New England Transportation Consortium (NETC)

RESEARCH HIGHLIGHTS

Annual Research Solicitation Process and Research Roundtables

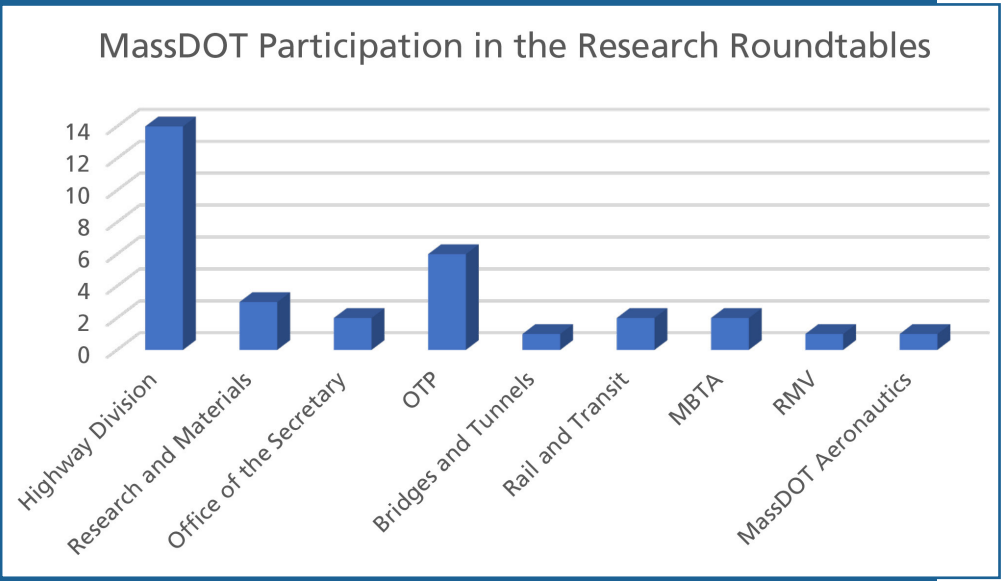
MassDOT's annual process of soliciting and selecting research projects for the coming fiscal year starts with a solicitation period to gather Research Problem Statements for potential future projects in surface transportation infrastructure or intermodal transportation, based on current internal needs and challenges. Each Research Problem Statement is submitted for consideration by a MassDOT or MBTA staff member who, if the project advances to receive funding, then serves as Project Champion (PC). The annual process includes outreach to state transportation practitioners and academic researchers.

MassDOT began holding Research Roundtables during the solicitation period in 2019. Research Roundtables established a new way to connect state transportation practitioners with academic researchers, and to foster future collaborations between the two groups. The Research Roundtables also provide the participants with a baseline understanding of statewide transportation research needs. The format of the Research Roundtables was restructured from in-person to online in 2020 due to the COVID-19 pandemic forcing a change in group collaborative efforts and communication methods. The online format for the Research Roundtables continued in 2021. During the Spring 2021 solicitation period for FFY2022 Research Projects, MassDOT, together with the UMTC, hosted a Research Roundtable online series for MassDOT and MBTA staff and researchers from academia. The series started with a pre-recorded informational session at which MassDOT presented an overview of the research project solicitation and selection process. This initial session was followed by live, conversational Research Roundtables. At these Roundtables, MassDOT staff members discussed their challenges, needs, and potential ideas for future research projects; additionally, researchers from various Massachusetts universities and colleges briefly presented on their areas of expertise, and their current and past transportation research. Each of the Roundtables focused on different, overlapping transportation-related themes:

- First Roundtable: Roadway Engineering, Safety, and Maintenance
- Second Roundtable: Engineering, Design, and Asset Management
- Third Roundtable: Active Transportation, Mobility, Health, Safety, and Policy
- Fourth Roundtable: Construction, Materials, and Maintenance
- Fifth Roundtable: Transit Services and Research

Combined, the five interactive Roundtable sessions had a total of 145 attendees, with some MassDOT staff members, researchers, and consultants coming to multiple sessions. The attendees included 32 individual MassDOT staff, 24 researchers from five academic institutions, five consultants, and four UMTC staff.

MassDOT also hosted a Lunch and Learn session, internal to MassDOT. These sessions informed and engaged MassDOT and MBTA staff in the SP&RII research process and program. MassDOT personnel also became more familiar with transportation challenges and problems that can be addressed through research and the research support structure that exist for future research projects.



Research Recognition, Presentations, Publications

A research study on "Characterization of Reclaimed Asphalt Pavement (RAP) for Hot Mix Asphalt Surface Courses in Massachusetts" championed by Edmund Naras, MassDOT Pavement Engineer and conducted by UMass Dartmouth Professor Dr. Walaa Mogawer, Civil & Environmental Engineering and his team at the Highway Sustainability Research Center (HSRC) was selected as an American Association of State Highway and Transportation Officials (AASHTO) Sweet Sixteen High Value Research project for 2021. Mogawer presented his research at the 2022 Transportation Research Board Annual Meeting (in-person) and the 2021 AASHTO Research and Advisory Board Summer Meeting (virtual). Dr. Mogawer was also the lead PI on four MassDOT research projects in 2021: Implementing the AASHTO Mechanistic-Empirical Pavement Design Guide (Phase I), Implementing AASHTO M-E Pavement Design Guide Phase II, Understanding Asset Management Systems Utilized by Municipalities in Massachusetts, and Optimization of MassDOT's High Performance Thin Lift Mixtures, and Understanding Asset Management Systems Utilizes by Municipalities in Masschusetts.

In the spring of 2021, UMass Amherst Assistant Professor Simos Gerasimidis, Civil & Environmental Engineering, was awarded a CAREER grant from National Science Foundation (NSF) Early Career Development Program. Dr. Gerasimidis will use the half-million-dollar award for his research to create a new class of reinforced concrete structures, based on the unique mechanical properties of architected metamaterials. Some of the research will be conducted at UMass Amherst's Brack Structural Testing Facility which Dr. Gerasimidis and colleagues established for large-scale structural component testing. Dr. Gerasimidis has been a principal investigator (PI) or co-PI on a number of MassDOT funded research projects on bridge structures and steel beam ends which have utilized the Brack testing facility, including: Revised Load Rating Procedures for Deteriorated Prestressed Concrete, Improved Load Rating Procedures for Deteriorated Steel Beam Ends with Deteriorated Stiffeners Feasibility and 3D Printing Applications for Highway Infrastructure Construction and Maintenance, which have utilized the Brack testing facility.

UMass Amherst Assistant Professor Kara Peterman, Civil & Environmental Engineering, recently was recognized with the Terry Peshia Early Career Faculty Award from the American Institute of Steel Construction (AISC). The award provides recognition to faculty who demonstrate promise in the areas of structural steel research, teaching and other contributions to the structural steel industry. In addition to research in structural steel, Dr. Peterman is the lead PI on two MassDOT research projects investigating best practices to incorporate into the materials and construction of concrete sidewalks to mitigate surface scaling damage induced by freeze-thaw cycles in the presence of deicing chemicals.

Dr. Walaa Mogawer

Dr. Simos Gerasimidis

Dr. Kara Peterman

RESEARCH PROJECTS

During Federal Fiscal Year 2021, 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 the UMass Transportation Center Interdepartmental Service Agreement between MassDOT and the University of Massachusetts Amherst. The project status of the following projects reflects the time when this report was finalized, April 2022.

Active MassDOT Research Projects, FFY 2021 (Project Status is as of April 2022)

Short-Term Research Projects
1. Effectiveness of Bicycle Boxes in Massachusetts (Completed)
2. Exploring Short-Sea Shipping as an Alternative to Non-Bulk Freight Trucking in Southeastern Massachusetts (Completed)
3. Improving the Future of the Commonwealth's Curb (Completed)
4. Improved Load Rating Procedures for Deteriorated Steel Beam Ends with Deteriorated Stiffeners (Completed)
5. Tracking the Energy and Emissions of MBTA Rapid Transit Vehicles Project (Completed)
6. Using Traffic Signals to Limit Speeding Opportunities on Arterial Roads (In Progress)
7. Uncovering the Root Causes for Truck Rollover Crashes on Ramps (In Progress)
8. Using Mycrofiltration Treatment for Stormwater Management (In Progress)
Medium-Term Research Projects
1. Measuring Accessibility to Improve Public Health (In Progress)
2. Post-Fire Damage Inspection of Concrete Structures (Completed)
3. Implementing the AASHTO Mechanistic-Empirical Pavement Design Guide (Phase I) (Completed)
4. Feasibility of 3D Printing Applications for Highway Infrastructure Construction and Maintenance (In Progress)
5. Impact of Advanced Driver Assistance Systems (ADAS) on Road Safety and Implications for Education, Licensing, Registration, and Enforcement (Completed)
6. A Pavement Marking Inventory and Retroreflectivity Condition Assessment Method Using Mobile LiDAR (In Progress)
7. Detecting Subsurface Void in Roadways Using UAS with Infrared Thermal Imaging (Completed)
8. Use of UAS in Surface Transportation Emergency Incident Response (In Progress)
9. Developing Massachusetts Specific Trip Generation Rates 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 (In Progress)
12. Massachusetts Depth to Bedrock Project (In Progress)
13. Outdoor Information Panels to Convey Real-Time Travel Information for Ridership Recovery (In Progress)
14. Implementing AASHTO M-E Pavement Design Guide Phase II (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. Translating Data Generated by the Transit App into Insights on Transportation Use in Greater Boston (Completed)
3. Flexible Transit Services in Rural Areas (Completed)
4. Development of Comprehensive Inspection Protocols for Deteriorated Steel Beam Ends (Completed)
5. Understanding Asset Management Systems Utilized by Municipalities in Massachusetts (In Progress)
6. Optimization of MassDOT's High Performance Thin Lift Mixtures (In Progress)
7. Revised Load Rating Procedures for Deteriorated Prestressed Concrete (In Progress)
Cooperative Research Program Projects
1. Evaluating the Safety Impacts of Flashing Yellow Permissive Left-Turn Indications in Massachusetts (Completed)
2. Construction and Materials Best Practices for Concrete Sidewalks (Completed)
3. Synthesis study: Best Practices for Designer Cost Recoveries (Completed)
4. Automated Guardrail Inventory and Condition Evaluation (In Progress)
5. Construction & Materials Best Practice for Concrete Sidewalks Phase II (In Progress)

SHORT-TERM RESEARCH PROJECTS

1. Effectiveness of Bicycle Boxes in Massachusetts

Principal Investigators: Dr. Eleni Christofa and Dr. Chengbo Ai, UMass Amherst
MassDOT Project Champion: Andrew Wilkins
Allocated Funding Amount: $100,000

◆ Project Overview:

Bike boxes had been installed at several intersections in Massachusetts, but they had not yet been evaluated fully. This project conducted a comprehensive assessment of bike boxes, including how they are utilized by bicyclists, their impact on bicyclist and motorist safety, and which design characteristics of bike boxes were most effective.

◆ Key Findings:

- Motorist compliance rate at bike boxes is lower at some intersections and is dependent on the turning movement performed.
- Bicyclist compliance is high at bike boxes.
- Implementation of two-stage queue-turn boxes can facilitate left turning movements.
- Motorist and bicyclist education is critical for the proper use of bike boxes in order to improve safety for all.

Timeframe: Completed September 2021.

Web link to Final Report: https://www.mass.gov/doc/effectiveness-of-bike-boxes-in-massachusetts-final-report/download

2. Exploring Short-Sea Shipping as an Alternative to Non-Bulk Freight Trucking in Southeastern Massachusetts

Principal Investigators: Kristin Uiterwyk, Jack Wiggin, Kim Starbuck, Allison Novelly, UMass Boston
MassDOT Project Champion: Benjamin Muller
Allocated Funding Amount: $88,700

◆ **Project Overview:**

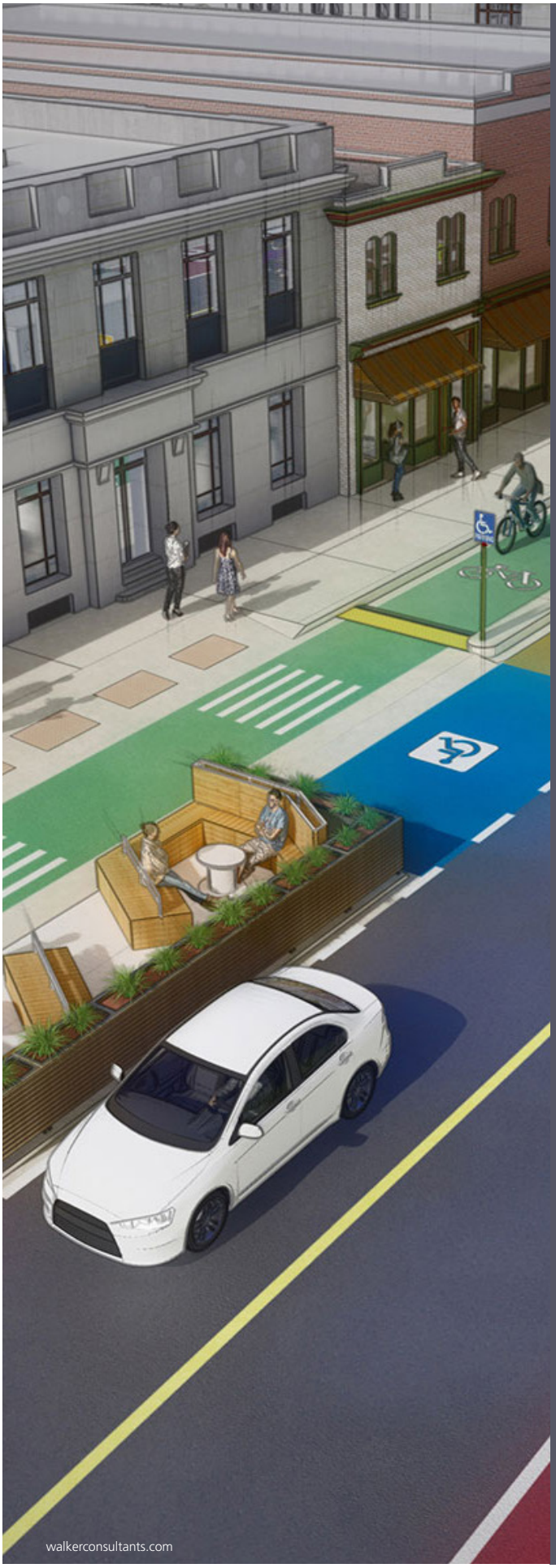
The purpose of this project was to explore whether or not new options for short-sea shipping (i.e., using coastal waterways to transport commercial freight to its destination) could be utilized to ease roadway congestion and reduce emissions associated with the transport of non-bulk freight to Martha's Vineyard. Under present conditions, coastal areas in southeastern Massachusetts are heavily reliant on trucking for freight distribution, which has a relatively large environmental footprint. Truck freight destined for Martha's Vineyard, in particular, utilizes roadways with heavy traffic and congested choke points, such as the Cape Cod Canal bridges.

◆ **Key Findings:**

- The New Bedford State Pier was identified as the most promising port for diverting some of the non-bulk freight from the current port in Woods Hole.
- This report studied the effort to quantify the potential difference in roadway congestion between the existing condition of moving non-bulk freight through Woods Hole and a shift to moving some of this freight through a New Bedford port. The findings indicated this would have little impact on traffic volume both on Cape Cod and to/from Cape Cod via the Bourne and Sagamore Bridges.
- This study also compared the emissions generated from the shipping non-bulk freight between Martha's Vineyard and mainland Massachusetts in 2019 under existing conditions, i.e., all freight passes through Woods Hole, and (2) scenario conditions i.e., almost half of all freight leaves through New Bedford on vessels scheduled roughly three times each day, year-round, while the remaining freight is transported via the terminal at Woods Hole.
- The study results indicated that a shift to scenario conditions as modeled in this report, would generate additional NOx and CO^2 emissions.

Timeframe: Completed in September 2021.

Web link to Final Report: https://www.mass.gov/doc/exploring-short-sea-shipping-as-an-alternative-to-non-bulk-freight-trucking-in-southeastern-ma-final-report/download



3. Improving the Future of the Commonwealth's Curb

Principal Investigators: Dr. Eric J. Gonzales and Dr. Shannon Roberts, UMass Amherst
MassDOT Project Champion: Derek Shooster
Allocated Funding Amount: $100,000

◆ **Project Overview:**

There are diverse, competing, evolving demands for the use of curb space in municipalities throughout Massachusetts. These demands come from transit, transportation network companies, pedestrians, delivery vehicles, and more. This project investigated current curb management practices, curb use patterns, needs and concerns. It then proposed a framework for communities to identifying appropriate curbside lane designs and management strategies based on different municipal contexts.

◆ **Key Findings:**

- The three strategies developed for managing curb functions were relocation, flexibility, and conversion. Implementations may require different types of infrastructure, including signage and paint, technology, and constructed infrastructure.

- Input gathered from 15 stakeholders brought to light four general themes around existing curb uses, needs, and expectations for the future:
  - ✧ Primary Users of the Curb
  - ✧ Data
  - ✧ Policy Changes
  - ✧ Future Needs

- The literature review and stakeholder engagement supported the following insights and recommendations: 1. Effective curb management starts with data; 2. Policies should promote the "best" use of space, which depends on context; 3. Engage stakeholders through the process; 4. Use pilots to get data and build support; and 5. Embrace active and flexible curb space management practices.

Timeframe: Completed in June 2021.

Web link to Final Report: https://www.mass.gov/doc/improving-future-of-the-commonwealths-curb-final-report/download

4. Improved Load Rating Procedures for Deteriorated Steel Beam Ends with Deteriorated Stiffeners

Principal Investigators: Dr. Simos Gerasimidis and Dr. Sergio Breña, UMass Amherst
MassDOT Project Champion: Alexander Bardow
Allocated Funding Amount: $100,000

◆ **Project Overview:**

This study built upon earlier research by the same Principal Investigators regarding the inspection and evaluation of corroded steel beam ends on bridges. The purposes of this study were to experimentally test corroded deteriorated beams, analyze the stiffened beam-end corrosion topologies utilizing high-fidelity Finite Element Models (FEM), and then introduce updates for the MassDOT Bridge Manual's load rating procedures accordingly.

◆ **Key Findings:**

- 210 corroded stiffened ends were examined in detail. Based on this real data, numerous parameters were defined and quantified through an extensive statistical analysis.
- Regarding the experimentally obtained failures, the beam end specimens were characterized by instant capacity drop governed by large displacements developed at peak load. The analytical provisions, currently in use by MassDOT, encapsulated the corrosion effect on a damaged end with a unique value describing the gross area above the support.
- The stiffeners section loss was found to have a very harmful effect on the bearing strength compared to web thickness loss; this highlighted the need for extensive bearing stiffener condition documentation for field girders.

Timeframe: Completed in September 2021.

Web link to Final Report: https://www.mass.gov/doc/improved-load-rating-procedures-for-deteriorated-steel-beam-ends-with-deteriorated-stiffener-final-report/download

5. Tracking the Energy and Emissions of MBTA Rapid Transit Vehicles Project

Principal Investigators: Dr. Jimi Oke, Dr. Eleni Christofa, and Dr. Eric J. Gonzales, UMass Amherst
MassDOT Project Champion: Sean Donaghy, MBTA
Allocated Funding Amount: $123,000

◆ **Project Overview:**

This project aimed to enhance the environmental sustainability of the MBTA's rapid transit network. The project analyzed real-time train position and electricity consumption data to quantify the energy use, costs, and subsequent emissions of the rapid transit vehicle system of the MBTA. It also expanded current knowledge on how the speed and acceleration of the trains relates to the demand draw of the traction power network.

◆ **Key Findings:**

- Through this project, baseline planning metrics were calculated for the MBTA based on 2019 data. These metrics indicated that distance is a higher-impact dimension with regard to energy usage. For costs, however, operating time is of much greater significance. In terms of emissions, twice as much greenhouse gases (GHG) are emitted for each mile traveled than for each hour.

- Observed that ridership impacts on energy usage were relatively minimal. What was also found was that the intercept of the energy usage model is 59 MWh (Megawatt hour), much of which can be attributed to operating energy overnight when trains are not running.

- The project's high performance energy consumption model showed impacts of large disruptions, such as COVID-19. The model predicted 2020 energy usage to a high degree of accuracy (4% error), despite the significant service disruptions and demand reductions experienced in that year.

Timeframe: Completed in August 2021.

Web link to Final Report: https://www.mass.gov/doc/tracking-the-energy-and-emissions-of-mbta-rapid-transit-vehicles-final-report/download

6. Using Traffic Signals to Reduce Speeding Opportunities

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

◆ **Project Overview:**

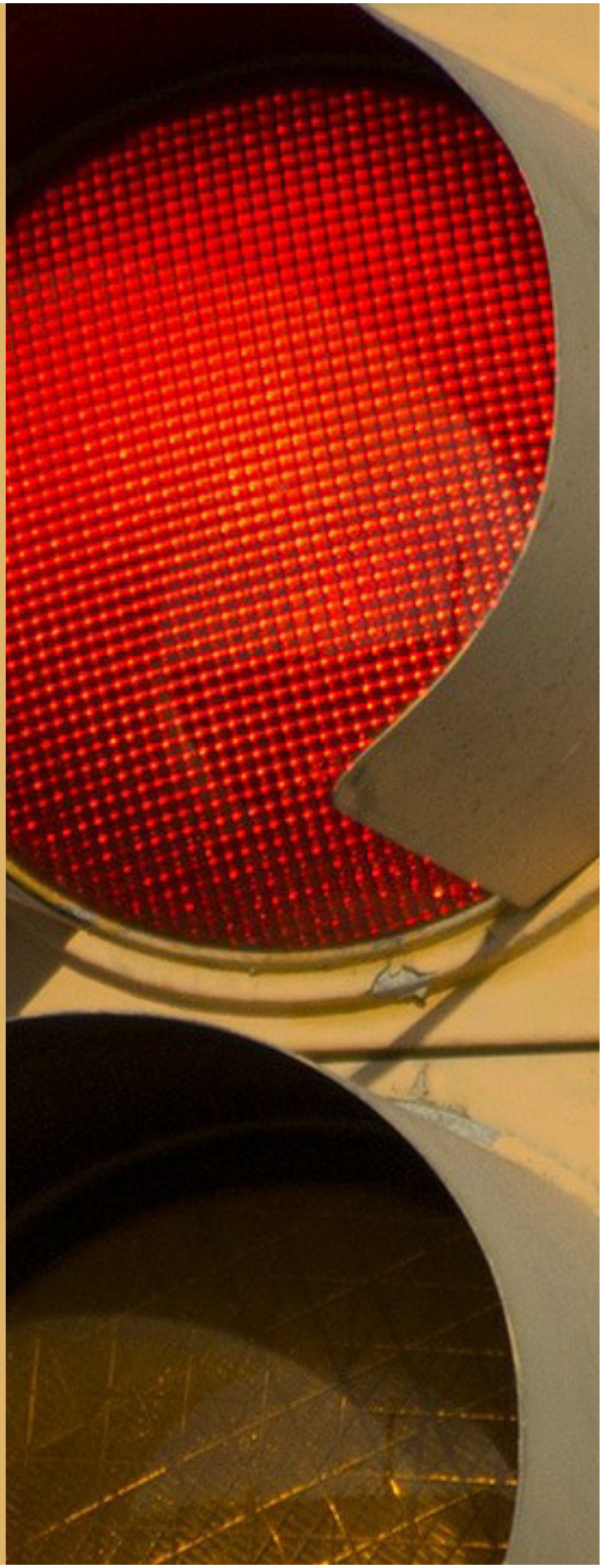
Traffic signal timing may be able to reduce incidence of dangerous speeding by removing opportunities to drive at high speeds through multiple intersections. This project is focused on preventing speeding on multilane arterials while still providing for good traffic flow at a safe speed. Preliminary 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 a traffic signal timing plan produces. That 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.

Timeframe: Expected Completion in May 2023.

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



7. Uncovering the Root Causes for Truck Rollover Crashes on Ramps

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

◆ Project Overview:

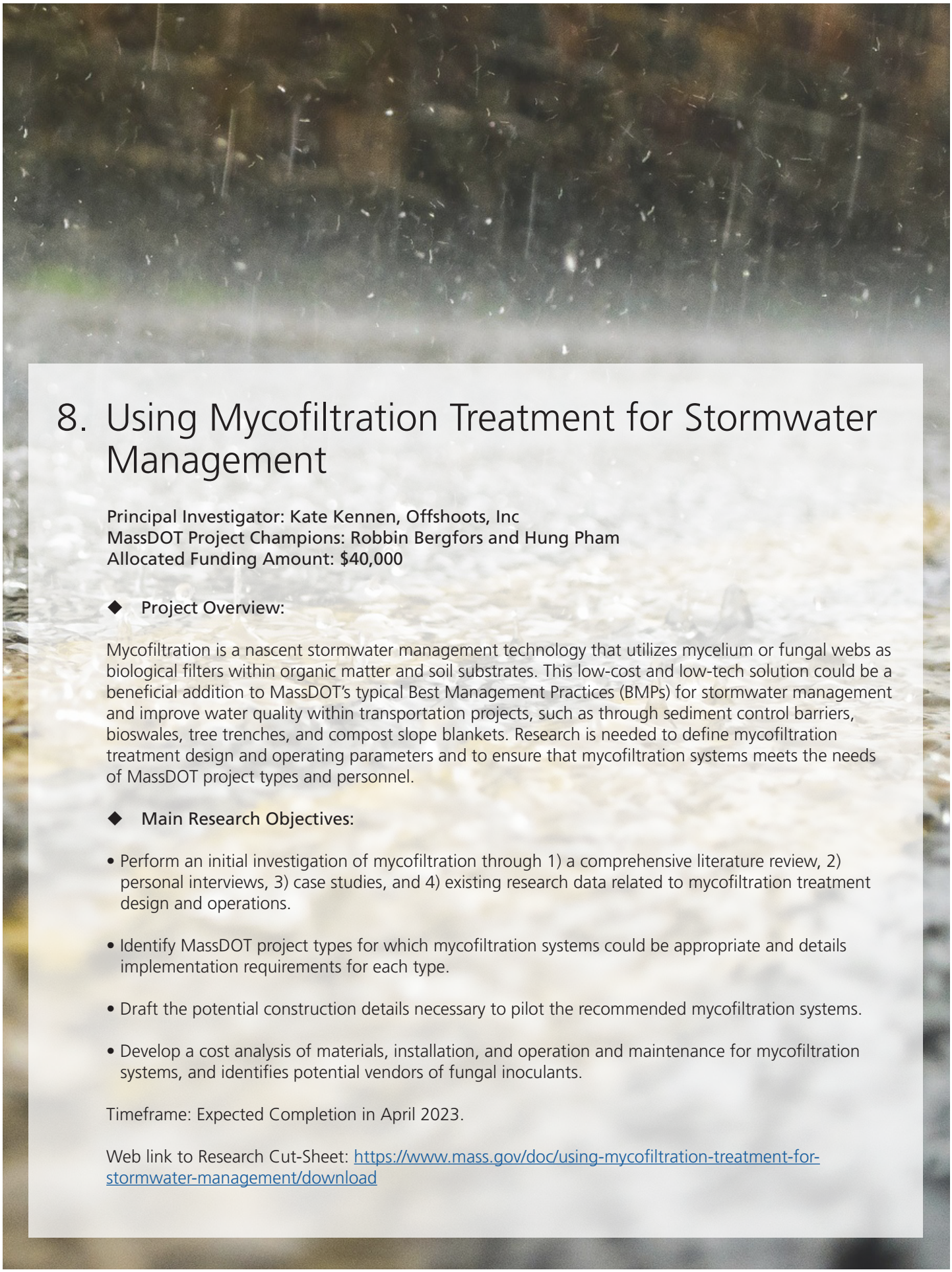
The sharp horizontal curves of highway ramps make them hotspots of truck rollover crashes. Such crashes can block the entire ramp and cause severe congestion. Understanding the major causes of ramp truck rollover crashes is important for developing effective crash risk mitigation strategies and improving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

Timeframe: Expected Completion in September 2022.

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



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 utilizes 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 meets the needs of MassDOT project types and personnel.

◆ **Main Research Objectives:**

- Perform an initial investigation of mycofiltration through 1) a comprehensive literature review, 2) personal interviews, 3) case studies, and 4) existing research data related to mycofiltration treatment design and operations.
- Identify MassDOT project types for which mycofiltration systems could be appropriate and details implementation requirements for each type.
- Draft the potential construction details necessary to pilot the recommended mycofiltration systems.
- Develop a cost analysis of materials, installation, and operation and maintenance for mycofiltration systems, and identifies potential vendors of fungal inoculants.

Timeframe: Expected Completion in April 2023.

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

MEDIUM-TERM RESEARCH PROJECTS

1. Measuring Accessibility to Improve Public Health

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 socio-economic 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.

Timeframe: Expected Completion in January 2023.

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

2. Post-Fire Damage Inspection of Concrete Structures (Phase I)

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

◆ **Project Overview:**

Post-fire inspections of tunnels and decisions on subsequent tunnel closures can involve some uncertainty. Visual inspections to assess fire damage can be difficult as the extent of the damage may not easily be observable. This project sough to improve the understanding of tunnel structural conditions post-fire.

◆ **Key Findings:**

- A survey of post-fire inspection procedures at transportation organizations across the country revealed a lack of existing post-fire inspection procedures for tunnels.
- A preliminary post-fire inspection checklist was developed based on a review of existing literature.
- A proposed radiant heating system for heating tunnel components was tested and validated.

Timeframe: Completed in April 2021.

Web link to Final Report: https://www.mass.gov/doc/post-fire-damage-inspection-of-concrete-structures-final-report/download

3. Implementing the AASHTO Mechanistic-Empirical Pavement Design Guide (Phase I)

Principal Investigator: Dr. Walaa Mogawer, UMass Dartmouth
MassDOT Project Champion: Edmund Naras
Allocated Funding Amount: $200,600

◆ Project Overview:

AASHTO's new Mechanistic-Empirical pavement design method (M-E design) has not yet been implemented at MassDOT and once implemented, M-E design could enhance pavement design, performance, and resiliency. This research project to assist with implementation is proposed in four phases. This first phase (Phase I) focused on a thorough literature review to determine the overall state-of-practice with regards to AASHTO M-E Pavement Design Guide (MEPDG) implementation with focus on local verification and calibration.

◆ Key Findings for Phase I:

- This study is Phase 1 of a four phase larger research project aimed at implementing the AASHTO MEPDG in Massachusetts. The goal of Phase I was to conduct a thorough literature review to determine the overall state-of-practice with regards to AASHTO MEPDG implementation with focus on local verification and calibration.

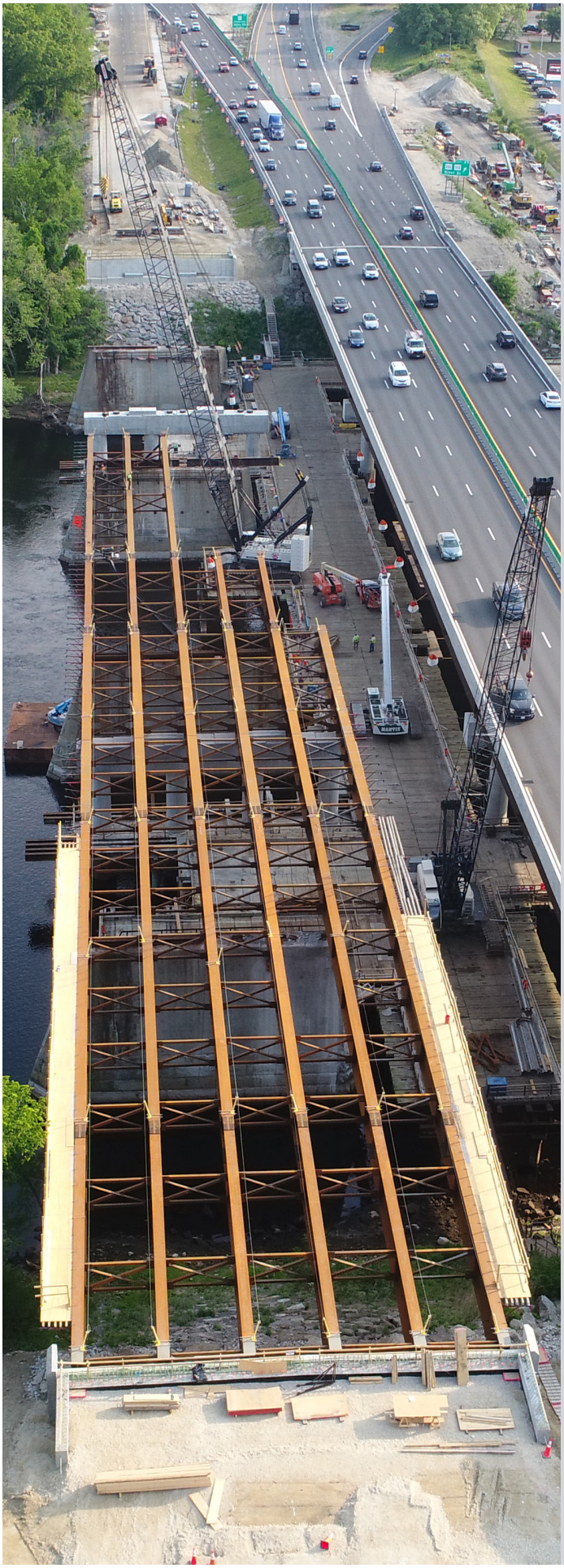
- The literature review of published works by other state agencies that are implementing the AASHTO M-E design method indicated that it is critical to calibrate the distress models using local inputs and available performance data. This is critical because the distress prediction models included in the AASHTO M-E design method were calibrated using a national database which likely does not represent local climatic conditions, traffic, and materials.

- In an effort to accelerate future phases of this research, the research team started generating data for the database needed to conduct the local calibration. Seven plant-produced mixtures were sampled and tested. These mixtures represent the most produced (based on tonnage surface and intermediate course mixtures placed in Massachusetts. From the testing, the necessary Level 1 hierarchal inputs for the asphalt layers were determined. The results were inputted into the AASHTOWare® Pavement M-E to perform trial designs.

Timeframe: Completed in June 2021.

Web link to Final Report: https://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-1-final-report/download

Transportation.org



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

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 will explore 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.

◆ **Main Research Objectives:**

- Survey transportation colleagues to learn about their experiences using AM for construction and maintenance of highway infrastructure.
- Explore additive repair techniques and individual component manufacturing for highway infrastructure projects.
- Engage with MassDOT Highway's maintenance and engineering departments to create a list of potential candidate objects for test printing with AM.
- Develop draft business process recommendations for MassDOT on AM technologies.

Timeframe: Expected Completion in May 2022.

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

5. 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 become more common. The study will gather information to investigate this topic, and then propose strategies to address current driver knowledge gaps and safety concerns.

◆ Main Research Objectives:

- Conduct a literature and market review of the current state of commercially available ADAS technologies, and the deployment of ADAS-equipped vehicles in Massachusetts.
- Assess drivers' knowledge, perceptions, and attitudes towards ADAS.
- Study the impact of drivers' knowledge of ADAS on its use and misuse.
- Develop and evaluate training and other strategies to improve drivers' understanding of ADAS.

Timeframe: Expected Completion in March 2022.

Web link to Research Cut Sheet: https://www.mass.gov/doc/impact-of-advanced-driver-assistance-systems-adas-on-road-safety/download

6. 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:

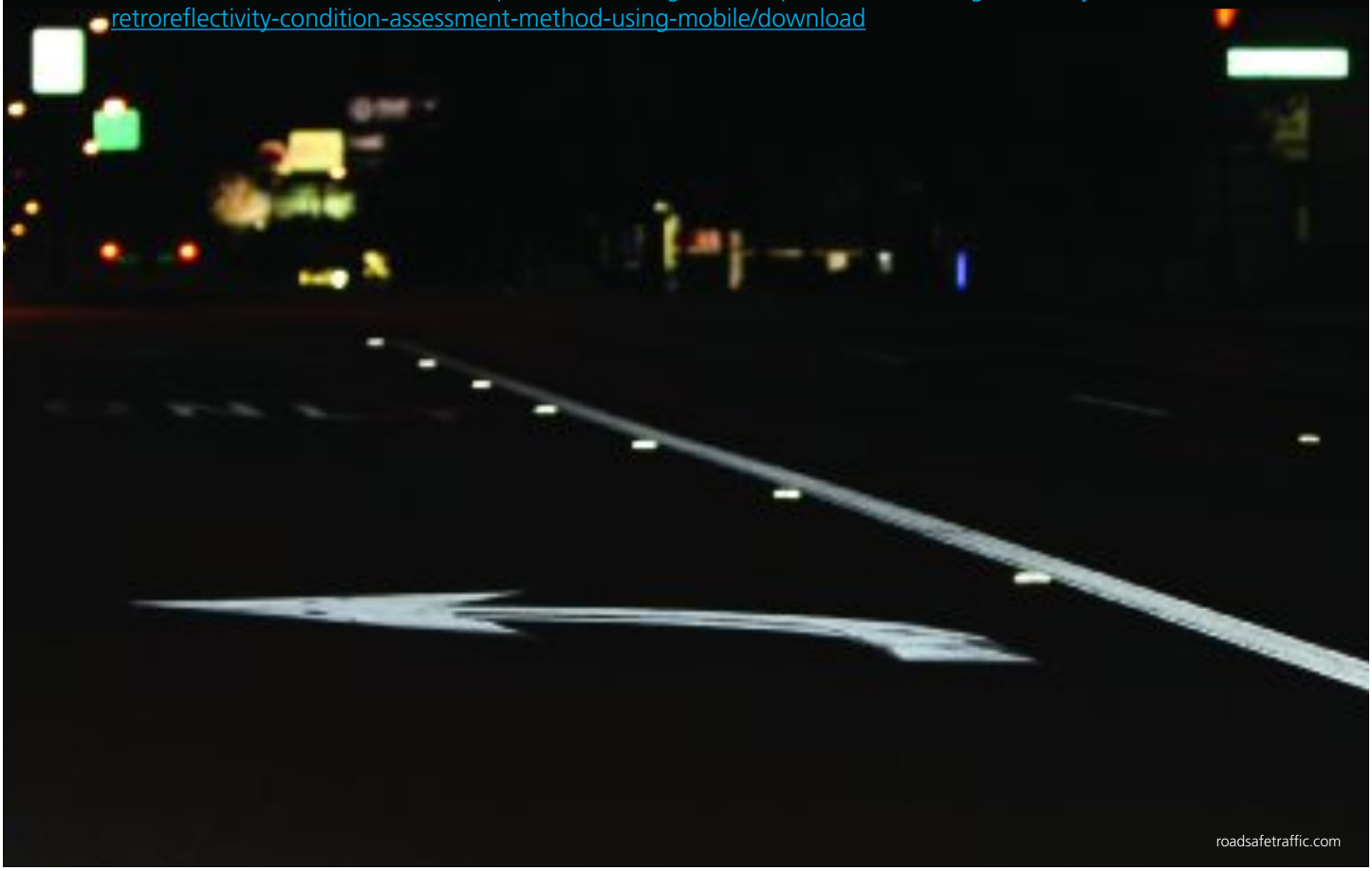
The FHWA is proposing regulations to guide minimum pavement marking retroreflectivity levels. This study seeks to help MassDOT prepare for these regulations by developing an automated method for locating pavement markings and assessing their retroreflectivity, and testing it on a discrete sample of road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

◆ Main Research Objectives:

- Generate a complete inventory of pavement markings and their retroreflectivity for the selected road segments .
- Compare historic and current data to inform the deterioration trends of specific marking materials.
- Define the benefits-to-cost ratio for each of the marking materials, to help inform MassDOT's pavement marking standards

Timeframe: Expected Completion in June 2022.

Web link to Research Cut Sheet: https://www.mass.gov/doc/a-pavement-marking-inventory-and-retroreflectivity-condition-assessment-method-using-mobile/download



7. 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 will explore 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 non-destructive 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 to during future real-world operations using IRT to detect and assess subsurface voids.

Timeframe: Completed in February 2022.

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

8. 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:

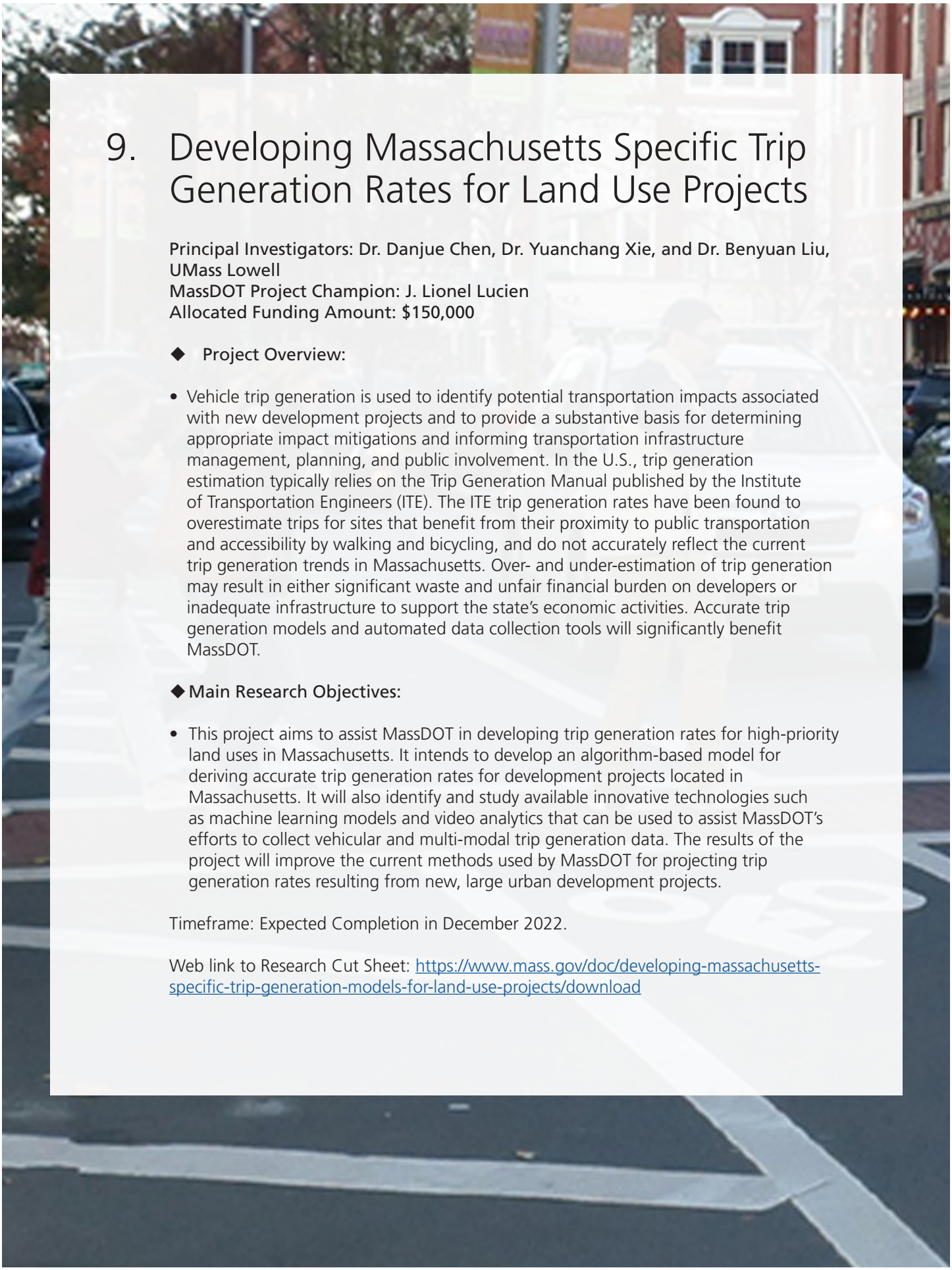
This study builds on research conducted by the same Principal Investigators in an earlier project "The Application of Unmanned Aerial Systems in Surface Transportation", which developed a conceptual UAS emergency response network for emergency highway incident and natural disasters. This subsequent project investigates regarding 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.

◆ Main Research Objectives:

- Conduct a tabletop exercise to test the feasibility of applying UAS for highway incident response.
- Analyze UAS operational parameters based on literature review and tabletop exercise data.
- Based on these analyses, update operational parameters and the initial UAS network for emergency response defined in the earlier study.
- Develop recommendations for effectively integrating UAS into current highway emergency response practices.

Timeframe: Expected Completion in July 2022.

Web link to Research Cut Sheet: https://www.mass.gov/doc/a-uas-network-for-transportation-emergency-response/download



9. Developing Massachusetts Specific Trip Generation Rates 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 and to provide a substantive basis for determining appropriate impact mitigations and informing transportation infrastructure management, planning, and public involvement. In the U.S., 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 under-estimation 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 MassDOT.

◆ Main Research Objectives:

- This project aims to assist MassDOT in developing trip generation rates for high-priority land uses in Massachusetts. It intends to develop an algorithm-based model for deriving accurate trip generation rates for development projects located in Massachusetts. It will also 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 multi-modal trip generation data. The results of the project will improve the current methods used by MassDOT for projecting trip generation rates resulting from new, large urban development projects.

Timeframe: Expected Completion in December 2022.

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

10. Multisource Data Fusion for Real-Time and Accurate Traffic Incident Detection

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

◆ **Project Overview:**

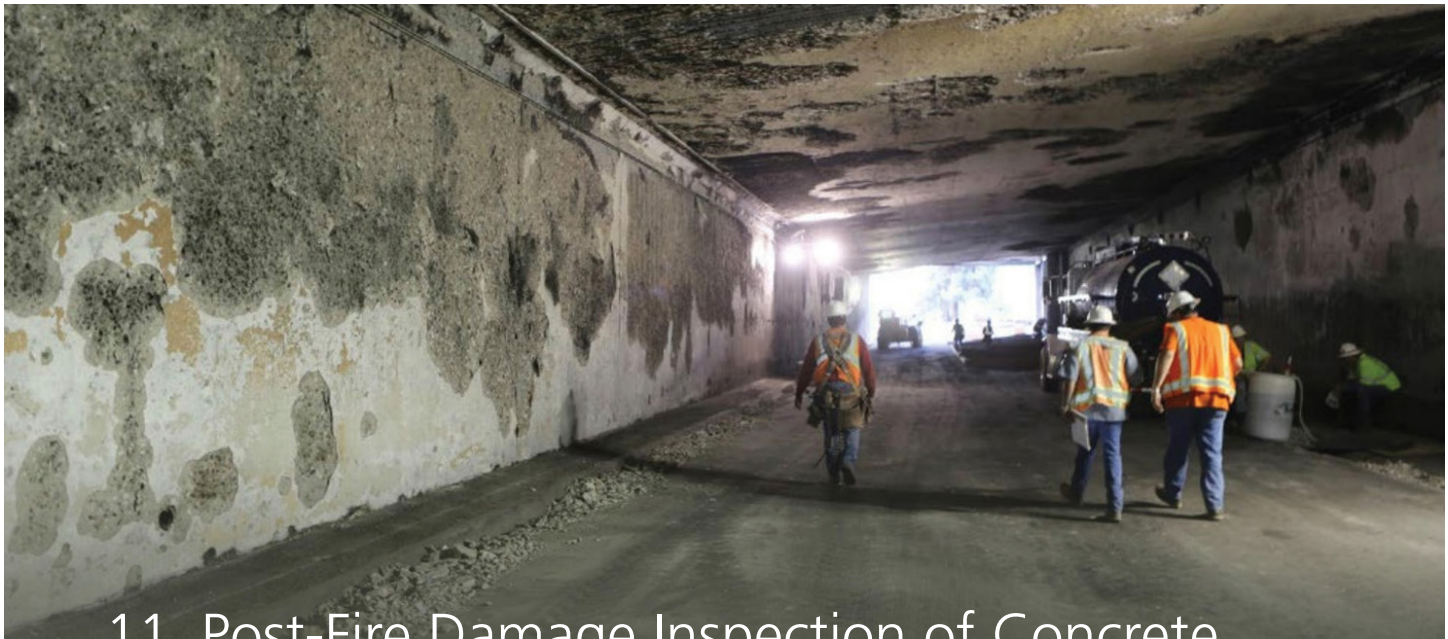
This research will investigate how data from the various traffic data sources that MassDOT owns or has access to can be merged for accurate, real-time traffic incident detection, to improve travel time reliability. It will assess the current traffic incident detection methods employed by MassDOT and develop new tools for improved traffic incident detection based on available traffic data. The research 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 (RTTM) 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 data sets 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 (HOC) operators about incidents on the roads.
- Perform a field test of the "trigger points" on the platform that MassDOT is using for data acquisition.

Timeframe: Expected Completion in December 2022.

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



11. Post-Fire Damage Inspection of Concrete Structures in Tunnels (Phase II)

Principal Investigators: Dr. Simos Gerasimidis and Dr. Scott Civjan, UMass Amherst
MassDOT Project Champions: John Czach, PE
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 will 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 non-destructive 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 non-structural 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 non-destructive testing techniques.

Timeframe: Expected Completion in February 2023.

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

12. 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.

Timeframe: Expected Completion in November 2022.

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

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

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 non-users to 'nudge' them towards 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 non-user preferences on types of RTTI and the value users and non-users place on the information, before and after the implementation of OIPs.
- Estimate the potential of OIPs in reducing greenhouse gas emissions.

Timeframe: Expected Completion in November 2022.

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

14. 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 will develop an AASHTOWare® Pavement M-E user manual and develop a local experimental plan and sampling template for Massachusetts. During this phase, the project team will develop a standalone manual that shows a user a thorough step-by-step procedure on how to use the AASHTOWare Pavement M-E Design software. The manual will guide 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. Additionally, in Phase II, 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 will be developed. The primary tier parameters in the sampling template should be distress dependent and likely will include pavement type; surface layer type and thickness; and subgrade soil type. This experimental and sampling plan will provide the foundation for Phase III efforts.

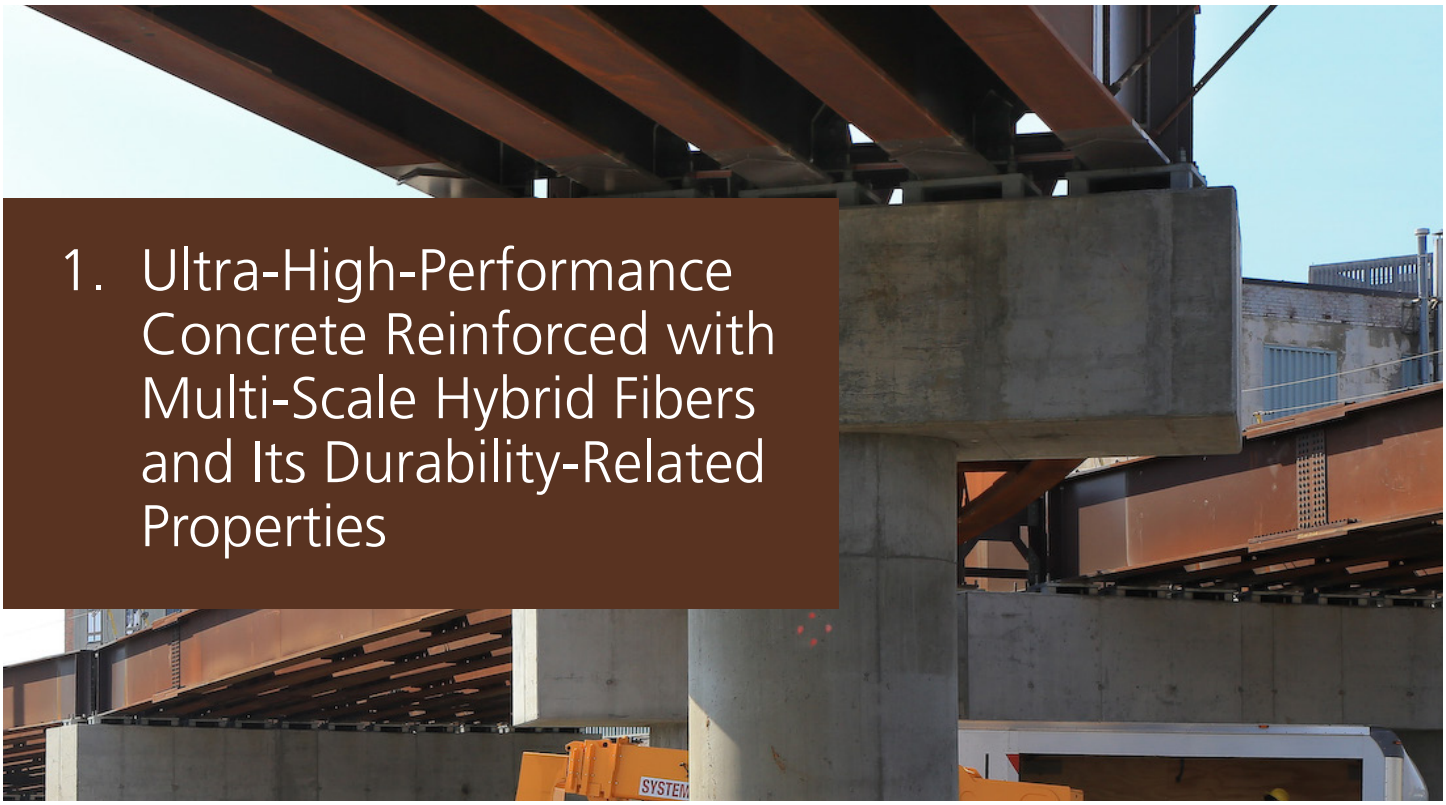
◆ Main Research Objectives:

- Develop an AASHTOWare® Pavement M-E user manual & local experimental plan and sampling template.
- Continue initial testing of already sampled mixtures to accelerate future phases of this research.

Timeframe: Expected Completion in September 2022.

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

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 Breña, 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 and 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 threats 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, non-proprietary, Fibe 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.

Timeframe: Expected Completion in October 2023.

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

2. Translating Data Generated by the Transit App into Insights on Transportation Use in Greater Boston

Principal Investigators: Dr. Daniel O'Brien, Dr. Qi Wang,
Dr. Justin de Benedictis-Kessner, Northeastern University
MassDOT Project Champions: Jen Elise Prescott and Anna Gartsman
Allocated Funding Amount: $300,000

◆ Project Overview:

This research project used data from the Transit App to gain a fuller understanding of customers' journeys to improved bus networks, improve real-time response to disruptions and information provision, and allow more holistic planning. This app captured the real-world decision-making of riders as they considered multiple travel options.

◆ Key Findings:

- The descriptive analyses and machine learning models revealed patterns of both competition and complementarity between Transportation Network Companies (TNC) and public transit, adding evidence and nuance to both sides of an ongoing debate.
- Highlighted areas in which TNC services may complement public transit, particularly in addressing the "last-mile problem."
- Generated results including that users who regularly ride public transit during commuting hours were more likely to tap on TNCs and that other contextual factors, including time of day and precipitation, were not predictive of TNC selection.

Timeframe: Completed in April 2021.

Web link to Final Report: https://www.mass.gov/doc/translating-data-generated-by-the-transit-app-into-insights-on-transportation-use-in-greater-boston-final-report/download

3. Flexible Transit Services in Rural Areas

Principal Investigators: Dr. Eric Gonzales and Dr. Eleni Christofa, UMass Amherst
MassDOT/MBTA Project Champion: Abril Novoa Camino
Allocated Funding Amount: $165,000

◆ **Project Overview:**

Conventional transit service can be inefficient for areas with low density and dispersed demand. There is a need to identify flexible transit services that could be operated more cost-effectively in communities that are difficult to serve with fixed routes. The research provided quantitative models and identified appropriate markets for flexible transit. The research also provided qualitative insights on the best practices for planning and implementing flexible transit.

◆ **Key Findings:**

- The demand threshold to select flexible transit or microtransit depends on the size of the region, the distribution of demand in time and space, and the characteristics of the vehicles. Both the literature and modeling suggest that when demand is distributed and the density is less than 10 trips/hr. per square mile, flexible transit is more efficient than fixed routes.

- Demand responsive microtransit often either replaced under-performing fixed route service or introduced service to areas with low demand density. Several RTAs have expanded or are planning to expand microtransit to more geographic areas or more hours of service.

- COVID-19 suppressed demand for most travel, but microtransit continued to serve a critical need in some communities. Lower demand made the initial implementation easier, as RTAs could take time to work out the details of apps, scheduling, marketing, etc. The viability of microtransit during the pandemic showed that it is a resilient transit solution, especially for rural and suburban communities.

Timeframe: Completed in July 2021.

Web link to Final Report: https://www.mass.gov/doc/flexible-transit-service-final-report/download

berkshireeagle.com

4. Development of Comprehensive Inspection Protocols for Deteriorated Steel Beam Ends

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

◆ **Project Overview:**

Recently completed MassDOT research projects have found new parameters which are extremely important for assessing the residual capacity of deteriorated bridge steel beams for the load rating procedure. Drawing on the recent findings during the development of the new load rating procedures, this project first documents the current state of practice of beam end inspections, then explores new technological solutions for improvement of inspection techniques using LiDAR and unmanned aircraft systems (drones), and finally performs preliminary analysis of a bridge system.

◆ **Key Findings:**

- Developed effective and consistent procedures for collecting important data from deteriorated steel beam ends and providing 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 or drone technology to obtain the critical measurements.
- Developed a comprehensive inspection and documentation protocol which 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 which would require future research or advanced modeling that cannot be described by the new load rating procedures.

Timeframe: Completed in September 2021.

Web link to Final Report: https://www.mass.gov/doc/revised-load-rating-procedures-for-deteriorated-prestressed-concrete-beams/download

5. Understanding Asset Management Systems Utilized by Municipalities in Massachusetts

Principal Investigator: Dr. Walaa Mogawer, UMass Dartmouth
MassDOT Project Champions: Edmund Naras, Bryan Pounds, 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 utilizing differing approaches. MassDOT needs 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.

◆ **Main Research Objectives:**

- Catalog the different asset management systems being used by cities, towns (municipalities), metropolitan planning organizations (MPOs), and regional planning agencies (RPAs) throughout Massachusetts.

- Prepare a report describing the different asset management systems used, type of data collected, and how that data is being utilized in decision making.

- Explore if the data collected and the condition assessment can be harmonized.

Timeframe: Expected Completion in September 2022.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/understanding-asset-management-systems-utilized-by-municipalities-in-massachusetts/download

6. 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 which 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 utilizing a Beam Fatigue, Semi-Circular Bend (SCB) and Hamburg Wheel Tracking tests. Through this research project, MassDOT would like to determine if using a dense graded polymer modified high performance thin overlay mixture provides the same (or better) performance and life cycle costs compared to the asphalt rubber gap graded mixtures in which MassDOT have 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 life cycle cost analysis for the optimized mixture types.

Timeframe: Expected Completion in October 2023.

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

7. Revised Load Rating Procedures for Deteriorated Prestressed Concrete

Principal Investigators: Dr. Sergio Breña, Dr. Simos Gerasimidis, Dr. Scott Civjan, and Dr. Jessica Boakye, UMass Amherst
MassDOT Project Champion: Matthew Weidele
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 which exhibit deterioration to avoid unnecessary bridge closures while also keeping the public safe. This project is envisioned to be 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.

Timeframe: Expected Completion in August 2023.

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

COOPERATIVE RESEARCH PROGRAM PROJECTS

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

Principal Investigators: Dr. Francis Tainter and Dr. Cole Fitzpatrick, UMass Amherst
MassDOT Project Champion: Jim Danila
Allocated Funding Amount: $100,000

◆ Project Overview:

MassDOT has been working to retrofit over 350 traditional protected-permissive left-turn (PPLT) traffic signals to include the flashing yellow arrow (FYA) permissive signal indication. This purpose of this project was to investigate the safety impacts and cost-effectiveness of the FYA signal indication and the retrofit installations.

◆ Key Findings:

- The results provided overwhelming evidence that the FYA reduced the average annual number of injury-related crashes, and ultimately led to a lower economic cost of injuries at all three of the treatment types investigated in this study.
- Economic benefits suggest that the FYA signal retrofits should be widely implemented, regardless of intersection type.

Timeframe: Completed in April 2021.

Web link to Final Report: https://www.mass.gov/doc/evaluating-the-safety-impacts-of-flashing-yellow-permissive-left-turn-indications-in-massachusetts-final-report/download

2. Construction and Materials Best Practices for Concrete Sidewalks (Phase I)

Principal Investigators: Dr. Sergio Breña and Dr. Kara Peterman, UMass Amherst
MassDOT Project Champions: Richard Mulcahy and Amy Bisbee
Allocated Funding Amount: $285,000

◆ **Project Overview:**

This project explored the potential factors that are thought to contribute to the deterioration of concrete sidewalks over winter freezing and thawing cycles and identified materials and construction practices for reducing this deterioration. Identification of these factors was performed through a combination of laboratory testing of hardened concrete (scaling resistance, petrographic analysis, air void structure analysis, and chloride content) and photographic documentation conducted at the site. Phase II of this research project will focus on curing/sealing compounds and workmanship under hot weather conditions.

◆ **Key Findings:**

- Following cold weather concreting practices in accordance with the American Concrete Institute guidelines is essential to avoid surface scaling damage of sidewalks subjected to the rigors of winter treatment and freeze-thaw cycling.

- Quality control during all phases of mixture design, fabrication, construction, and maintenance is fundamental to control the tendency of concrete sidewalks to scale after being subjected to only a few freeze-thaw cycles. Concrete curing that strictly complies with cold weather concreting techniques should be followed to decrease susceptibility of surface scaling.

- Best practices can be developed in the construction and maintenance of concrete sidewalks to increase their freeze-thaw durability by mitigating surface scaling. The best practices are intended to translate in lower maintenance and replacement costs.

- Standard specification can be developed for the construction and maintenance of concrete sidewalks subjected to freeze-thaw cycles and winter treatment operations to prevent surface scaling in the short term. Quality control during all phases of mixture design, fabrication, construction, and maintenance is fundamental to control the tendency of concrete sidewalks to scale after being subjected to only a few freeze-thaw cycles. Concrete curing that strictly complies with cold weather concreting techniques should be followed to decrease susceptibility of surface scaling.

Timeframe: Completed in April 2021.

Web link to Final Report: https://www.mass.gov/doc/construction-and-materials-best-practice-for-concrete-sidewalks-final-report/download

3. Synthesis study: Best Practices for Designer Cost Recoveries

Principal Investigator: Dr. Michael Plotnikov, UMass Amherst
MassDOT Project Champion: Jerrell Riggins
Allocated Funding Amount: $40,000

◆ **Project Overview:**

MassDOT wants to enhance its cost recovery procedures for construction projects, focusing on holding designers accountable for their mistakes, improve overall design quality, and save resources. The objective of the research was to gather and analyze information regarding best cost recovery practices used by State DOTs and to modify and enhance as appropriate existing MassDOT Cost Recovery Procedures previously revised in 2017.

◆ **Key Findings:**

The report made the following recommendations:

- Encourage the Designer's involvement in the construction and early operation stages of the project.
- Reconsider the threshold to initiate a CR process; the current amount of $5,000 is based on the dated 1997 CR policy and much lower construction costs; Consider at least $20,000 for a single occurrence and $50,000 for cumulative occurrences.
- Consider establishing a threshold to initiate litigation; Consider at least $100,000 as a starting point.
- Improve the Designer evaluation process; consider the implementation of evaluation methods outlined in Caltrans and FDOT CR policies; establish the Designer's rating database with the Department as one of the elements to initiate the cost recovery process.
- Expand a training program on both project delivery and cost recovery process for MassDOT employees, Designers, and construction contractors.

Timeframe: Completed in September 2021.

Web link to Final Report: https://www.mass.gov/doc/best-practices-for-cost-recovery-final-report/download

4. Automated Guardrail Inventory and Condition Evaluation

Principal Investigator: Dr. Chengbo Ai, UMass Amherst
MassDOT Project Champions: Neil Boudreau
Allocated Funding Amount: $100,000

◆ **Project Overview:**

MassDOT actively works with FHWA to plan and manage Manual for Assessing Safety Hardware (MASH) upgrades. The need exists to integrate the guardrail asset within MassDOT's asset management plan with a complete guardrail inventory. This project will develop and validate new automated LiDAR and video-log imagery processing methods for identification and extraction of in-service guardrail, and then will evaluate the condition of the guardrails using representative pilot-testing road sections.

◆ **Main Research Objectives:**

- Develop an automated method for determining the presence of guardrails along the roadway and for extracting critical information, including georeferenced starting and ending points, terminal types, curb presence, lateral offset and elevation.
- Develop an automated method for identifying typical conditional changes for guardrails, including face dent, end terminal damage/missing, guardrail support deficiency.
- Investigate the feasibility of identifying missing bolt or connection failure of guardrails using image processing.

Timeframe: Expected Completion in May 2022.

Web link to the Research Cut Sheet: https://www.mass.gov/doc/automated-guardrail-inventory-and-condition-evaluation/download

5. Construction & Materials Best Practice for Concrete Sidewalks (Phase II)

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

◆ **Project Overview:**

Building off from Phase I of this research, MassDOT is seeking to improve the durability of concrete sidewalks under hot weather conditions in Massachusetts to reduce the maintenance and reconstruction costs. This project will continue to explore the deterioration, such as scaling of concrete sidewalks. There are currently extensive knowledge gaps in developing durable concrete.

◆ **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.

Timeframe: Expected Completion in September 2022.

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

RESEARCH IMPACTS AND OUTCOMES

Utilizing Research Findings at MassDOT

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 all MassDOT Project Champions (PCs), to the Principal Investigators (PI) and Project Managers (PM) involved with recently completed research projects to understand how research results are utilized by the agency, and research implementation impacts the agency's processes and procedures, as well as on related industry practices. The PIs provided information on knowledge transfer efforts including the dissemination of research findings and the future workforce development impacts that the funded projects have by engaging students in research investigation.

The survey responses from the PCs included a range of implementation techniques within MassDOT. In the most successful cases, research findings/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 incorporated into the updated version of the MassDOT Bridge Manual. The findings from the "Characterization of Recycled Asphalt Pavements in Massachusetts" project provided scientific foundation for the Pavement Section to pilot high-percent (25-35%) RAPs at selected interstate pavement sites. The most common theme from the PCs who responded was the findings/results from the research reports have been shared with other MassDOT personnel who may play a crucial role in implementing or utilizing the research results. Some of this information has also been disseminated to private firms (working with MassDOT), regional and federal transportation agencies (e.g. MPOs, Regional Transit Agencies and FHWA). Sharing this information across different transportation spectrums allows key stakeholders to be involved and provide feedback. The PC is also looking to include the report findings in the guidance that is provided to consultants designing MassDOT projects, and to internal Highway Design staff performing relevant safety and design components in proposed transportation construction projects.

Disseminating Research Results through Digital Publication

All final MassDOT research reports are publicly accessible in the sense of both being available online and being compliant with accessibility requirements. MassDOT, FHWA and UMTC work together to finalize and have each report be 508 compliant. Once a report is 508 compliant, the report is published on the MassDOT Research and Technology transfer webpage alongside with 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 and International and National Conferences

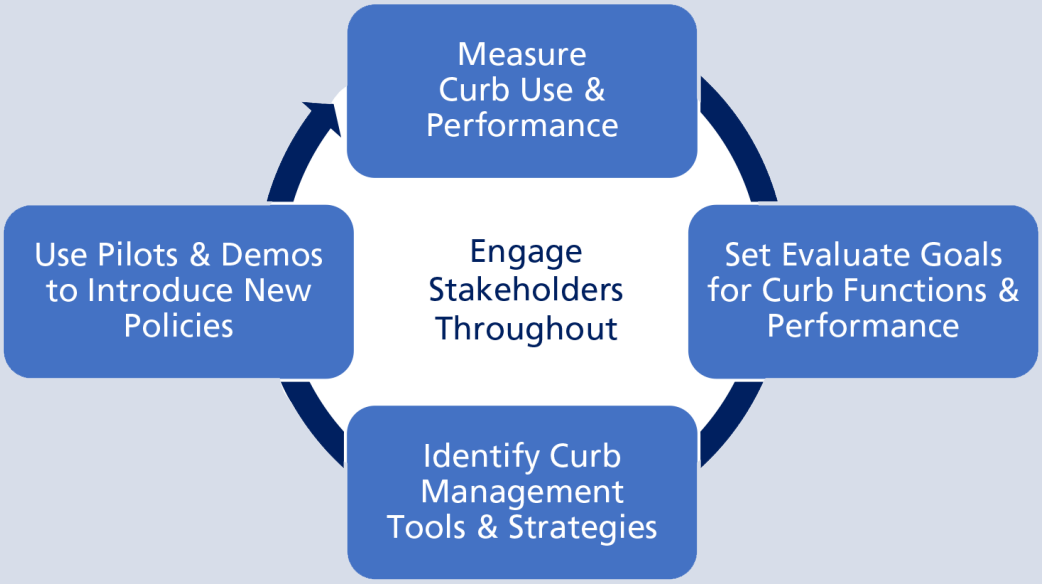
MassDOT research projects and findings were shared internationally, across the nation and within the Commonwealth during 2021. Key findings and data were presented at two national/international conferences - the 2021 Transportation Research Board (including presenting at the poster sessions) Annual Meeting (held virtually) and the 2021 Rural Transportation Association Workshops (also virtual). On the state level, research reports and project findings were presented at the 2020 MassDOT Moving Together Conference (virtual) and 2021 MassDOT Innovation Conference (virtual). MassDOT's virtual conference were able to reach audiences on a local, state, regional, national, and international scale. The conferences' virtual format allowed for more attendees, including from different states and countries than would have been possible if the conferences had been held only in-person.

Sharing Research within Massachusetts

Baystate Roads provides municipalities with community forums and opportunities to connect with peers across the state via the weekly Stump the Instructor webinars and the Baystate Roads Listserv. During 2021, MassDOT utilized the Stump the Instructor forum to share research findings, and recommendations with municipalities and their departments of public works. The MassDOT Project Champions and the Principal Investigators of two completed research projects in this report presented a summary of their research at Stump the Instructor webinars during FFY2021. These research projects were Best Practices for Cement Concrete Sidewalk Materials, and Construction and Improving the Future of the Commonwealth's Curb. These Stump the Instructor webinars allowed the research PCs, PIs and practitioners to engage in dialogue on the research and ways the projects' recommendations can be implemented.

The Improving the Future of the Commonwealth's Curb project demonstrated there are many competing needs and uses for curb space in Massachusetts. Examples of current use include storage, green space, repair and maintenance, waste management, mobility, access for people and access for commerce. Accommodating certain uses may require diverse types of infrastructure, including signage and paint, technology, and constructed infrastructure. Input from 15 stakeholders brought to light four general themes around existing curb uses, needs, and expectations for the future: 1) Primary Users of the Curb, 2) Data, 3) Policy Changes, and 4) Future Needs.

The Question-and-Answer session following that webinar allowed representation from local, town, and regional levels to ask questions about the methodology of this research and gather ways to approach curb use in their communities.



Rapid deterioration of concrete sidewalks has been observed across the Commonwealth after only a few cycles of freezing and thawing. The Construction and Materials Best Practices for Concrete Sidewalks (Phase 1) project determined best construction practices that result in durable concrete sidewalks. Best practices include activities during concrete fabrication and placement, finishing procedures and time to initiate finishing operations, and curing method and duration. Based on the results of this project, the PC and PIs launched a second phase to study the effects of concrete placement during warm summer months instead of the cold fall months.

The Stump the Instructor webinar on the concrete sidewalk research provided members of the public and private sectors with an opportunity to gather information on a variety of materials, concrete mixtures, and construction practices. It also allowed questions on curing and sealing compounds, curing set-time, condition assessment and prohibitive mix to be addressed.

When appropriate, MassDOT project champions utilized their formal roles, professional connections and regular interactions with the metropolitan planning organizations, regional planning agencies and regional transit authorities within Massachusetts to update them relevant research activities and share complete research findings. For example, the Flexible Transit project key recommendations were presented at a Massachusetts Association of Regional Transit Authorities quarterly meeting, and the MPOs were regularly briefed on the progress of the "Understanding Asset Management Systems by Municipalities" at the their statewide working group meetings, and the Future of Commonwealth Curb final report was shared with all MPOs.

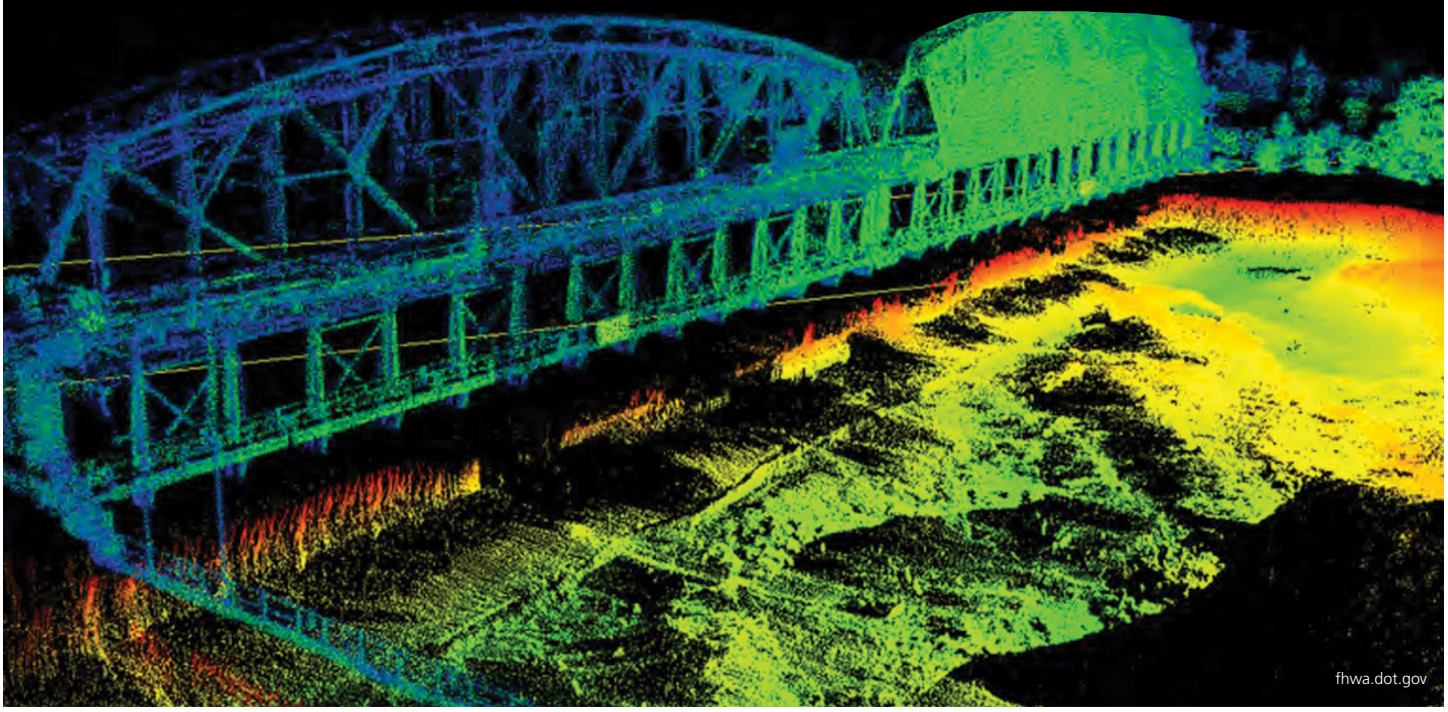
Training the Next Generation of Transportation Professionals

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, developing and calibrating computational models, they are continuously exposed to designing research, choosing methodologies, conducting research investigation, drawing conclusions, and presenting results effectively. With this hands-on experience and having some of the PIs incorporate their research projects 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% 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 carefully 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' perspective and real-world experiences and 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, utilizing 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 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. This will make it possible to create and update comprehensive state-wide asset inventories and condition assessments.



TECHNOLOGY TRANSFER AND TRAINING SERVICES

In FFY 2021, 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).

COVID constraints remained a challenge to provide the LTAP audience, and much of the usual MTS training, as face-to-face (F2F) classroom training. Consequently, a variety of remote options and new support materials continued to be the predominant training and outreach methods used, including virtual classroom, blended learning, online training, and webinars. These various remote options can be defined as:

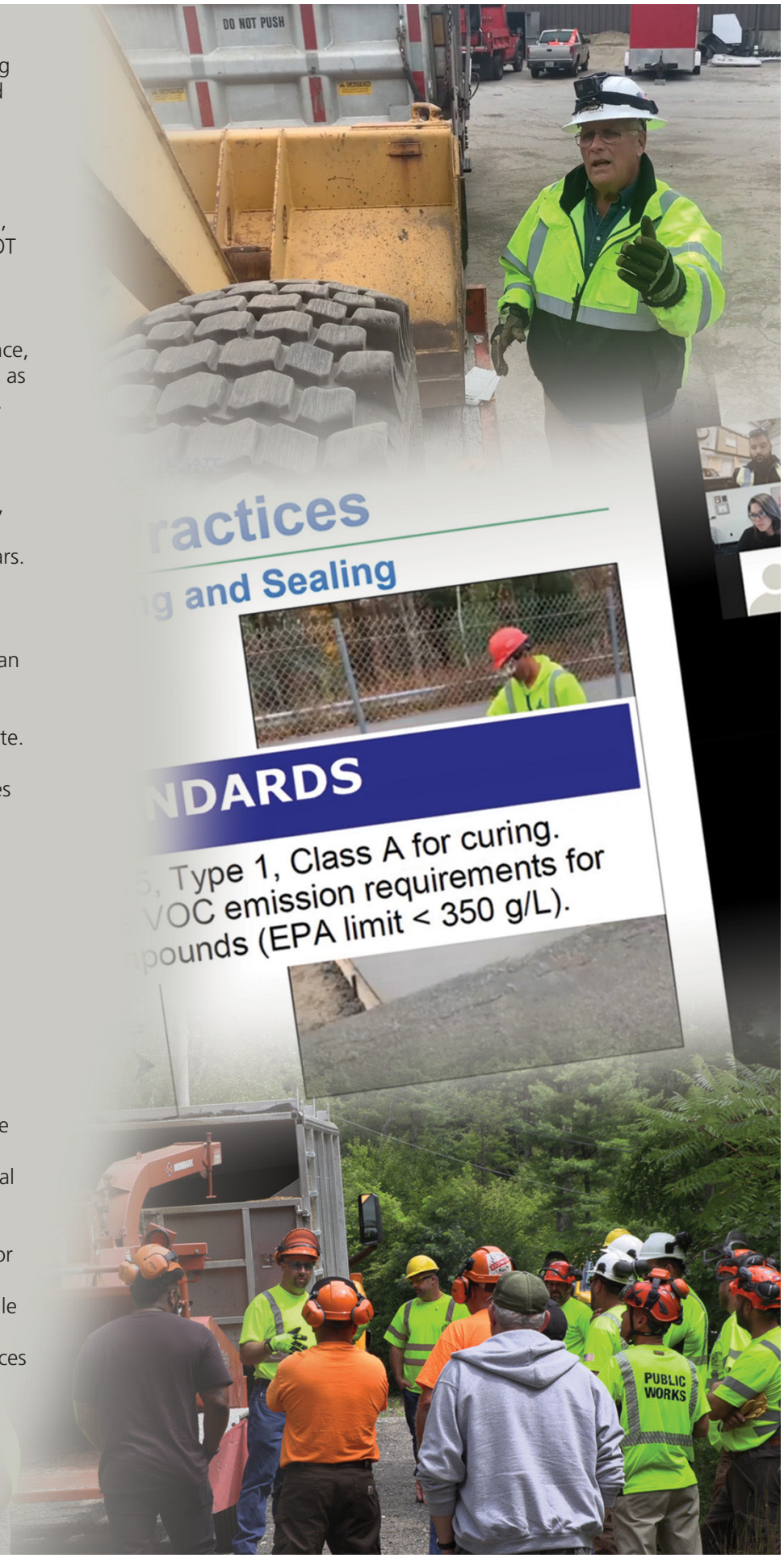
Virtual classroom: Live training via an online platform (ie., Zoom). Classes may be condensed or broken into several presentation dates to complete.

Online Training: 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 1-hour presentation conducted on a virtual platform (i.e., Zoom).

People learn differently and respond to different approaches. Face-to-face training works best for some; others prefer the convenience of a live virtual class. A self-paced approach allows the most flexibility, whether working through a structured online course, or linking to reading, watching videos, or listening to related podcasts. While classroom options continued to be limited this year, new training resources were developed with a variety of learning preferences and ongoing public safety efforts in mind.



Overview

During FFY2021, Baystate Roads (BSR) conducted a total of 120 training sessions on 57 topics to municipalities and towns across the Commonwealth. Adjusting and expanding virtual training options this year, BSR increased events provided by 25% over FFY2020 numbers.

In addition to Baystate Roads municipal training focus, the technical training needs of Massachusetts DOT Highway Division personnel were addressed through the MassDOT Training Services (MTS). A total of 77 classes were conducted in FFY21, providing training services to 1,609 participants. These numbers reflect an increase of 175% additional training sessions, compared with FFY2020.

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 an annual training plan, classes are offered to municipal personnel and contractors based on local needs and MassDOT priorities. Training, including customized classes, are offered statewide from a technical training specialist and a variety of additional professional providers.

Following the launch of remote training options in FFY2020, the growth in virtual and blended training opportunities in FFY2021 was unprecedented, with virtual class offerings increasing by 650% and blended learning sessions increasing by 633%. Overall BSR training participation rates fell 13%, while the overall number of training options increased by 25%. Webinar attendance was the primary training category with a participation loss. However the development of more virtual training options, and participation gains moved attendees to more substantive events, i.e., from 1 hour webinars to 2 to 6 hour virtual classes. Concrete reasons for the loss in webinar attendance is difficult to pinpoint, but webinars could be familiarizing this new audience with the benefits and ease of virtual training. Once comfortable with 'how things work', attendees graduated to longer virtual and blended classes. With the expansion of virtual and blended training options, training topics more specific to audience needs was one draw. Almost twice as many virtual training classes became available during this time.

A breakdown of the 120 training session approaches and participation numbers follows, with FFY20 comparison data.

Training Approach	# Sessions FFY21 (FFY20)	# Participants FFY21 (FFY20)	Training Options % Change FFY20 to FFY21	Participation % Change FFY20 to FFY21
Face-to-Face	0 (55)	0 (1,225)	NA	NA
Webinar	34 (28)	1,213 (2,063)	+ 21%	- 41%
Virtual Class	60 (8)	1,546 (118)	**+ 650%**	**+ 1,210%**
Online	3 (2)	35 (87)	+ 50%	- 60%
Blended Learning	22 (3)	278 (22)	**+ 633%**	**+ 1,163%**
	120 (96)	3,072 (3,515)	**+ 25%**	- 13%

Baystate Roads - New Topics, Formats & Resources

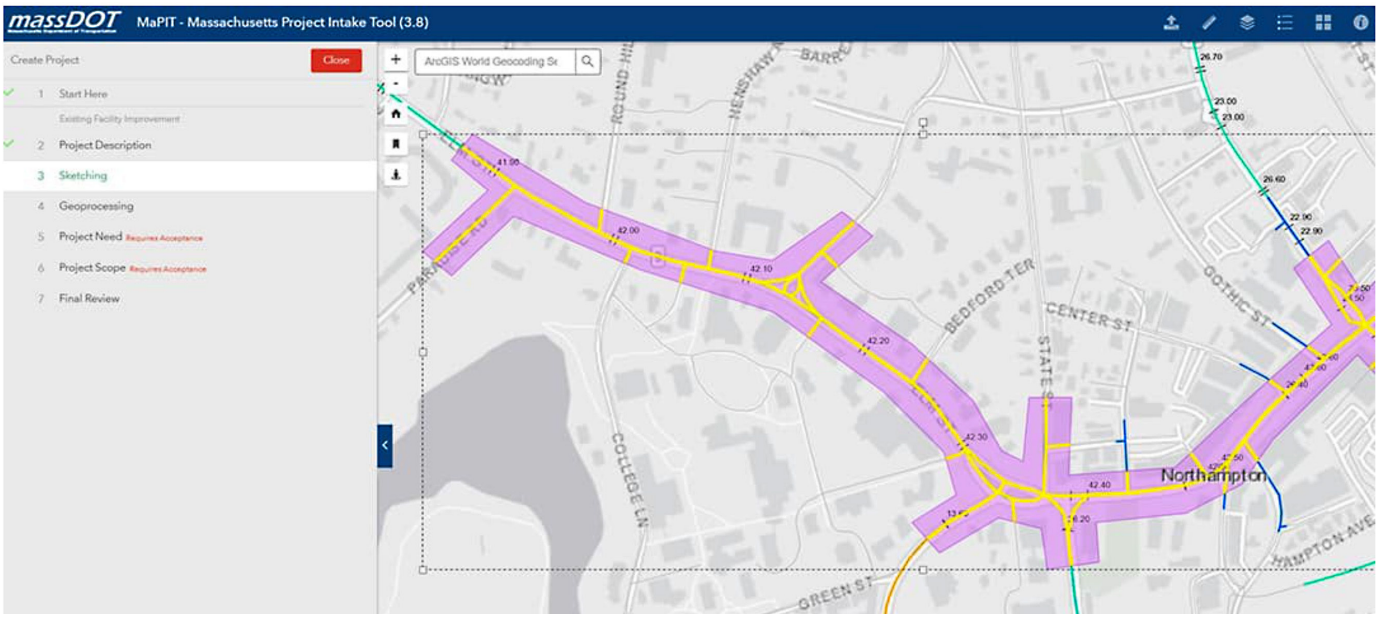
During FFY21, 57 unique training topics were presented, some in multiple formats (i.e., several associated webinars or a webinar and longer virtual class). Of these 31 – or 46% - were new topics or sub-topics, addressing local roadway safety, construction, maintenance, operations, and personnel development. Training subjects addressed both the changing needs of the LTAP core audience and ongoing efforts that now required a remote presentation format. New training topics ranged from: APWA and Your LTAP, How to Hire Competent People, and Social Media training, to Asphalt Project Estimating and Stormwater System Maintenance and Green Infrastructure Retrofitting in MA. A complete list of training subjects follows this report section.

Virtual Classroom Highlights

Hosted on the Zoom Meeting platform, Baystate Roads virtual training continued as a strong alternative to face-to-face classes. Virtual training opportunities rose dramatically with continued social-distancing constraints, increasing from 8 to 60 classes (a gain of **650%**), and participation similarly rising from 118 to 1,546 (a **1,210%** gain).

Roundabouts

Presented in conjunction with the new MassDOT Guidelines for the Planning and Design of Roundabouts (Sept 2020), virtual training highlights this year included a unique **10-part** Roundabouts series. LTAP training was a natural accompaniment to this publication, as the Guidelines were designed to improve the planning and design process for Baystate municipalities. Each monthly segment presented a stand-alone sub-topic, including segments on Introduction, Planning, Stakeholders & Public Outreach, Analysis, Design Overview, Design Checks, Single Lane Roundabout Design, Design Details, People Walking & Biking, and Large Vehicles. The series was attended by 236 participants.



Using MaPIT for Chapter 90

Anticipating an influx of new municipal Complete Streets project proposals, the MassDOT MaPIT training initiative increased this year to include **7** virtual classroom sessions and development of an updated instructional recording. The virtual training efforts were attended by **469** participants. UMTC and Mass.Gov Chapter 90 websites also posted copies of the recorded video, resulting in an additional **265** views, to date.

Complete Streets
The MassDOT Complete Streets initiative also expanded this year, with the provision of **7** virtual classroom sessions. Attended by **190** participants, this new series included the required 201: Designing Your Streets for People class, as well as a new 300-level series with training on Bicycle/Pedestrian Network Planning, Traffic Calming Design, Design Workshop, and Public Engagement.

The expanded series provided partner municipalities an opportunity to expand their Complete Streets knowledge, guide them to think differently about their transportation networks, devote time to specific important topics relevant to them, help them improve the scopes of their local projects be implemented more successfully.

MassDOT understands that best practices change over time, so these courses keep folks up to speed on the latest safety and design standards. While geared more towards municipal staff, local officials and private consultants working closely with Complete Streets found the courses immensely helpful as well.

Blended Learning Highlights

Development of blended learning options was the second highest training growth area in FFY2021, with sessions offered increasing by 633% and participation rates by 1,163%. Five courses were designed or redesigned for a blended approach this year. Class components included virtual classroom meeting(s) preceded by self-paced modules and/or followed by a web-based certification exam.

Flagger/1st Aid Certification
Redesign and MassDOT approval of a blended learning Flagger/1st Aid Certification class allowed the renewal of a backlog of municipal flagger certifications. New course materials included the addition of props for virtual instruction, revised PowerPoint presentation, and development of a video that included a construction work zone drive-through, and recap of the primary flagger role, responsibilities, and safety measures. Participants attend a virtual Red Cross approved first aid section, flagger-specific training, and then return to the UMTC web site to complete their individual Flagger Exam. Fourteen Flagger/First Aid Certification courses were presented this year and attended by 187 participants. The exam passing rate was 95%, with 178 attendees receiving their certification.

Webinar Highlights

Stump the Instructor
During FFY21, Baystate Roads presented 34 Stump the Instructor (STI) episodes, attended by 1,213 participants. This popular webinar series kicked off shortly after the pandemic started, providing the public works audience a means to connect with Baystate Roads personnel, subject matter experts, MassDOT representatives and each other. Seeking to educate and inform, program segments covered a broad range of topics, including environmental, safety, engineering, regulations, maintenance, operations, design, and public health information. Webinar recordings were captioned and are available on-line.

Online (Self-Paced) Training

Three online courses were available in FFY2021. To the existing UMTC courses on *Traffic Signal Warrants: How to Perform, Assess, and Satisfy the Requirements of Each* and *FAA Drone Pilot Exam Prep* was added a full-length on-demand recorded *Rigging and Load Securement* class. This free 45 minute video includes both onsite and class PowerPoint segments, providing a concise, yet thorough understanding of the rigging and load securement process. This resource has been viewed 73 times to date. https://vimeo.com/469849758.

Online multi-module training employs the largest effort to develop in-house. Current expansion plans include contracting training provided by other sources, including self-paced safety training from SafetySkills.com and promotion of well-designed AASHTO TC3 courses, including their *Plan Reading* and *Introduction to GIS Mapping* courses.

Additional Resources

The FFY20 development of Resource Sheets, on-demand and micro-training videos continued in FFY21, allowing Baystate Roads to address additional information needs and learning preferences.

Resource Sheets provided in FFY21 include:
- *Capital and Municipal Budgeting*
- *Funding Resources*
- *Street Trees*

The FFY20 development of Resource Sheets, on-demand and micro-training videos continued in FFY21, allowing Baystate Roads to address additional information needs and learning preferences.

Additional video training development included three projects; a Leadership training series, Transportation Take-Away series, and a new safety Lock Out/Tag Out Tailgate training video.

Leadership series videos offer multiple tips & tools to assist new (and old) supervisors with workplace and communication strategies. They are specifically helpful for those who are transitioning from colleague to supervisor or those interested in a leadership position.

Shorter, micro-training videos continue to be a popular way to learn something new. The Transportation Take-Away series continued its 3rd year, with video development produced via a socially distanced approach, with most presenters filming themselves and sharing the video for post-production editing. The results were a unique blend of informative and entertaining shorts, including:

- *Transportation Applications of LiDAR*
- *Auto Stop-Start Engine Function*
- *Transportation Safety in the Post-COVID*
- *Developing a Traffic Management Plan*

Technical assistance is the heart of any LTAP center. In FFY21 Baystate Roads responded to over 25 reported requests from different agencies and municipalities. Information, expertise shared, and materials included:

- Hoisting regulations and laws
- Gravel road maintenance
- Attending virtual Select Board meetings
- CDL requirements
- USDOT contact information
- HMA estimating
- geoDOT accounts
- MassDOT Work Zone Safety booklets
- Stormwater retrofitting
- General snow and ice control
- Work sheets for estimating salt and brine usage for pretreatment
- Liquid Anti-Icers
- FMCSA drive time exemption for municipal drivers
- Programming a new ground speed controller
- Troubleshooting salt brine issues
- Calibration charts
- Study materials for the Massachusetts Hoisting Engineers exam
- Geotextile expert recommendation
- Trench/Excavation safety checklists
- GEO Grid systems
- Trench safety
- Proper work zone safety signs

These new and expanded FFY21 training options and resources highlight the ongoing transition underway at the Massachusetts LTAP center. As we wait for in-person classroom training to resume, the number and variety of training and support options continues to expand the Baystate Roads toolbox.

FFY 2021 Training Topics Provided

- A Sign of the Times
- *APWA and Your LTAP
- *Backhoe and Equipment Maintenance
- Better Concrete Sidewalks
- *Better Mouse Traps
- Chainsaw – Part 1
- Chainsaw – Part 2
- *Chainsaw Live Demo*
- *CMV/CDL new requirements are coming!
- *Culvert Assessment Success Stories
- *COVID-19 Vaccination Resistance in the Workplace
- *DigSafe
- Don't Go in the Hole
- Excavation & Trench Safety
- Got Mud?
- Gravel Roads Maintenance
- How is the Weather in Sudbury?
- *How to Deal with Difficult People
- *How to Hire Qualified People
- *Lexington Pavement Management Excellence
- *Lighting Sidewalks, Cycle tracks and Crosswalks
- MA Hoisting Engineer Regulations and Questions
- *New England Road Talk: A Different* Approach to Virtual Education and Training
- Porous Pavement Do's & Don'ts
- *Road Resources
- *Roadway Slope Stabilization
- *Spotted Lanternfly and Other Invasive Insects in Massachusetts
- *Social Media as Easy as 1, 2, 3
- *Stump the Highway Administrator
- To Pre-treat or Not to Pre-treat?
- Want to Walk on Water?
- What's Dripping from that Truck?
- What Is That White Stuff?
- Work Zone Safety

Virtual Classroom:

- All About Liquids
- *Asphalt Inspection: Best Management Practices
- *Asphalt Project Estimating
- *Best Management Practices for Beaver Control
- *Capital Budgeting
- Class 2 and 4G Hoisting CEU
- Complete Streets:
  - 201: Designing Your Streets for People
  - *303- Bicycle/Pedestrian Network Planning
  - *304- Traffic Calming Design
  - *305 - Workshop Design
  - *306 - Public Engagement
- *Drainage – Roadway Maintenance and Reconstruction
- *Elements and Maintenance of Back Road Drainage
- Gravel Roads: When the Dust Settles
- *Invasive Species
- MaPIT 3.0
- Municipal Operating Budget
- *NHI-131139V Constructing and Inspecting Asphalt Paving Projects
- *NHI-133121V Traffic Signal Design and Operation
- OSHA 10 Hour Construction Training
- *Over-the-Rail Mower Safety & Operation
- *Pavement Markings: Use, Application, Compliance and Materials
- *Rigging & Load Securement
- *Roundabouts Series
- Snow and Ice Operations for Front Line Employees
- Snow and Ice Operations for Supervisors
- Spreader Calibration
- *Stormwater System Maintenance and Green Infrastructure Retrofitting in MA
- *Street Tree Essentials
- Trenching and Excavating Safety
- *Using MaPIT for Chapter 90
- *Wood Chipper Safety
- Work Zone Safety

Blended Learning (5/4):

- *Confined Space Training
- *Flagger/First Aid Certification
- *Grader Operator
- Pavement Preservation: Right Treatment, Right Time, Right Road
- *Sign Installation & Maintenance

Online/Self-Paced (3/1):

- Traffic Signal Warrants: How to Perform, Assess, and Satisfy the Requirements of Each
- FAA Drone Pilot Exam Prep
- *Rigging and Load Securement

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

MassDOT Training Services (MTS)

The technical training needs of Massachusetts Department of Transportation Highway Division personnel were addressed by MassDOT Training Services (MTS). A total of **77** classes were conducted this year, reflecting an increase of **175%** over the initial pandemic closure in FFY 2020. Services were provided to **1,609** MassDOT employees, reflecting a similarly high increase of **118%**.

MassDOT Training Services (MTS) continued to offer a variety of training approaches in FFY 2021, including: virtual and blended classes, online self-paced courses, video options and face-to-face (F2F) training. As pandemic conditions allowed, classroom training was provided with appropriate safety procedures in place.

MTS: New Topics, Formats and Resources

During FFY2021, MTS presented 22 unique training topics, of which 7 – or 32% - were new topics, including bridge software and inspection, highway construction specifications, and intersection design and operation. An additional 11 – or 50% - were prior presentations that were redesigned for a remote format. Overall, remote training represented 86% (66) of the classes presented and 90% (1,452) of the FFY2021 audience.

Topics addressed both the changing needs of the MassDOT audience and ongoing efforts that required a remote presentation format. A complete list of training subjects follows this report section.

Training Approach	# Trainings Provided FY2021	Participants FY2021	% Training Change from FFY2020 to FFY2021	% Participant Change from FFY2020 – FFY2021
Face-to-Face	11	157	- 50%	- 71%
Virtual	26	816	**333%**	**444%**
Blended	38	623	**3,800%***	**62,300%***
Online	2	13	**100%**	**333%**
	77	**1,609**	**175%**	**118%**

**No Blended classes were presented in FFY2020*

FFY2021 MTS Highlights

Highlights this year included a new effort to improve concrete finishing results and development of a unique approach to Work Zone Safety training.

Virtual Classroom Highlights

Exterior Flatwork Finisher Certification
Improving concrete durability is a high priority, that was addressed this year with a significant effort to train MassDOT personnel through the National Ready Mixed Concrete Association (NRMCA)'s *Exterior Flatwork Finisher Certification* class. The goal of certification is to ensure that knowledgeable contractors are selected to install concrete slabs and minimize the potential for failure resulting from installation practices.

Five hundred and ten people were identified for *Exterior Flatwork Finisher Certification* and a series of 10 virtual sessions completed the training for 384 employees this year. Certification provided personnel with information on accepted industry practices to minimize the occurrence of scaling and other durability-related problems.

Blended Training Highlights

Work Zone Safety
Four unique blended *Work Zone Safety* training classes were also kicked off this year, with specific information for MassDOT Construction Field Personnel, Construction Supervisors, Maintenance Field Personnel, and Maintenance Supervisors. The course included three self-paced online modules, followed by a 2-hour virtual or F2F (live) classroom session. Video segments, PowerPoint information and graphic elements were included in the self-paced segments and allowed participants to complete more fundamental information as schedules permitted. More advanced and interactive discussions could then be provided during the virtual or F2F meeting; 32 classroom sessions were held.

Over 500 Construction supervisors and field personnel participated in this training series, with additional Maintenance training to follow.

Training Topics

The 22 topics presented this year varied significantly, including numerous safety, construction, maintenance, and design options.

*Listed by presentation approach, *indicates new FFY2021 topics, and **indicates those presented previously, but using a new remote format.*

Virtual

- *BridgeSight PG Super Software Training
- *FHWA-NHI-130041V - Principles and Applications of Highway Construction Specifications
- FHWA NHI - 130053V - Bridge Inspection Refresher Training
- *FHWA-NHI-131139V - Constructing and Inspecting Asphalt Paving Projects
- FHWA-NHI-133121V Traffic Signal Design and Operation
- *FHWA-NHI-380078V - Signalized Intersection Guidebook Workshop
- FHWA-NHI-380091V Planning and Designing for Pedestrian Safety
- **FHWA-NHI-134006 Utility Coordination for Highway Projects
- FHWA-Performance Based Intersection Design & Operation Workshop (PBIDO)
- NRMCA Exterior Flatwork Concrete Certification
- **OSHA-10 Hour Construction Training
- **Trenching & Excavation Safety

Online

- Traffic Signal Warrants: How to Perform, Assess, and Satisfy the Requirements of Each
- Rigging and Load Securement - On Demand Video

Blended

- **Confined Space
- Sign Installation & Maintenance
- **Work Zone Safety for Construction Field Personnel
- **Work Zone Safety for Construction Supervisors

F2F Training

- Bucket Truck Operation & Safety
- Chainsaw Safety and Storm Damage Awareness Training
- FHWA-NHI-134006 Utility Coordination for Highway Projects
- FHWA-NHI-380032A - Roadside Safety Design
- Large Mower Operation & Safety
- Wood Chipper Operation & Safety

Gauging Impacts of Training

Remote Training Evaluation

Training evaluation is an essential part of the development process. This year, several sources provided audience feedback, including specific training, remote training acceptance, and post training application. Input from 962 LTAP and MTS participants was gathered from the following three sources:

- Annual LTAP Training Needs Survey (102)
- Cumulative LTAP FFY2022 virtual training evaluations (357)
- MTS blended Work Zone Safety participant evaluations (503)

Although some participants lamented the loss of classroom training, the response to virtual options was highly positive. Seventy-nine percent of annual needs survey respondents participated in some type of remote training this year, primarily the weekly Stump the Instructor webinar (53%), but a variety of other virtual classroom options as well (43%). And LTAP audience acceptance of remote training has significantly increased, with a combined 90% either **Very likely (64%) or Somewhat likely (26%)** to participate in this option in the future.

The outcomes of these virtual training evaluations further supports an increased acceptance and appreciation of virtual training, with a combined 87% identifying that the training they attended was either Extremely Effective (38%) or Very Effective (49%) for the topic presented.

The key to gauging training success is tied to the application of skills and information learned. Seventy-two percent of LTAP Needs Survey participants reported applying webinar or virtual classroom skills/ information to their workplace. Specific details shared included:

Winter operations courses saved about 25% of budget. Safety courses have also helped.

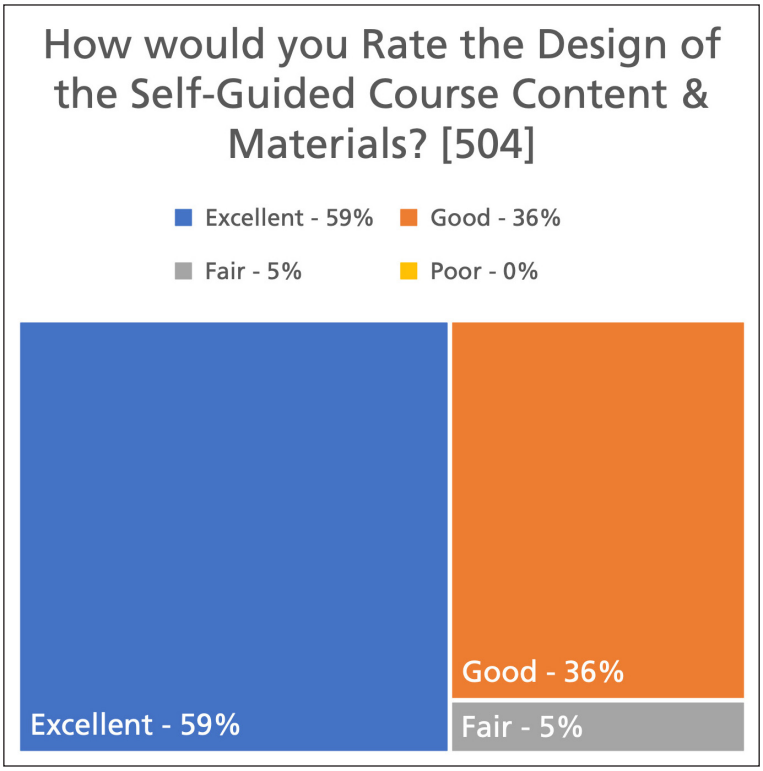
Pavement management training has helped in our assessment/implementation of annual street improvement projects.

We used the culvert assessment training. We developed a digital assessment form (for GIS) based on the form provided at the training. We sent some interns to the training who were then able to do field work for us.

Pavement management course was helpful while reviewing consultant's PCI analysis.

And moving forward, even as F2F training resumes, a majority of Needs Survey respondents (72%) selected a variety of remote options and independent resources as top delivery methods to meet their training needs. These results are encouraging as they support continued expansion of training delivery methods, even as we return to in-person classes.

In-Person Classes	**29%**
Remote Interactive Options	**40%**
Virtual class	*19%*
Webinar	*8%*
Blended training	*13%*
Self-Paced/Applied Resources	**32%**
Tailgate talk materials	*5%*
On-demand video	*8%*
Self-paced online training	*6%*
Resource sheets	*6%*
Job Aids	*7%*



MassDOT Training Services - Work Zone Safety

Design – how a course is laid out, presented, how effectively information is shared and how engaged the participant is a vital component to program success, whether in the classroom or remote. The FFY2021 blended Work Zone Safety training series included online modules specific to DOT requirements, followed by virtual classes. Initial self-paced elements allowed participants to complete more basic training on their own timetable, while the virtual class focused on more advanced and interactive components. To assess the success of this approach, a Level 1 evaluation was included upon completion. Data from over 500 participants follows.

How was the self-guided content and materials rated?

Of the 504 participants who completed the training, 59% rated this portion of the blended program Excellent and another 36% (a combined 95%) Good.

How likely are you to take another blended class?

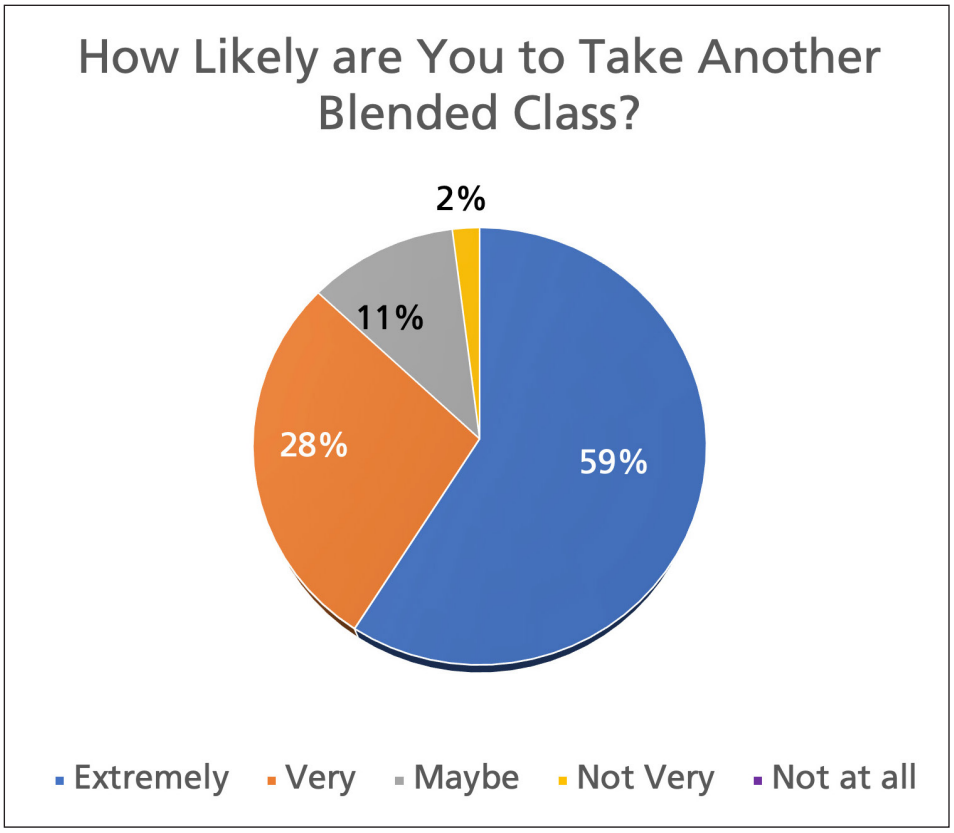
Fifty-nine percent of participants indicated that they would be Extremely Likely to take another blended training class, with another 28% in the Very Likely category; a combined 87%. A few related comments received included:

- "This was a great format with both self-guided and the virtual. Only suggestion would be to continue in this fashion."
- "I Love This Training. Very Informative."

What new information will you apply to your job or share with your supervisor/team?

Several thoughtful comments were received on specific information participants were most likely to apply and/or share with others, including:

- "I learned quite a bit about how we as engineers are responsible on site for safety and how we can manipulate and inspect safety setups to be as effective as possible on various roadways."
- "Better communications with all involved, police fire, coworkers, etc."
- "Where police cruiser should be located, Police Officer Ahead sign should be used if the police officer will be directed traffic, and more."
- "I learned new information on pedestrian access and rolling road-blocks that will be very useful in the future."
- "Everything taught in the course was new to me because I am a new hire."



Additional comments?

Additional comments received focused on a variety of related suggestions and preferences, including learning styles, scheduling, content, access, and audience:

- "It was an excellent refresher course because we change projects and different scenarios arise."
- "It was very well presented, and material was put into a simple form that everyone could relate to."
- "All private personnel working for contractors working on MassDOT projects should have to complete this course and pass. This will not be done 100% correct until you have them pass the course."

Public Outreach: Providing Assistance and Identifying Needs

Baystate Roads acts not only as a training and resource clearinghouse, but also provides our municipal partners with a community forum, an opportunity to connect with peers across the state via the weekly Stump the Instructor webinars and the Baystate Roads Listserv. This year, 43 job openings and 122 additional topics were posted for discussion on the listserv. Subjects ranged from manhole repair to software for snowplow routes, to free webinars, such as *COVID Preparedness for Municipalities? What if?*

Baystate Roads fosters connections with municipal peers and organizations, allowing opportunities for public input and training needs identification. Several approaches provided these opportunities in FFY2021, including the first hybrid Baystate Roads Summer Advisory meeting, participation at county and state highway association meetings, New England Public Works Exposition, New England APWA Snowplow Roadeo, and responses to multiple requests for technical assistance.

The M3 newsletter provides another opportunity to connect with and engage the municipalities. Content includes information on municipal success stories, MassDOT initiatives, Baystate Roads classes and resources, upcoming conferences and events, new Baystate Roads Scholars, transportation research, and other specific topics of interest to the DPW community.

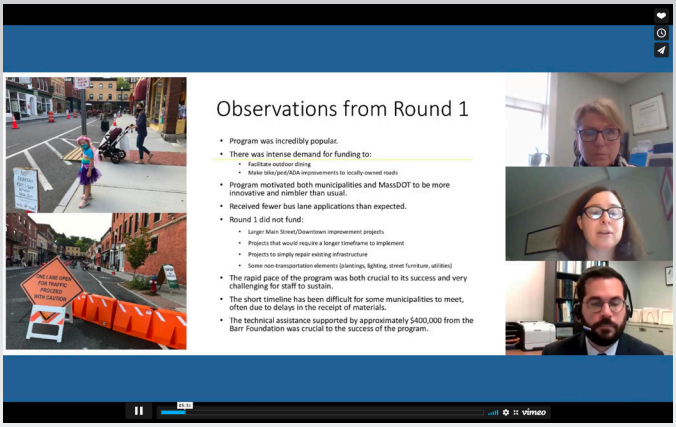
Baystate Roads' participation in broader National Local Technical Assistance Program Association (NLTAPA) and industry training events continues to open a world of potential resource sharing, ultimately improving Baystate Roads products and services. FFY2021 events attended remotely included NLTAPA Regional, Monthly Board and annual meetings, and the live Associated Talent Development International Conference.

MassDOT Conferences

MassDOT hosted their two annual transportation conferences, Moving Together and the Transportation Innovation Conference. Due to COVID-19, the 2020 Innovation Conference, usually held in April, was postponed to Spring 2021 and held virtually.

Moving Together - November 17-19, 2020 (virtual)

For the first time, MassDOT held its annual Moving Together Conference virtually. Over 1280 people registered for the conference across the private and public sectors and nationally and internationally. The conference included 26 sponsors and exhibitors with 30 sessions held. The majority of the audience feedback was they were 'satisfied' or 'very satisfied' with their experience at this virtual conference.



Event Participation

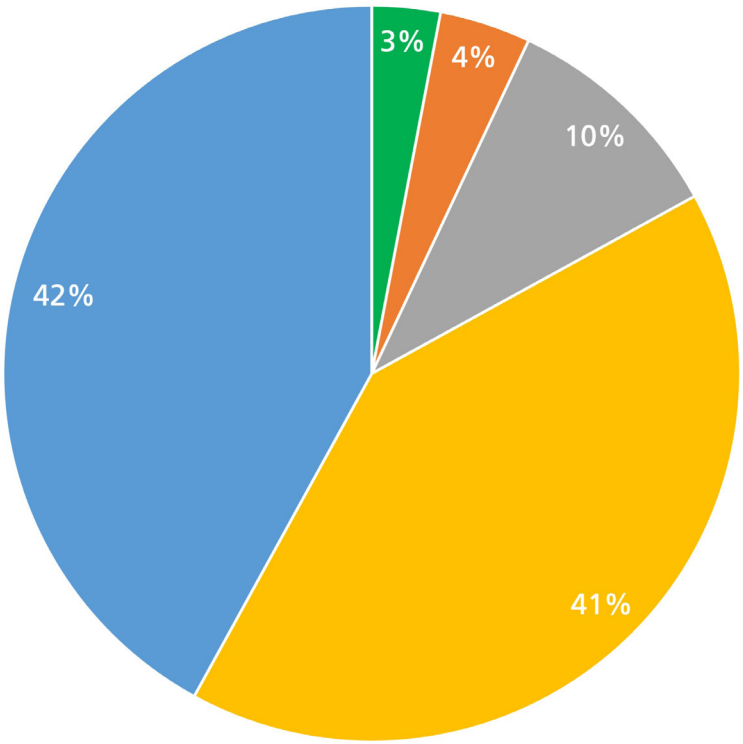
Registrations

MassDOT.....248
Private Sector.....693
Public Sector.....268
UMass Transportation Center.....16
FHWA.....24
RTA.....20
Student.....17

Total Registrations **1,286**

116 attendees responded to the conference evaluation

Overall how would you rate your experience at this conference?



> *"The sessions were done really well. I feel there was something new for everyone this year. I also enjoyed the focus on equity within transportation."*

Transportation Innovation Conference
May 25-27, 2021

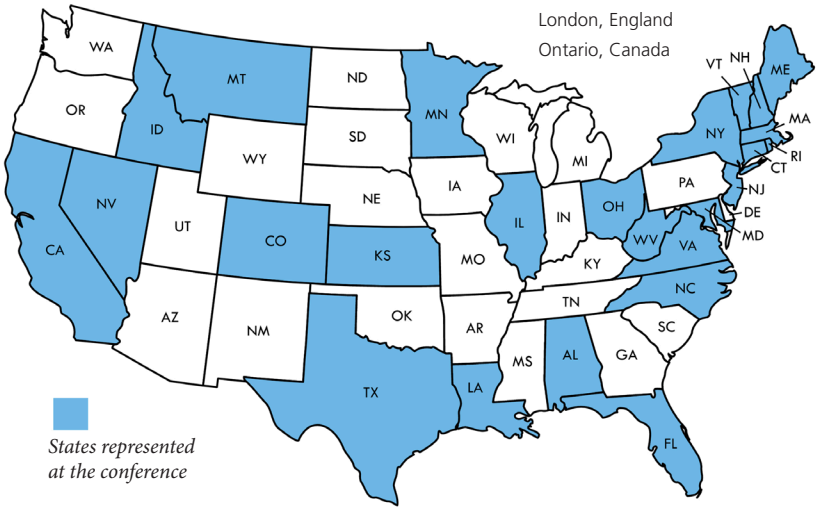
Event Participation

Registrations

MassDOT/MBTA	356
MA State Govt (Non-MassDOT/MBTA)	17
Private Sector	372
Municipal	51
Regional Government/Planning	41
Other State DOT	64
Transit Agency (Non-MBTA)	35
Federal Agency	21
Non-Profit/ Transportation Organization	38
Academia	25
Conference Staff	31

Session Attendance per Day

Day One	544
Day Two	496
Day Three	465

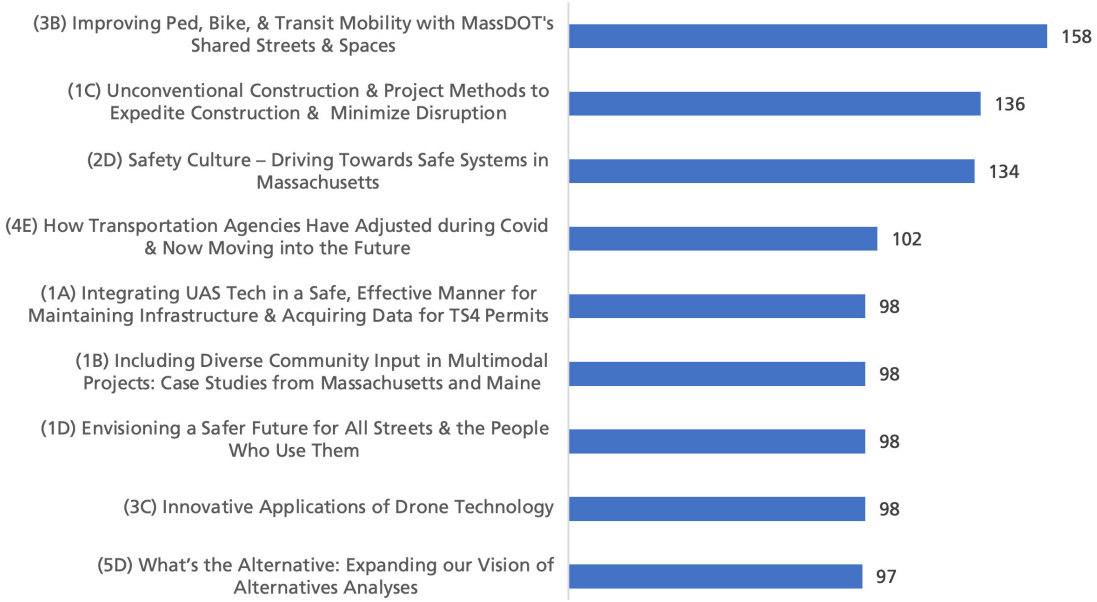


Attendees from Other State DOTs

MassDOT was able to bounce back during COVID and hold the Innovation Conference, virtually, on May 25-27, 2021. There were 1050 conference registrations including attendees from FHWA, US DOT, and at least 16 state DOTs besides MassDOT (Alabama, California, Colorado, Connecticut, Florida, Idaho, Louisiana, Maine, Maryland, Minnesota, New Hampshire, Nevada, North Carolina, Ohio, Vermont, West Virginia). Academic attendees were from: Montana State University; University of Kansas, University of California Los Angeles; Minnesota State University, UMass Amherst; UMass Lowell; UMass Dartmouth; UMass Medical School, and Worcester Polytechnic Institute (WPI).

Total Registrations **1,051**

Most Attended Panel Sessions
(attendance figures do not include panelists)

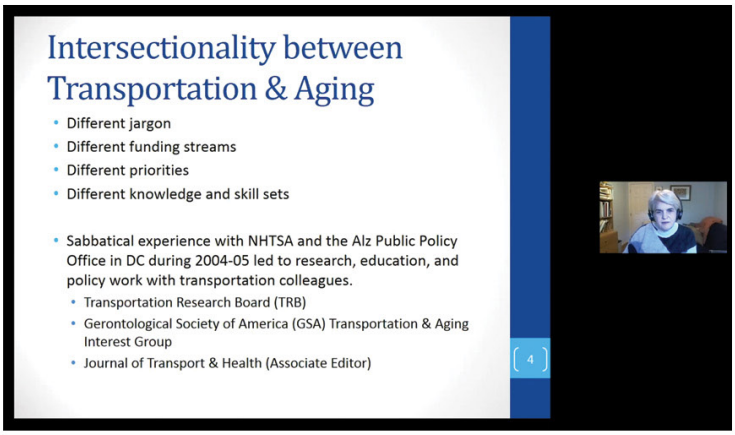


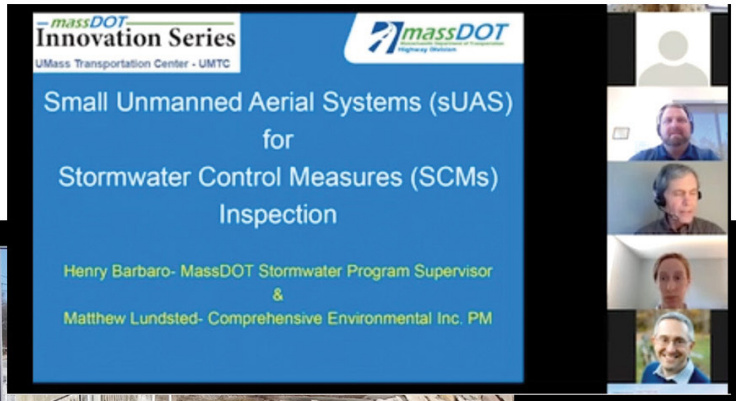
Transportation Innovation Webinar Series, September – October 2020

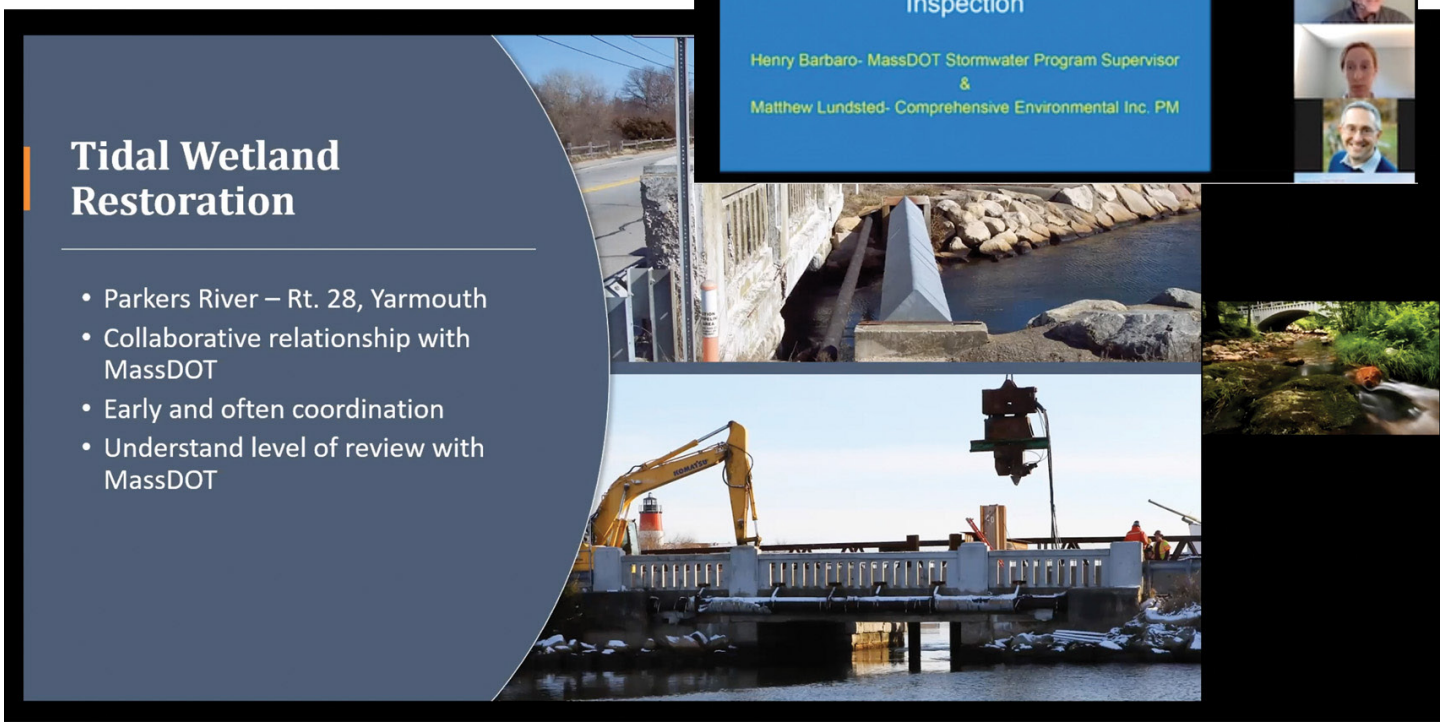
As previously mentioned, the Transportation Innovation Conference was put on hold due to COVID-19. In its place, the Transportation Innovation Webinar Series was held during September and October 2020. Relevant and innovative abstracts submitted for the postponed in-person Innovation Conference were used to create an eight-webinar series program:

- *MassDOT, MassWildlife, & MassDER: Partnering for Resilient Infrastructure & Ecosystems*
- *Managing, Analyzing, & Tracking Materials through LIMMS (Laboratory Information Materials Management System)*
- *Standards & Design for Stream Crossings & Geomorphic Compatibility*
- *New Tools to Characterize Geotechnical Site Conditions*
- *MassDOT's New Design Criteria & Design Justification Process*
- *Universities Exploring Community Transportation*
- *Capital Improvement Initiative - Cross Functional Collaboration for Project Delivery*
- *Small Unmanned Aerial Systems (sUAS) for Wetlands & Storm Control Monitoring*

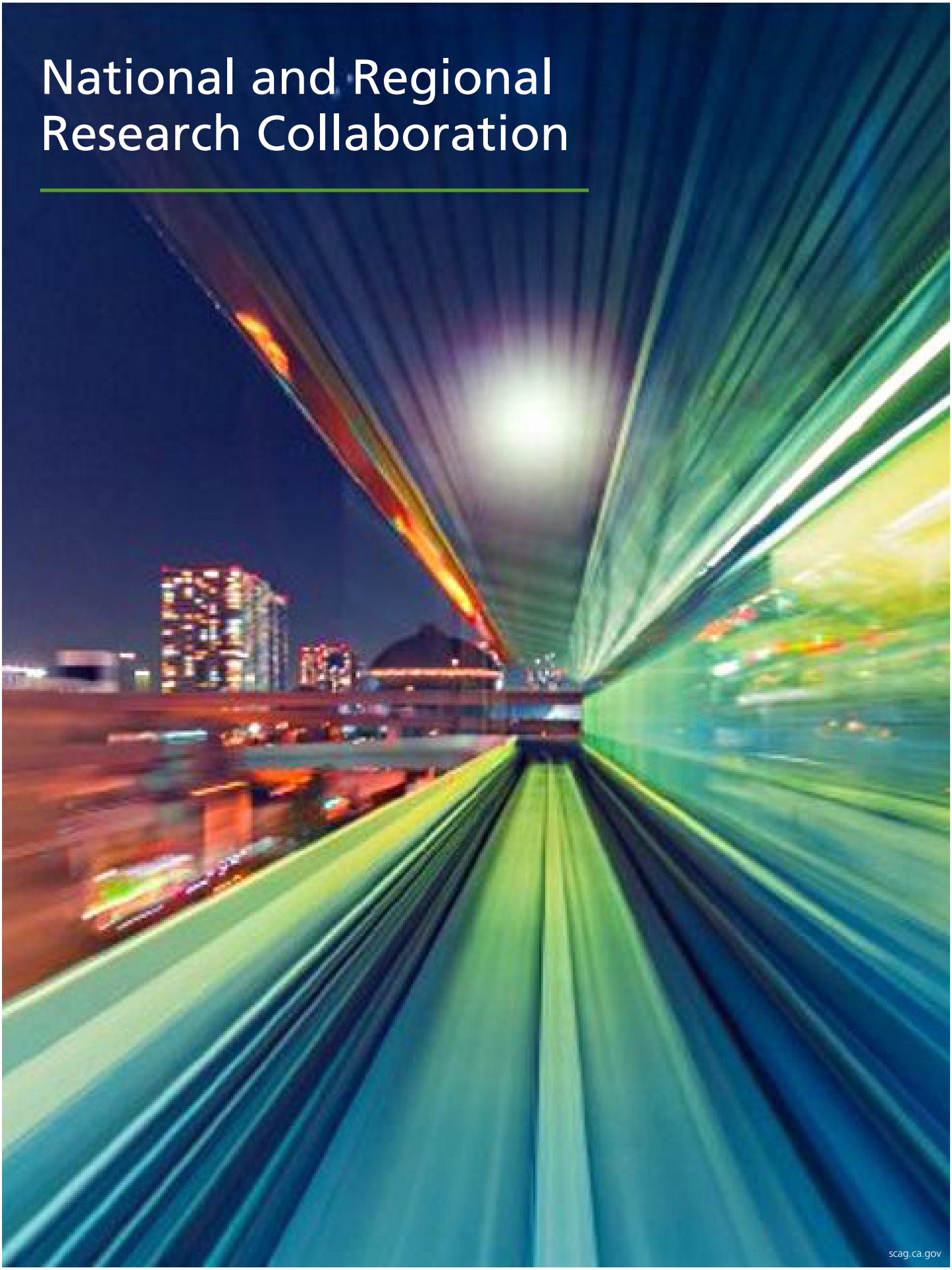
Over 820 participants registered across all eight webinars. The webinar series proved successful, and plans are underway to include this series as a showcase for other abstracts that were not selected for in-person conferences in the future. Another series is scheduled for Summer/Fall of 2021.







National and Regional Research Collaboration



Transportation Research Board (TRB)

MassDOT staff members participate on a number of the 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 the 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 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 Non-Standard 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 Pedestrians 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 U.S. – 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 Non-Fatal 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 Population with the 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 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.

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.

FFY2021 TPFs 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(353)	Clear Roads Phase II	Minnesota DOT	$25,000
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(420)	National Cooperative Highway Research Program	FHWA	$723,000
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

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, and participation on project technical committee, and in monthly meetings and annual events.

Active NETC research projects in 2021 included:

0. 19-1: Curved Integral Abutment Bridge Design
1. 19-2: Multi-Scale Multi-Season Land-Based Erosion Modeling and Monitoring for Infrastructure Management
2. 19-3: Experimental Validation of New Improved Load Rating Procedures for Deteriorated Steel Beam Ends
3. 20-1: In-Service Performance Evaluation of NETC Bridge Railings
4. 20-2: Current Status of Transportation Data Analytics and A Pilot Case Study Using Artificial Intelligence (AI)
5. 20-3: Investigating Thermal Imaging Technologies and Unmanned Aerial Vehicles to Improve Bridge Inspections
6. 20-4: New England Connected and Automated Vehicle Legal and Regulatory Assessment
7. 21-1: Quality Review and Assessment of Pavement Condition Survey Vehicle Data Across New England
8. 21-2: Sustainable Biomass Based Sealant for Service Life Extension of Concrete Structures and Pavements
9. 21-3: Initiating Seed Production for Effective Establishment of Native Plants on Roadsides in New England

Identified project for 2022 -

1. 21-4: Determining the Effect of Changing the Asphalt Binder Source Between Mixture Design and Production on a Balanced Mixture Design (BMD) in New England

NEW ENGLAND TRANSPORTATION CONSORTIUM

Appendix

MassDOT Research Contracts FFY21 Spending

Project Title	*Contract Number*	*Total Amount*	*FFY21 Spending*
UMTC Interdepartment Service Agreement	109600	***$ 11,429,386***	***$ 2,694,621***
1. MCRP (Research Support, including research subtasks below)		3,717,617	$ 950,771
a. Concrete Sidewalk Phase I		285,185	$ 151,848
b. Flash Yellow Arrow Phase I		100,000	$ 55,849
c. Cost Recovery		40,000	$ 29,956
d. Guardrail Inventory and Condition Assessment		100,000	$ 34,565
e. Concrete Sidewalk Phase 2		250,000	$ 20,930
2. LTAP (Local Training)		$ 4,748,525	$ 1,098,565
3. MTS (MassDOT Training)		$ 2,963,244	$ 645,285
Short-Term Research Projects		***$ 800,454***	***$ 290,491***
1. Effectiveness of Bicycle Boxes in Massachusetts (Continuing Project)	110439	$ 100,000	*$ 54,922*
2. Short Sea Shipping in Southeastern Mass (Continuing Project)	111256	$ 88,640	*$ 55,843*
3. Future of the Commonwealth Curb (Continuing Project)	110995	$ 100,000	*$ 84,295*
4. Improved Rating for Deteriorated Bridge Steel Beams with Deteriorated Stiffeners (Continuing Project)	107678	$ 99,292	*$ 9,363*
5. Energy Consumption, Cost and Emissions of MBTA Rapid Transit Vehicles (Continuing Project)	110755	$ 112,522	*$ 52,313*
6. Using Traffic Signals to Limit Speeding Opportunities on Arterial Roads (FFY21 New Project)	114372	$ 140,000	*$ 15,029*
7. Uncovering the Root Causes to Truck Rollover Crashes on Ramps (FFY21 New Project)	113772	$ 120,000	*$ 12,501*
8. Synthesis study: Myrofiltration Treatment and Design Options (FFY21 new research project)	114903	$ 40,000	*$ 6,225*

Project Title	*Contract Number*	*Total Amount*	*FFY21 Spending*
Medium-Term Research Projects		***$ 1,966,260***	***$ 721,360***
1. Measuring Accessibility to Improve Public Health (FY21 New Project)	114069	$ 150,000	*$ 25,411*
2. A Method for Pavement Marking Inventory and Retroreflectivity Condition Assessment Using Mobile LiDAR (Continuing Project)	110352	$ 200,000	*$ 85,051*
3. Feasibility of the 3D Printing Application for Highway Infrastructure Construction and Maintenance (Continuing Project)	110756	$ 175,000	*$ 90,540*
4. Implementing the AASHTO Mechanistic-Empirical Pavement Design Guide - Phase I (Continuing Project)	110555	$ 200,632	*$ 160,578*
5. UAS for Surface Transportation Emergency Response (Continuing Project)	113771	$ 60,000	*$ 25,801*
6. Detecting Subsurface Voids Using UAS with Infrared Thermal Imaging (Continuing Project)	112754	$ 60,000	*$ 37,674*
7. Impact of Advanced Driver Assistance Systems (ADAS) on Road Safety and Implications for Education, Licensing, Registration and Enforcement (Continuing Project)	110757	$ 120,000	*$ 76,180*
8. Post-Fire Damage Inspection of Concrete Structures in Tunnels Phase I (Continuing Project)	110353	$ 99,998	*$ 29,105*
9. Developing Massachusetts Specific Trip Generation Rates for Land Use Projects (FY21 New Project)	113773	$ 150,000	*$ 45,014*
10. Multisource Data Fusion for Real-Time and Accurate Traffic Incident Detection (FY 21 New Project)	113774	$ 150,000	*$ 25,070*
11. Post-Fire Damage Inspection of Concrete Structures in Tunnels Phase II (FY 21 New Project, continuation of Subtask F.8.)	114201	$ 160,000	*$ 20,927*
12. Massachusetts Depth to Bedrock Project (FY 21 New Project)	113776	$ 115,000	*$ 33,428*
13. Outdoor Information Panels to Convey Real-Time Travel Information for Ridership Recovery (FY 21 New Project	114217	$ 125,000	*$ 31,487*
14. Removed			
15. Implementing AASHTO M-E Pavement Design Guide Phase II (FY21 New Project, continuation of F.4.)	114775	$ 200,630	*$ 35,094*

Project Title	*Contract Number*	*Total Amount*	*FFY21 Spending*
Long-Term Research Projects		**$ 1,465,450**	***$ 401,518***
1. Ultra-High Performance Concrete Reinforced with Multi-Scale Hybrid Fibers and Its Durability-Related Properties (FY21 New Project)	115287	$ 200,000	*$ -*
2. Transit Data Infrastructure (Continuing Project)	105589	$ 300,000	*$ 83,644*
3. Asset Management Systems at Municipalities (Continuing Project)	110556	$ 200,497	*$ 32,923*
4. Revised Load Rating Procedures for Deteriorated Prestressed Concrete Beams (FY21 New Project)	114071	$ 199,955	*$ 19,370*
5. Flexible Transit for Rural Areas (Continuing Project)	110532	$ 165,000	*$ 124,841*
6. Development of Comprehensive Inspection Protocols for Deteriorated Steel Beam Ends (Continuing Project)	110354	$ 149,998	*$ 88,643*
7. Optimization of MassDOT''s High Performance Thin Lift Mixtures (FY21 New Project)	114557	$ 250,000	*$ 52,097*