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Recipient Organization (name and address): The University of Maine, Transportation Infrastructure Durability Center, 35 Flagstaff Road, Orono, Maine 04469

Recipient Identifying number or account number, if any: N/A

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Report term or frequency: Semi-Annual

Signature of submitting official:

I. ACCOMPLISHMENTS

a. What are the major goals and objectives of the program?

Research

The over-arching research objective of the TIDC is to improve the durability and extend the life of transportation infrastructure, including roads, bridges, and rail facilities. This objective will be achieved through (1) fundamental and applied research that will broaden our overall knowledge base while providing practical solutions to the state and federal agencies responsible for constructing and maintaining the nation's transportation facilities; (2) educational offerings in various fields of transportation that include comprehensive course work and student participation in research; (3) workforce development activities and programs to expand the workforce of transportation professionals; and (4) a perpetual program of technology transfer to ensure TIDC research results are disseminated and applied as widely as feasible.

Specific research projects are selected through a combination of peer-review and state DOT/industry input, and are expected to fall within TIDC's four research thrust areas identified in the table below.

Table 1: TIDC Research Thrusts Areas

Thrust Area Title	Description
Thrust Area 1: Transportation Infrastructure Monitoring and Assessment for Life	Managing aging civil infrastructure is a major challenge facing every country in the world. Research conducted under this theme tackles this issue through the development and implementation of novel strategies for the assessment and health monitoring of highway bridges, rail structures, pavements, slopes, embankments, and foundations. The ability to monitor the performance and health of these vital elements will provide the information required to prioritize the repair and replacement of our transportation infrastructure, while advanced assessment will justify extending the service life of these assets.
Thrust Area 2: New Materials for Longevity and Constructability	This thrust investigates new materials and technologies to improve durability and extend the life of transportation infrastructure. The materials and technologies investigated can apply to a range of transportation modes (vehicular, rail, etc.).
Thrust Area 3: New Systems for Longevity and Constructability	This research thrust focuses on evaluation, development, performance, reliability, and application of engineering systems to improve the durability and longevity of new and existing transportation infrastructure. New England's transit networks face challenges related to cold weather, changing climate, age-related deterioration, evolving load demands, construction efficiencies, and congestion, among others. In these times of economic austerity, innovative engineering systems are needed to alleviate existing and future financial strain on the region.
Thrust Area 4: Connectivity for Enhanced Asset and Performance Management	The system operational efficiency of transportation infrastructure can be improved by smart technologies that connect the infrastructure to information/management systems, vehicles, and roadway users. These emerging, connected technologies – coupled with appropriate and evolving management systems – can improve the durability of existing and new infrastructure. This is essential in the coming age of highly automated, connected vehicles and given the need to improve the performance of the existing infrastructure through more cost-effective and targeted assessments of asset vulnerabilities due to extreme weather events. This research theme applies to all forms of infrastructure including highway, railroad, marine ports, and airports.

TIDC will provide base funding to each member university contingent upon performance. An additional annual amount of $250,000 is available through an internal competitive RFP Process. The competitive RFP is released in conjunction with the base-funded RFP solicitation. The competitive project proposals are reviewed and scored by

the TIDC Advisory Board and other technical professionals. Upon completion of the review, the Advisory Board meets and provides their recommendation(s) for the selection of the competitive proposal(s). The TIDC administrative team (Center Director, Senior Program Manager, Grant and Fiscal Manage, Program Coordinator, and Advisory Board Chair) then reviews the recommendation(s) and makes the final selection of the successful proposal(s). A similar process is followed for the base-funded project selection.

Base and competitive funding are contingent upon performance, and all funded activities must meet metrics defined in technology transfer, education and workforce development, and collaboration. Each member university will provide performance metrics information to UMaine through quarterly progress reports for each research project to ensure performance is adequately tracked. In order to ensure successful implementation of research findings, each project's funding is also contingent on the commitment of a Technical Champion in implementing the potential findings of the work. See the Collaboration section on page 4 for more details about the role of the Technical Champion. Funding for research projects is also contingent upon collaboration with transportation organizations, including the region's DOTs and transportation companies.

Formal metrics to measure program effectiveness includes the number of new research initiatives/projects funded, number of continued base-funded research projects funded at member universities, number of research projects completed during the reporting period, number of active industrial and DOT partners involved in TIDC projects, dollar amount invested in TIDC research, and number of times findings have been implemented. Formal metrics under the research section overlap with metrics in other subsections.

Education & Workforce Development

TIDC seeks to attract a more diverse pool of talented students into careers in science and engineering and ensure that these students receive the best education possible. Beyond providing students with a detailed knowledge of existing public transportation infrastructure and system challenges in the realm of durability and life extension, TIDC activities will (1) enhance student communication skills to ensure they can reach a variety of audiences including researchers, the public, and decision-makers; (2) create an inclusive multi-cultural and multi-disciplinary student body by recruiting women and underrepresented racial and ethnic groups into our program; and (3) foster the development of leadership skills through vertically integrated research teams (faculty, post-docs when applicable, graduate students, and undergraduate students) and peer mentoring. Undergraduate and graduate students will be directly supported by TIDC research projects and make meaningful contributions under the mentoring and guidance of faculty that is essential to student success.

TIDC will strengthen diversity and STEM education by sharing research with future members of the workforce at middle and high schools. This will include both exposing young people to opportunities that exist within the field of transportation infrastructure and engaging them in transportation-related educational activities.

Formal metrics to measure program effectiveness includes the number of undergraduate and graduate students participating in industrial internships; number of presentations and poster sessions led by students; number of papers published by students; number of seminars, workshops, and conferences hosted by TIDC researchers; number of presentation led by TIDC supported students; number of K-12 students who participate in transportation-focused tours or activities at member institutions; total number of K-12 classrooms reached by TIDC personnel, students, and/or researchers, including specifics on classrooms populated by under-represented groups of students.

Technology Transfer

As identified in the TIDC Technology Transfer Plan, the Center's mission is to develop innovative, sustainable, next-generation solutions to improve the durability and extend the lifespan of existing and new transportation assets in New England and beyond. TIDC is committed to making dramatic impacts in the cost-effectiveness of transportation infrastructure through transformative research, education, outreach, workforce development, and technology transfer through the four research thrust areas identified in Table 1.

TIDC's technology transfer objectives are:

- Ensure research developments and findings are accessible, disseminated, and transferred to a variety of users.

- Ensure research developments have long-term value and significant impact to the transportation industry through collaboration with government and non-profit organizations.

The technology transfer objectives of TIDC support the TIDC mission through their emphasis on research impact and dissemination. The TIDC goals and performance metrics reflect the full spectrum of research activities through technology concept inception and assessment to technology adoption. See Table 2: Technology Transfer Goals & Performance Measurers for the goals and performance metrics that TIDC-funded research projects are striving are striving to meet during the course of their work.

Table 2: Technology Transfer Goals & Performance Measures

Goal	Performance Metrics	Annual Target
Output: Develop new technologies, techniques, or methodologies	Number of successfully demonstrate proof-of-concept activities for newly developed technologies, techniques, or methodologies	2
Output: Publish journal, conference, and/or policy papers that become references for practitioners for the modification of codes and standards for technology adoption	Number of technical reports, theses, dissertations, DOT reports, and other report types submitted and/or published	5
	Number of papers published in peer-reviewed journals	4
	Number of papers, abstracts, or posters published and/or presented in conferences, symposia, workshops, and/or meetings	12
Outcome: Deploy new technologies, techniques, or practices	Number of technologies deployed in transportation applications through pilot or demonstration studies	2
Outcome: Improve the processes, technologies, and techniques in addressing transportation issues	Number of licenses granted to industry or patent applications submitted	1
Impact: Workforce development	Number of webinars given to disseminate findings to industry professionals	6
	Number of seminar, workshop, and/or conference sessions led by researchers to present findings of research activities to industry professionals	45
Impact: Adoption of technologies, techniques, or practices	Number of instances of technology adoption by industry or transportation agencies and of commercialization	1
	Number of instances that TIDC supported findings were referenced, cited, or mentioned in journal articles, presentations given by others not active in the research project, newspaper or magazine articles, etc.	5
Impact: Development or modification of codes and standards to facilitate wider technology adoption	Number of instances of research changing industry or transportation agency practices, decision making, or policies	1

*To see how TIDC performed against these targets during this reporting period, see section I.b. – Technology Transfer.

Collaboration

Institutional leads serve on the TIDC Management Team which ensures each institution has ownership in and is committed to the success of the program. Additionally, in an effort to ensure all TIDC research projects are relevant

to Department of Transportation and/or Industry needs, each TIDC research project is required to have a Technical Champion. The Technical Champion has subject matter expertise and is actively involved in the research activities, from the creation of the project proposal to assisting with the implementation of successful research findings as a result of the work. The Technical Champion acts as a resource, connecting the researchers to the industry and meeting with the researchers to continue to help the teams keep their research relevant. Technical Champions on each project are providing in-kind support and are not monetarily compensated for the time they spend working with the principal investigators and research team. As more projects are added and advanced, the number of Technical Champions and their contributions will change. See Table 5 on page 11 for a complete list of Technical Champions.

To ensure the successful selection and implementation of relevant research projects, TIDC has assembled an Advisory Board. The role of the Advisory Board is to ensure TIDC continues to meet the needs and challenges of Region 1, as described within its designated Fast Act topic, in collaboration with New England Transportation Agencies. The Advisory Board evaluates and recommends the Selection of competitively funded research projects through an open RFP process that encourages collaboration and implementation of next-generation solutions. The Advisory Board also reviews TIDC's annual performance metrics from each member university to determine the status of performance based base funded projects. Additionally, the goal is to have all Advisory Board Members work toward facilitating the engagement of researchers and students with Design and Maintenance Department members to encourage real-world solutions. The Advisory Board is currently comprised of members from each state DOT/AOT in Region 1. The Advisory Board meets two to three times annually to ensure effective partnership in achieving TIDC's research objectives and goals and adding value to New England's Transportation Infrastructure.

Formal metrics to measure collaboration goals include presentations given at non-member universities, documented conversations regarding collaboration between TIDC and other UTCs, documented conversations/meetings between researchers, DOTs, industry partners, and technical champions, the number of industrial partners and state DOTs participating in TIDC research, dollar amount of state DOT and industry invested into TIDC research projects, number of technical champions actively involved in TIDC research projects, and number of outside attendees to the TIDC Annual Conference.

b. What was accomplished under these goals?

Research

In order to ensure TIDC is conducting relevant and transferable research projects, individual projects are required to submit periodic reports to ensure the approved goals and objectives of each research project are being met and are working toward TIDC's mission and research goals. During this reporting period, TIDC has 42 projects that were active, 2 projects that concluded their work, 2 projects were canceled, 11 projects were selected for funding, and 7 projects were approved for additional phases during the reporting period. See Table 3 for a list of the 51 TIDC funded research projects that were active and/or selected/extended during the reporting period. (* indicates a newly selected/awarded project during the reporting period. ** indicates a project that was approved for additional phases during the reporting period.)

Table 3: TIDC Projects Active During the Reporting Period

Project Number & Title Institution	Institution(s)	Start Date
Thrust Area 1: Transportation Infrastructure Monitoring and Assessment of Enhanced Life		
1.2 – Condition/Health Monitoring of Railroad Bridges for Structural Safety, Integrity, and Durability	University of Connecticut	10/1/2018
1.4 – Electromagnetic Detection and Identification of Concrete Cracking in Highway Bridges**	University of Massachusetts Lowell	1/1/2019
1.5 – Distributed Fiber Optic Sensing System for Bridge Monitoring**	University of Massachusetts Lowell	1/1/2019
1.6 – Progressive Fault Identification and Prognosis of Railway Tracks Based on Intelligent Inference	University of Connecticut	10/1/2018

1.8 – Enhancing Intelligent Compaction with Passive Wireless Sensors	University of Vermont	7/1/2018
1.12 – Improved UAV-Based Structural Inspection Techniques & Technologies for Northeast Bridges	University of Maine	10/1/2020
1.13 – Structural Integrity, Safety, and Durability of Critical Members and Connections of Old Railroad bridges Under Dynamic Service Loads and Conditions.*	University of Connecticut	10/1/2021
1.14 – Exploring the Safety Impact of Rumble Strips on Prevention of Lane Departure Crashes in Maine*	University of Maine	10/1/2021
1.15 – Non-Contact Intelligent Inspection of Infrastructure*	University of Connecticut	10/1/2021
1.16 – Wireless Joint Monitoring (j-JMS) for Safety of Highway Bridges*	University of Connecticut	10/1/2021
1.17 – Determining Layer Thickness and Understanding Moisture Related Damage of State-Owned Roads Using GPR and Capturing Such in a GIS-Based Inventory*	University of Rhode Island	9/1/2021
C3.2018 – Condition Assessment of Corroded Prestressed Concrete Bridge Girders	University of Massachusetts Lowell & Western New England University	1/1/2019
C5.2018 – Leveraging High-Resolution LiDAR and Stream Geomorphic Assessment Datasets to Expand Regional Hydraulic Geometry Curves for Vermont: A Blue Print for New England States	University of Vermont	6/1/2019
C11.2019 – Development of System-Level Distributed Sensing Technique for Long-Term Monitoring of Concrete and Composite Bridges	University of Massachusetts Lowell, University of Vermont, University of Maine	1/1/2020
C19.2020 – Damage Modeling, Monitoring, and Assessment of Bridge Scour and Water Borne Debris Effect for Enhanced Structural Life	University of Connecticut	10/1/2020
C20.2020 – Advanced Sensing Technologies for Practical UAV-Based Condition Assessment	University of Maine	10/1/2020
Thrust Area 2: New Materials for Longevity and Constructability		
2.2 – Concrete Systems for a 100-Year Design Life	University of Maine	3/1/2020
2.3 – Avalanche study of the fiber-reinforced cementitious composites	University of Vermont	7/1/2020
2.4 – Thermoplastic Composites by 3D Printing and Automated Manufacturing	University of Maine	1/1/2019
2.5 – Development and testing of High/Ultra-High Early Strength Concrete for Durable Bridge Components and Connections	University of Connecticut	10/1/2018
2.7 – High Performance Concrete with Post-Tensioning Shrinking Fibers	University of Vermont	1/1/2019
2.9 – Carbonating Subgrade Materials for In Situ Soil Stabilization	University of Maine	9/1/2018
2.10 – Durability Evaluation of Carbon Fiber Composite Strands in Highway Bridges	University of Maine	6/1/2019
2.11 – Culvert Rehabilitation Using 3D Printed Diffusers	University of Maine	7/1/2020
2.12 – Evaluation of Processed Glass Aggregate for Utilization in Transportation Projects as a Sand Borrow	University of Vermont	10/1/2020

2.13 – Performance Structural Concrete Optimized for Cost, Durability, and Manufacturability	University of Vermont	10/1/2020
2.14 – Implementation of UHPC Technology into the New England Construction Industry*	University of Connecticut	10/1/2021
2.15 – Incorporation of Pollinator Planning to Enhance Ecosystem Functions and Durability of Transportation Right-of-Way Infrastructure*	University of Rhode Island	10/1/2021
2.16 – Enhancing the Durability of Bridge Decks by Incorporating Microencapsulated Phase Change Materials (PCMs) in Concrete*	University of Rhode Island	1/1/2022
2.17 – Design and Development of High-Performance Composites for Improved Durability of Bridges in Rhode Island*	University of Rhode Island	1/1/2022
C7.2018 – Alternative Cementitious Materials (ACMs) For Durable and Sustainable Transportation Infrastructures	University of Maine	6/1/2019
Thrust Area 3: New Systems for Longevity and Constructability		
3.4 – Testing, Monitoring, and Analysis of FRP Girder Bridge with Concrete Deck	University of Maine	3/1/2019
3.5 – Prevention of Stressed-Induced Failures of Prestressed Concrete Crossties of the Railroad Track Structure**	Western New England University	9/1/2018
3.7 – Development of General Guidelines on the Effects of Bridge Span Range and Skew Angle Range on Integral Abutment Bridges (IAB's)**	University of Massachusetts Lowell	7/1/2018
3.8 – Bridge Modal Identification via Video Processing and Quantification of Uncertainties	University of Massachusetts Lowell	11/1/2018
3.10 – Assessment and Optimization of Double CT Bridge Girder Sections with Longitudinal Precast Decks	University of Maine	7/1/2020
3.11 – Phase 1: Assessment of Micropile-Supported Integral Abutment Bridges Phase 2: Development of a Simplified Methodology to Evaluate the Factor of Safety and Link the Magnitude of Lateral Spreading for CSEs Supported on Rigid Inclusions**	University of Maine	9/1/2019
3.12 – Phase 1: Lateral Loading of Unreinforced Rigid Elements and Basal Stability of Column-Supported Systems Phase 2: Flexural Strength and Durability of Micropile Threaded Connections**	University of Maine	6/1/2019
3.13 – Investigating the Effectiveness of Enzymatic Stabilizers for Reclaimed Stabilized Base Products	University of Vermont	10/1/2020
3.14 – FRP-Concrete Hybrid Composite Girder Systems: Web Shear Strength and Design Guide Development	University of Maine	10/1/2020
3.15 – Nonstructural Approaches to Reduce Sediment and Pollutant Runoff from Transportation Infrastructure in Urbanized Areas*	University of Rhode Island	9/1/2021
C9.2019 – A New Method for Determining Payment for In-Pace Concrete with Double-Bounded Compressive Strength Pay Factors	University of Vermont	10/1/2020
C17.2020 – Durability of Modified Helical Piles under Lateral and Torsional Loads: Embracing Efficient Foundation Alternative to Support Lightweight Transportation Structures	University of Maine & University of Rhode Island	10/1/2020
Thrust Area 4: Connectivity for Enhanced Asset and Performance Management		
4.1 – Highly Automated Vehicles and Bridge Infrastructure	University of Maine	9/1/2018

4.2 – Future-Proof Transportation Infrastructure through Proactive, Intelligent, and Public-involved Planning and Management	University of Connecticut	10/1/2018
4.3 – Towards Quantitative Cybersecurity Risk Assessment in Transportation Infrastructure	University of Connecticut	10/1/2018
4.4 – Bridge-stream Network Assessments to Identify Sensitive Structural, Hydraulic, and Landscape Parameters for Planning Flood Mitigation	University of Vermont	7/1/2018
4.9 – Analysis of Covid-19 and Travel In Maine (ACTIME) – Validation Study	University of Maine	8/1/2020
4.10 – Road Salt Impact Assessment	University of Maine	8/15/2020
4.11 – Safety Assessment of New England Roadways during the COVID-19 Pandemic	University of Maine	9/15/2020
4.12 – Proactive and Intelligent Risk Management in Complex Civil Infrastructure Project Systems*	University of Connecticut	10/1/2021

Projects 3.4 and C5.2018 concluded their work during the reporting period and submitted their final reports. Projects 2.3 and 3.8 were canceled during the reporting period due to staffing changes at the UVM and UMass Lowell.

The following are a few examples of the accomplishments achieved under individual research projects:

- The Project 1.5 research team returned to the Salmon Fall Railway Bridge in NH to verify the integrity of the sensors they installed in October 2019. The sensors were still viable and able to collect data.
- The Project 2.4 team deployed a 3D printed formwork prototype at a precaster plant to assess longevity during cycles of casting and demolding. Additionally the team designed a large 3D printed formwork system for a precast concrete railroad bridge ballast retainer.
- The Project 2.10 team acquired continuous wireless data from stay 10B along with fiber-optic sensor strain data from all six stay anchorages for at least two months prior to the end of the reporting period.
- The Project 3.5 research team used a parallel computing algorithm to analyze large numerical models of prestressed concrete crossties. This algorithm allows the team to analyze additional datasets faster than possible with a single computer workstation. The efficiency of the algorithm reduces the analysis from about a week to just 30 minutes.
- The Project 3.13 research team prepared, cured, and tested sub-base soil specimens and stabilized them with different types of materials, including xanthan gum and terrazyme, in the laboratory.
- The Project C5.2018 research team concluded their GIS analysis and the proposed research work. The final report was submitted in on 9/30/2021.
- The Project C11.2019 research team worked with MassDOT to identify three additional bridges (in Chelmsford, Lowell, and Methuen) to monitor after the successful application and positive findings as a result of the work conducted at the Grist Mill Bridge in Hampden, ME last reporting period. Additionally, the team began work to create a baseline for the bridge identified in Lowell to prepare it for instrumentation.

Additionally, TIDC worked with URI to identify, appoint, and train a new Institutional Lead who worked closely with RIDOT to submit five research proposals during the 2021 RFP Solicitation. TIDC also worked to appoint and train a new Advisory Board member from RIDOT to ensure a close working relationship between the two institutions. In fact, all five proposed projects from URI were selected for funding and three of the five received matching fund commitments from the RIDOT.

More TIDC research accomplishments can be found in sections III and IV of this report and on the TIDC website on each research project's individual page.

Education & Workforce Development

The TIDC Program Coordinator is actively working with K-12 educators to bring transportation activities into classrooms during the continued COVID-19 restrictions. The Program Coordinator has identified educators in area middle and high schools in Maine, as well as groups, such as Jobs for Maine Grads, that would like to implement the activities created in 2020 and help make adjustments to the curriculum for the target age groups. Additionally, the activities and curriculum will lead up to the TIDC Transportation Challenge planned for May 2022.

Additionally, in an effort to encourage more individuals to enter the transportation field, TIDC continues to collaborate with the Maine Engineering Promotional Council (MEPC) during the planning process of the Engineering Expo, with the TIDC Program Coordinator acting as a member of the Board. Upon reflections, the MEPC decided that the Feb. 2021 virtual event did not meet the goals and objectives of the Council. As a result, the next event has been rescheduled from Engineers Week in Feb 2022 to the end of April 2022 to increase the likelihood of it being an in-person event. The MEPC works to increase the visibility of engineering in Maine through two Engineering Events, an Engineering Banquet and the Engineering Expo. THE MEPC Board is comprised of academic and industry members who are all committed to raising awareness of engineering through the Banquet and Expo events.

Lastly, the TIDC Program Coordinator continues to collaborate with UMaine's 4-H cooperative extension and UMaine K-12 Outreach Committee, with meetings and events being planned for the spring in hopes of hosting in-person events again.

In an effort to provide TIDC supported students with the opportunity to develop and refine soft skills needed when entering the transportation workforce, TIDC created a monthly Showcase Presentation webinar. The Showcase Presentations not only supports student professional development, but also helps TIDC meet technology transfers and outreach goals. The following process was used each month: three universities will submit the title of the presentation and name(s) of student(s) presenting to allow Center to post the agenda on the TIDC website and Google calendar invitation. Students worked with their PI to record a 15-minute presentation and submitted it to tidc@maine.edu to be reviewed by an internal review team comprised of peers and TIDC administration. The feedback was given to the student and their PI and the student revised their pre-recorded presentation using the given feedback before the live webinar. On the day of the webinar, the pre-recorded presentation was played and was followed by a live Q&A session where the student had the opportunity to answer questions from the audience with the support of their PI. TIDC successfully held four of the Showcase Presentation Webinars.

Student researchers at member universities have been disseminating research findings through poster presentations, seminars, and conferences. Students have also participated in webinars and professional development opportunities. TIDC faculty taught 24 transportation-related undergraduate courses, reaching about 1,200 students, and 17 transportation-related graduate courses, reaching about 240 students, during the reporting period.

Technology Transfer

TIDC research results have been disseminated through a variety of ways including the TIDC website and social media platforms.

TIDC researchers gave 29 presentations at 18 conferences, workshops, and/or seminars during the reporting period. The following table indicates the conferences and workshops attended by TIDC researchers and the activity they conducted to disseminate information during this reporting period.

Table 4: Conferences, Workshops, and Seminars

Name of Conference/Workshop	Activity	Location	Dates
UMaine Student Symposium	Symposium	Virtual	4/16/2021
ASCE Earth and Space Conference	Conference	Virtual	4/19/2021-4/23/2021
ASME 2021 Joint Rail Conference	Conference	Virtual	4/20/2021
TIDC Showcase Presentations	Student Highlight Presentations	Virtual	4/21/2021
SPE-ANTEC 2021 Conference	Conference	Virtual	5/10/2021

TIDC Showcase Presentations	Student Highlight Presentations	Virtual	5/19/2021
4th International Conference on Transportation Geotechnics	Conference	Virtual	5/24/2021-5/27/2021
ASCE Engineering Mechanics Institute (EMI) 2021 Annual Conference	Conference	Columbia University, New York, NY	5/25/2021
International Bridge Conference 2021	Conference	Virtual	6/11/2021
11th Advances in Cement-Based Materials	Conference	Virtual	6/23/2021
TIDC Showcase Presentation	Student Highlight Presentations	Virtual	6/23/2021
TIDC Annual Conference 2021	Conference	Virtual	7/27/2021-7/29/2021
Worcester Polytechnic Institute	Seminar	Worcester, MA	9/1/2021
2021 VTrans Research and Innovation Symposium	Symposium	Virtual	9/8/2021-9/9/2021
VT STIC Stakeholders Meeting and the 2021 AOT Research and Innovation Symposium	Symposium	Virtual	9/8/2021-9/9/2021
TCI (Taiwan Concrete Institute) 2021 Concrete Conference	Conference	Kaohsiung, Taiwan (virtual)	9/9/2021
ASCE 2021 International Conference on Computing in Civil Engineering	Conference	Orlando, FL	9/12/2021-9/14/2021
UConn TUE Graduate Seminar	Seminar	Storrs, CT	9/13/2021

Additionally, TIDC has published or submitted 3 journal papers/articles, 3 conference papers, and 12 other publications and presentations during the reporting period. For a complete list of the submitted papers, please see Section III, Outputs.

Collaboration

Critical to TIDC's success is the development of partnerships and collaborations with state DOT's, the transportation industry, transportation professionals, and various stakeholders that assist in addressing the center goals.

Integral to meeting the TIDC collaboration goals, the TIDC Advisory Board and the inter-institutional collaboration is the collaboration that happens with the Technical Champions (TC), industry partners, and State DOT (including maintenance and operations) collaborators. All TIDC funded projects have met the goal of having a Technical Champion (as described in Section I a, Collaboration) assigned to each. Some research projects have additional Technical Champions and Advisors involved in their projects. Each PI is responsible for submitting their quarterly reports to their TC and working with them to ensure their research with have the greatest impact on the transportation industry. In addition to sending their reports to the TC, PIs from multiple projects are meeting with their TC to discuss and adapt their research.

Additionally, TIDC is actively working with industry partners during their research efforts. For example, the research team for Project 1.12 (UMaine) met with VHB and MaineDOT to identify uses of the UAV technology being created through this work. These meetings and collaborative efforts help ensure the commercialized and future accepted use of new technologies being developed by the Center. More collaborations and stakeholders are identified in Table 5 below.

Also, during this reporting period, the TIDC Management Team met each month, with the exception of July and August (due to the TIDC Annual Conference and scheduling conflicts), for a total of four meetings. All four meetings were held via Zoom. The Semi-Annual in person meeting was unable to happen during the Summer Annual Conference due to the Conference's virtual format.

The following table identifies the 56 active Technical Champions and Advisors involved in TIDC research projects during this reporting period. (* Indicates newly added Technical Champions and Advisors during this reporting period.)

Table 5: Active Technical Champions & Advisors	
Name and Title of Technical Champion or Advisor	**Organization**
Ulrich Amoussou-Gueno, Transportation Engineer II*	Maine Department of Transportation
Dr. Ian Anderson, Manager*	HMA Materials
August Arles, Geotechnical Engineer	Vermont Agency of Transportation
Warren Best, Assistant Deputy Director, Structures	Metro-North Railroad Company
Tanner Blackburn, Chief Geotechnical Engineer	Hayward Baker
Robert Blunt, Project Manager	VHB
Richard Bradbury, Director of Materials Testing*	Maine Department of Transportation
Peter J. Calcaterra, Transportation Planner	Connecticut Department of Transportation
Andy Cardinali, Principal Engineer of Bridge Design*	Connecticut Department of Transportation
David Cist, Chief Technology Officer	Geophysical Survey Systems, Inc. (GSSI)
Bao Chuong, Supervising Engineer of Bridge Design	Connecticut Department of Transportation
Taylor Clark, Assistant Engineer*	Maine Department of Transportation
Cassidy Cote, Hydraulics and Structures Engineer	Vermont Agency of Transportation
Jeff DeGraff, P.E., Hydraulics Project Engineer	Vermont Agency of Transportation
Haresh Dholakia, Transportation Engineering Supervisor	Connecticut Department of Transportation
Anthony Diba, Engineer*	AIT Bridges
Manesh Dodia, Transportation Engineer	Connecticut Department of Transportation
Lamont Dutra*	Maine Department of Transportation
Dennis Emidy, State Safety Engineer	Maine Department of Transportation
Callie Ewald, P.E., Geotechnical Engineering Manager	Vermont Agency of Transportation
Jeff Folsom, Assistant Bridge Program Manager*	Maine Department of Transportation
Benjamin Foster, P.E., Deputy Chief Engineer	Maine Department of Transportation
Edward Hanscom, Head of Transportation Systems Analysis*	Maine Department of Transportation
Robert Haradon, Senior Technician*	Maine Department of Transportation
Joshua Hasbrouck, Civil Engineer, Bridge Program	Maine Department of Transportation
Peter Healey, Pavement Engineer*	Rhode Island Department of Transportation
Dr. Mark Jen, P.E., S.E., Technical Manager	Michael Baker Engineering, Inc.
Gregory Krikoris, Area Bridge Engineer*	Massachusetts Department of Transportation
John Kocur, Director of Engineering	Sperry Rail Service
Laura Krusinski, Senior Geotechnical Engineer	Maine Department of Transportation
James Lacroix, P.E., State Bridge Design Engineer	Vermont Agency of Transportation
Alexander Mann, Hydrologist	Maine Department of Transportation
Tanya Miller, Research Engineer	Vermont Agency of Transportation
Andrew Mrockowski, Transportation Engineer	Connecticut Department of Transportation
Richard Myers, Senior Structural Engineer*	Maine Department of Transportation
Deirdre Nash, Assistant Research Engineer	New Hampshire Department of Transportation
Lily Oliver, Manager of Research*	Massachusetts Department of Transportation
Dr. Emily Parkany, P.E., Research Manager	Vermont Agency of Transportation
Dale Peabody, Director, Transportation Research	Maine Department of Transportation
Michael Redmond, Business Systems Manager, Concrete Quality Control Specialist, Bridge Program	Maine Department of Transportation

Karen Riemer, Asset Management Group	Connecticut Department of Transportation
Ann Scholz, Research Engineer	New Hampshire Department of Transportation
Gary Seider, Engineering Manager	Hubbell
Rite L. Seraderian, P.E., FPCI, LEED AP, Executive Director	Precast/Prestressed Concrete Institute Northeast
Robert Skehan, Director, Office of Safety	Maine Department of Transportation
Joseph Stilwell, Fabrication Engineer	Maine Department of Transportation
Craig Stratton, Director of Sensing Sales*	Luna Incorporated
James Surwilo, Environmental Analyst*	VTDEC, Solid Waste Management Program
Ken Sweeney, President	AIT Bridges
Josh Tyler, Director of Operations	Chittenden Solid Waste District (CSWD)
Nicholas Van Den Berg, Materials & Certification Manager	Vermont Agency of Transportation
Susan Votta*	Rhode Island Department of Transportation
Nick Wark, P.E., Hydraulics Engineer, Project Delivery Bureau, Structures	Vermont Agency of Transportation
James Wild, Concrete Materials Manager	Vermont Agency of Transportation
Christos Xenophontos, Assistant Director*	Rhode Island Department of Transportation
Hailing Yu, Civil Engineer	U.S. DOT Volpe Center

The following table identifies the 45 active collaborators and stakeholders and their contributions during the reporting period. (* indicates new project collaborators during this period)

Table 6: Research Project Collaborators

Organization	Location	Contribution
AIT Bridges, a division of Advanced Infrastructure Technologies	Brewer, ME	In-kind, collaborative research, personnel, facilities
American Concrete	Auburn, ME	Financial support, facilities, collaborative research
Chittenden Solid Waste District (CSWD)	Williston, VT	Financial support, facilities, personnel
City of Lowell	Lowell, MA	Collaborative research, facilities, personnel
Connecticut Department of Transportation	Newington, CT	Collaborative research, personnel, facilities, in-kind support
Deep Foundations Institute	Hawthorne, NJ	Financial
ENSOFT Inc.*	Austin, TX	In-kind, Personnel
Ernst Conservation Seeds*	Meader, PA	In-kind
Geophysical Survey Systems, Inc. (GSSI)	Lowell, MA	Collaborative research, personnel, in-kind, facilities
Hayward Baker	Hanover, MD	Personnel
Helix Mooring Systems, Inc.*	Cumberland, ME	Financial, in-kind,
Hexagon PPM*	Madison, AL	In-kind, personnel
HMA Materials		Personnel
Hubbell Power Systems, Inc.*	Centralia, MO	Financial, in-kind, facilities, personnel
Jacobs Engineering	Herndon, VA	Personnel
Lehigh Cement*	Glen Falls, NY	In-kind
Luna Innovation*	Roanoke, VA	In-kind, collaborative research, personnel

Maine Department of Transportation	Augusta, ME	In-kind, collaborative research, financial, personnel, equipment
Massachusetts Department of Transportation	Boston, MA	Collaborative research, personnel, facilities, in-kind
Metro-North Railroad Company	Bridgeport, CT	Collaborative research, facilities, personnel, in-kind
Michael Baker Engineering, Inc.	Pittsburg, PA	Personnel
National Center for Supercomputing Applications	Urbana, IL	In-kind
NEC Laboratories America, Inc.*	Princeton, NJ	Financial, Facilities, Collaborative Research
New Hampshire Department of Transportation	Concord, NH	Personnel
Omnisens	Morges, Switzerland	In-kind, collaborative research, personnel, equipment
Polytec, Inc.	Hudson, MA	In-kind, collaborative research, personnel, equipment, facilities
Precast/Prestressed Concrete Institute Northeast (PCI-NE)	CT, MA, ME, NH, NY, RI, VT	Collaborative research, personnel
Rhode Island Department of Transportation	Providence, RI	In-kind, facilities, personnel
Saint-Gobain	Northborough, MA	In-kind, facilities, collaborative research, personnel, equipment
Sebago Technics*	Portland, ME	In-kind
Sperry Rail Service	Shelton, CT	In-kind, facilities, personnel
Texas Advanced Computing Center	Austin, TX	Facilities
U.S. DOT Volpe Center	Cambridge, MA	Personnel
Unistress Corporation*	Pittsfield, MA	In-kind, collaborative research
University of Connecticut	Storrs, CT	In-kind, collaborative research, personnel, facilities, financial
University of Maine	Orono, ME	In-kind, collaborative research, personnel, facilities, financial
University of Massachusetts Lowell	Lowell, MA	In-kind, collaborative research, personnel, facilities, financial
University of Rhode Island	Kingston, RI	In-kind, collaborative research, personnel, facilities, financial
University of Vermont	Burlington, VT	In-kind, collaborative research, personnel, facilities, financial
Vermont Agency of Transportation	Montpelier, VT	In-kind, collaborative research, personnel, financial
Vermont Agency of Transportation, Materials and Certification Section*	Barre, VT	In-kind
Vermont Department of Environmental Conservation	Montpelier, VT	Personnel, in-kind
Vermont Technical College	Randolph Center, VT	Facilities, collaborative research, personnel
VHB	Augusta, ME	Collaborative research, in-kind, personnel
Western New England University	Springfield, MA	In-kind, collaborative research, personnel, facilities, financial

c. How have the results been disseminated?

Research results have been disseminated in a variety of ways throughout this reporting period. Research results are provided on each project's page on the TIDC Website through quarterly progress reports are available at https://www.tidc-utc.org/research/tidc-funded-projects-and-reports/. Further results were disseminated through journal articles, professional magazines, and meetings with New England State DOTs. Additionally, research findings are being disseminated in undergraduate and graduate courses at each university. Lastly, presentations from webinars and the 2020 and 2021 Annual Conference are available on the TIDC YouTube page and the TIDC website.

d. What do you plan to do during the next reporting period to accomplish the goals?

Research

TIDC will continue to start new, high impact, relevant, and innovative research projects. During the next reporting period, the 2022 Request for Proposals will be released in October 2021 and the awards are estimated to be announced in April 2022. The performance of current research projects will continue to be evaluated against the mission, goals, and objectives of TIDC.

Education & Workforce Development

TIDC personnel at UMaine plan to work with local school districts to implement transportation related activities created as part of the curriculum developed by the TIDC Program Coordinator. The team is working to created virtual kits that can be sent to students working remotely. The TIDC Program Coordinator is also plans to collaborate with the Connecticut Invention Convention in the next reporting period to bring transportation related activities based on TIDC funded research conducted at UConn. The TIDC team hopes to expand the planned education and outreach activities in Massachusetts, as well.

TIDC personnel at UMaine are continuing to work to create better partnerships with MaineDOT departments (including the HR, training, operations, and maintenance departments), industry leaders in Maine and New England region, and Maine Community Colleges to create more opportunities for workforce development in the state and beyond.

TIDC personnel and researchers are working to create more professional development opportunities through webinar offering. During the reporting period, researchers from UConn and WNEU have worked with the TIDC Senior Program Manager and the Advisory Board Chair to put together a New England Railroad Symposium. The symposium is schedule for November 2021. TIDC personnel also plans to bring back the Showcase Presentation Webinars featuring student presenters, holding the presentations two times each semester starting in January 2022. Having added two new members to the TIDC administrative team, TIDC is better suited to meet these goals in the next reporting period.

TIDC faculty and principal investigators will continue to work with students on their research projects and add new students to replace those who have graduated. Additionally, research findings will continue to be disseminated in university classrooms and curriculum will be updated as new findings are presented.

Technology Transfer

To accomplish TIDC's technology transfer objectives identified in Section I. a., Technology Transfer, the following venues and mechanisms will be and/or continue to be employed: (1) a TIDC website and social media accounts that promote findings and opportunities for collaboration directly to the public; (2) the expansion of the 2021 TIDC Annual Conference on July 28-29, 2021 through early advertising and outreach activities in New England; (3) continued participation in regional transportation conferences; (4) a webinar series focused on sharing findings and engaging with industry professionals is scheduled to begin in the fall 2021; and (5) promotion of all market-ready technology transfer opportunities through industry/trade publications, the TIDC website, and social media accounts.

TIDC will also use the webinars and symposiums mentioned in the above section as a form of Technology Transfer. Not only will these provide opportunities for professionals to receive profession development hours (PDH), but it will allow TIDC research findings to be presented to the public.

TIDC will continue to update the Center website and social media accounts to inform the public of TIDC activities, workshops, and research. Publications and papers will be submitted for conferences and publication in journals. TIDC principal investigators will attend conferences and workshops to disseminate research findings.

Collaboration

Principal Investigators and TIDC Management team members will continue to collaborate with state DOT/AOT representatives. All TIDC projects will continue to be supported by at least one Technical Champion (as described in Section I c – collaboration). Projects are encouraged to seek support from additional technical advisors in DOTs, government agencies, and industry leaders. These additional partnerships will increase the applicability of TIDC's research findings and create more opportunities for the adoption of findings in the region and beyond. Monthly management team meetings will continue and the Program Manager will visit each member university on a quarterly basis, once travel restrictions have been lifted. Additionally, the TIDC Advisory Board will be meeting in May 2021 to discuss the TIDC program and the expansion efforts for greater success. Also, to help with the goal of expanding the next TIDC Annual Conference for more collaboration opportunities, the dates and location for the 2022 conference have been selected (a hybrid model is planned to allow for greater collaboration and attendance within the region and beyond).

II. PARTICIPANTS & COLLABORATING ORGANIZATIONS

a. What individuals have worked on the project?

In total, 54 principal investigators, faculty, administrators, and management team members and 116 students participated in TIDC research projects during the reporting period. As the projects progress, more student researchers will be added. All TIDC participants who were active during the reporting period are listed in the table below. (* Indicates students who graduated and received their degree during the reporting period.)

Table 7: Active Principal Investigators, faculty, administrators, students, and Management Team Members

Institution	Principal Investigators, Faculty, Administrators, and Management Team Members	Students
University of Maine	Dr. Habib Dagher, James Anderson, Kathryn Ballingall, Dr. Keith Berube, James R. Bryce, Amanda Collamore, Dr. Bill Davids, Dr. Wilhelm Friess, Dr. Aaron Gallant, Dr. Per Garder, Dr. Douglas Gardner, Dr. Andrew Goupee, Dr. Yousoo Han, Dr. Hosain Haddad Kolour, Dr. Eric Landis, Dr. Roberto Lopez-Anido, Vu Phan, Dr. Jonathan Rubin, Dr. Ali Shirazi, and Gavin Wasson	Madison Ala, Nicholas Alvarez, Zahra Ameli, Yugandhar Aremanda, Alexander Baur, Drew Bennett*, Peter Bohrbacher*, Danilo Botero-Lopez, Sunil Bhandari, Sebastian Carvajal, Jacob Clark, Dominic Dangelo*, Nathan Godbout*, Sheldon Green*, Justin Harris, Jeffrey Hollstien, SK Belal Hossen, Braedon Kohler, Tanner Laflamme, Jack Leopold*, Ennis Marshall, Nicolas Michaud*, Sebastian Montoya, Peter O'Brien, Felipe Saavedra, Alanie Sawtelle, Andrew Schanck, Parry Seddiqi, Amirhossein Shahlaeegilan, Nicholas Tiner, Kelsey Weir, Emma White, and Bruce Wyatt
University of Connecticut	Dr. Shinae Jang, Dr. Ramesh Malla, Dr. Jiong Tang, Dr. Kay Wille, Dr. Jin Zhu, Dr. Song Han, Dr. Wei Zhang, and Dr. Nalini Ravishanker	Ethan Beattie, Chris Boisvert-Cotulio*, Sudipta Chowdhury, Hernan Cortez Jr., Cydney-Alexis Delarosa, Celso de Oliveira, Suvash Dhakal, Santosh Dhakal, William Hughes, David Jacobs, Donghyun Kim, Kaitlyn Kondos, Qin Lu,

		Dominic, Xiaolong Ma*, Parciasepe, Bijaya Rai, Jeet Rosa, Leana Santos, Andrew Schroder, Sachin Tripathi, Kelly Voong, Ting Wang, Matthew Wendland, Peng Wu, Yixin Yao, and Yang Zhang.
University of Massachusetts Lowell	Dr. Tzuyang Yu, Dr. Xingwei Wang, Dr. Susan Faraji, and Dr. Zhu Mao	Aiyad Alshimaysawee, Emi Aoki, Ronan Bates, Andres M. Biondi Vaccariello, Lidan Cao, Celso do Cabo, Tek Dhant*, Harsh Gandhi, Yaneliz Garcis Ruiz, Nimun nak Khun, Tiana Robinson, Mark Todisco, Nick Valente, Rui Wu, and Sophe Ying.
University of Rhode Island	Dr. Christopher Baxter, Dr. Aaron Bradshaw, Dr. Rebecca Brown, Dr. Sumanta Das, Dr. Mayrai Gindy, Dr. Joseph Goodwill, and Dr. Vinka Oyanedel-Craver	Pamela Franco*, Katie Marcil, Andrew Pariseault*, and Andrew Sheerin
University of Vermont	Dr. Arne Bomblies , Dr. Mandar Dewoolkar, Dr. Ehsan Ghazanfari, Dr. Eric Hernandez, Dr. Dryver Huston, Dr. David Novak, Dr. Hamid Ossareh, Dr. Donna Rizzo, Dr. Gregory Rowangould, Dr. Matthew Scarborough, James Sullivan, Dr. Ting Tan, Dr. Kristen Underwood, and Tian Xia	Joshua Allen, Lane Feldeisen*, Maziar Foroutan, Damien Garland, Ahmad Ghazanfari, Nick Giallombardo*, Diarmuid Gregory, Matt Kaplita, Bijay K-C, Sam Langeleh*, Eric Licho, Yi Liu, Zhuang Liu, Harrison Lucas, Ashlie Mercado*, Kyle Murphy*, Linh Nguyen*, Brandon Nimberger*, Fiona Nutbeam, Colin Palmer*, Rachel Seigel, Ryan van der Heijden and Reed Winter*
Western New England University	Dr. Moochul Shin and Dr. ChangHoon Lee	Evan Blake, Christa-Elizabeth Cicerone, Cameron Cox*, Daniel Doyle, Jacob Eberli, Adam Garstka, Brian Leclair, Andrew Masullo*, Nicholas Pantorno, Archer Parker, Tiana Robinson, Georgii Tifaniuk, and Tyler Yesu
Total	54	116

b. What organizations have been involved as partners?

TIDC has received continued commitments of support and matching funds from 45 collaborators during this reporting period. The type of support provided by the collaborators varies from in-kind, financial, equipment, personnel, to supplies. In addition, many collaborators provide direct personnel links in research through Technical Champions. See Table 5 on page 11 and Table 6 on page 13 for an overview of the collaborators on TIDC research projects and what they have contributed.

c. Have other collaborators or contacts been involved?

TIDC has partnered with Oak Ridge National Laboratory on a new initiative to recycle the 3D printed concrete formwork to reduce emissions, minimize waste, and decrease the cost of concrete structures within the transportation industry.

III. OUTPUTS

a. Publications, conference papers, and presentations:

The following table includes a list of some of the 31 accepted, submitted, and published papers, reports, and presentations given during the reporting period:

Table 8: Publications, Conference Papers, and Presentations				
Type	**Title**	**Citation**	**Date**	**Status**
Conference Presentation	Improved Resilience Analysis of Existing Orthotropic Steel Bridge Considering the Debris Effects	(2021). Improved Resilience Analysis of Existing Orthotropic Steel Bridge Considering the Debris Effects.	4/19/2021-4/23/2021	Presented
Conference Presentation	Study of Prestressed Concrete Prisms Using a Parallel Computing Algorithm	(2021). Study of Prestressed Concrete Prisms Using a Parallel Computing Algorithm.	4/20/2021	Presented
Conference Presentation	Large-Scale Extrusion Based 3D Printing for Highway Culvert Rehabilitation	Bhandari, S. (2021). "Large-Scale Extrusion Based 3D Printing for Highway Culvert Rehabilitation".	5/10/2021	Presented
Conference Presentation	Subsurface Moisture Determination of Concrete specimens Using Synthetic Aperture Radar Imaging and the K-R-I Transform	(2021). "Subsurface Moisture Determination of Concrete specimens Using Synthetic Aperture Radar Imaging and the K-R-I Transform".	5/25/2021	Presented
Conference Presentation	Monitoring and Dynamic Response of Two More than Century Old Truss Railroad Bridge	Dhakal, Malla, Oliviera (2021). Monitoring and Dynamic Response of Two More than Century Old Truss Railroad Bridge	6/11/2021	Presented
Conference Presentation	Combined Effects of Slag and CO2 Curing on Mechanical and Transport Properties of Concrete	(2021, June 23). "Combined Effects of Slag and CO2 Curing on Mechanical and Transport Properties of Concrete".	6/23/2021	Presented
Conference Paper	Exploring the Impact of Seasonal Weather Factors on Frequency of Rural Lane Departure Crashes in Maine	Sawtelle, A, Shirazi M, Garder, P, and Rubin, J (2021)	7/31/2021	Submitted, Under Review
Seminar Presentation	Digital Twin for Dynamic Characteristics and Prognostics via Deep Learning and Advanced Sensing	(2021). "Digital Twin for Dynamic Characteristics and Prognostics via Deep Learning and Advanced Sensing".	9/1/2021	Presented
Symposium Presentation	A New Method of Determining Payment for In-Place Concrete with Double Bonded Compressive Strength Pay Factors	(2021). "A New Method of Determining Payment for In-Place Concrete with Double Bonded Compressive Strength Pay Factors".	9/8/2021-9/9/2021	Presented
Symposium Presentation	Leveraging High Resolution LiDAR and Stream Geomorphic Assessment Datasets to Expand Regional Hydraulic Geometry Curves for Vermont	(2021). "Leveraging High Resolution LiDAR and Stream Geomorphic Assessment Datasets to Expand Regional Hydraulic Geometry Curves for Vermont".	9/8/2021-9/9/2021	Presented
Symposium Presentation	Parameters Affecting the In-Plane Rotation of Skewed Integral Abutment Bridges (IABs) Under Thermal Expansion	(2021). "Parameters Affecting the In-Plane Rotation of Skewed Integral Abutment Bridges (IABs) Under Thermal Expansion".	9/8/2021-9/9/2021	Presented

Symposium Presentation	Advanced Sensing Technologies for Practical UAV-Based Condition Assessment of Underside Bridge Decks	(2021). "Advanced Sensing Technologies for Practical UAV-Based Condition Assessment of Underside Bridge Decks".	9/8/2021-9/9/2021	Presented
Symposium Presentation	High Performance Concrete with Post-Tensioning Shrinking Fibers	(2021). "High Performance Concrete with Post-Tensioning Shrinking Fibers".	9/8/2021-9/9/2021	Presented
Symposium Presentation	Performance Structural Concrete Optimized for Cost, Durability and Manufacturability	(2021). "Performance Structural Concrete Optimized for Cost, Durability and Manufacturability".	9/8/2021-9/9/2021	Presented
Symposium Presentation	Evaluation of Processed Glass Aggregate for Utilization in Transportation Projects as a Sand Borrow	(2021). "Evaluation of Processed Glass Aggregate for Utilization in Transportation Projects as a Sand Borrow".	9/8/2021-9/9/2021	Presented
Poster Presentation	Flood analysis of bridge-stream interactions using two-dimensional modeling of Vermont river reaches	(2021). "Flood analysis of bridge-stream interactions using two-dimensional modeling of Vermont river reaches".	9/8/2021-9/9/2021	Presented
Conference Presentation	Remote Microwave Imaging for Moisture Gauging of Concrete Specimens	(2021). "Remote Microwave Imaging for Moisture Gauging of Concrete Specimens".	9/9/2021	Presented
Conference Paper & Presentation	The Usage of Association Rule Mining Towards Development of Integrated Transportation Infrastructure Planning	Chowdhury, S., & Zhu, J. (2021). The Usage of Association Rule Mining towards Development of Integrated Transportation Infrastructure Planning. In International Conference on Computing in Civil Engineering. Reston, VA: ASCE.	9/12/2021-9/14/2021	Submitted, Accepted, Published, & Presented

b. Journal publications:

The following table includes a list of TIDC journal publications and their status during the reporting period:

Table 9: Journal Articles and Publications

Title	Citation	Date	Status
Electromagnetic Detection of Concrete Cracking by Using Synthetic Aperture Radar and Ground Penetrating Radar	NDT&E International	6/22/2021	Submitted, Under Review
Remote Characterization of Chloride Content in Oven-Dried Concrete Specimens by Using Synthetic Aperture Radar Image Models	Construction and Building Materials (CBM); doi.org/10.1016/j.conbuildmat.2021.124317	8/13/2021	Published
Exploring the Impact of Seasonal Weather Factors on Frequency of Rural Lane Departure Crashes in Maine	Sawtelle, A, Shirazi M, Garder, P, and Rubin, J (2021)	8/15/2021	Submitted, Under Review

c. Books or other non-periodical, one-time publications:

Nothing to Report

d. Other publications, conference papers, and presentations:

The following table includes a list of the articles and presentations that falls within the other publications, conference papers, and presentations section during the reporting period:

Table 10: Other Publications, Presentations, and Meetings

Type	Title	Citation/Description	Date	Status
Master's Thesis Defense	Material Efficiency and Cost Reduction in the Design of the UHPC	Boisvert-Cotulio, C. (2021). "Material Efficiency and Cost Reduction in the Design of the UHPC".	4/20/2021	Presented
Capstone Project Presentation	Warren Covered Bridge Flood Hazard Mitigation	(2021). "Warren Covered Bridge Flood Hazard Mitigation".	5/5/2021	Presented
Capstone Project Presentation	Mad River Waitsfield Bridge Flood Hazard Mitigation	(2021). "Mad River Waitsfield Bridge Flood Hazard Mitigation".	5/10/2021	Presented
Thesis Presentation	Two-Dimensional Model Development and Flood Analysis for Understanding Bridge Stream Interactions	(2021). "Two-Dimensional Model Development and Flood Analysis for Understanding Bridge Stream Interactions".	5/12/2021	Presented
Congressional Testimony	Bio-based 3D printed culvert diffusers to reduce roadway storm damage	Dagher, H. (2021). "Bio-based 3D printed culvert diffusers to reduce roadway storm damage".	5/13/2021	Presented
Meeting	Discussion of Design and Modeling of IAB's	Presentation to project Technical Champion	7/7/2021	Presented
Meeting	Portable Synthetic Aperture Radar Imaging Sensor for UAV Bridge Inspections – Radar Principles	Meeting and presentation to DOT stakeholders	8/8/2021	Presented
Meeting	Development of Ultras-High performance Concrete (UHPC Based on Locally Available Material	Presentation to 3MT	8/12/2021	Presented
Meeting	Discussion of Design and Modeling of IAB's	Presentation to project Technical Champion	8/27/2021	Presented
Technical Report	Assessment of Micropile Supported Integral Abutment Bridges	Montoya-Vargas, S., Gallant, A., Davids, W.G. (2021). "Assessment of Micropile Supported Integral Abutment Bridges". Final Report, MaineDOT, Under Review.	9/1/2021	Submitted, Under Review
Technical Report	Leveraging High-resolution LiDAR and Stream Geomorphic Assessment Datasets to Expand Regional Hydraulic Geometry Curves for Vermont	Underwood, K.L., Rizzo, D.M., Bomblies, A., Dewoolkar, M.M., 2021. "Leveraging High-Resolution LiDAR and Stream Geomorphic Assessment Datasets to Expand Regional Hydraulic Geometry Curves for Vermont." Technical Report to the Transportation Infrastructure Durability Center at the University of Maine.	9/8/2021	Submitted

Master's Thesis Defense	Implementation of a Structural Health Monitoring System for Carbon Fiber Composite Strands in the Penobscot Narrows Bridge	(2021). "Implementation of a Structural Health Monitoring System for Carbon Fiber Composite Strands in the Penobscot Narrows Bridge".	9/29/2021	Presented

e. Website(s) or other Internet site(s):

The following websites and social media sites are used to disseminate information about TIDC findings.
TIDC website: www.tidc-utc.org
Twitter: https://twitter.com/TIDCatUMaine
Facebook: https://www.facebook.com/TIDCatUMaine/
LinkedIn: https://www.linkedin.com/company/transportation-infrastructure-durability-center/
UMass Lowell's TIDC research page: https://www.uml.edu/Research/tidc/

f. Technologies or techniques:

A number of technologies and/or technical innovations were developed during the reporting period:

- Researchers developed and tested a portable SAR sensor under Project 1.4.
- The PI of Project 3.7 created four 3D finite element models of single span IABS.
- The research team on Project 1.12 created a prototype hexacopter drone capable of carrying a synthetic aperture radar module for under-bridge inspections and contact with structures.
- The Project 2.4 research team 3D printed form parts for a precast concrete panel window opening to be used by Unistress Corporation in Pittsfield, MA.
- A wireless Data acquisition system for structural health monitoring was installed in the Penobscot Narrows Bridge in Prospect, ME by the Project 2.10 (UMaine) research team. This system will allow for real-time capture of major carbon fiber composite strands force changes.
- The Project 2.11 research team 3D printed a culvert diffuser for installation in Thorndike, ME.
- The research team on Project 4.4 developed a framework that combined geomorphic and hydraulic characteristics of the bridge-stream intersections to determine the network's sensitivity to floods.
- The work under Project C5.2018 concluded during the reporting period. As a result of the work, the Regional Hydraulic Geometry Curves (RHGCs) for Vermont have been updated to improve the prediction ability and reduce estimation uncertainty of bankfull channel dimensions for ungauged sites.
- The Project C17.2020 research team implemented a novel collar vane during lateral and torsional load testing with the goal to improve the resistance of the helical piles.

g. Inventions, patent applications, and/or licenses:

Nothing to report.

IV. OUTCOMES

The TIDC has a number of outcomes to report as a result of the outputs from TIDC-funded research:

- The Project 2.11 research team successfully installed the 3D printed culvert diffusor in Thorndike, ME in collaboration with MaineDOT. As a result of the successful implementation, the Technical Champion for the project submitted a nomination for the AASHTO Innovation Initiative (2021-08-28). This program actively seeks out proven advancements in transportation technology.
- The Project 4.4 research team used their newly developed framework (mentioned in section III.f.) in conjunction with the 2D hydraulic modeling to identify the best intervention locations for improving the network's resilience to flooding on three study sites.

V. IMPACTS

a. What is the impact on the effectiveness of the transportation system?

Following the successful implementation of the G-Beams in the Grist Mill Bridge in Hampden, ME, AIT Bridges, the business that licenses this technology, has received several bridge design contracts from across the nation. These new structures will incorporate findings from TIDC research projects 3.4, 3.10, and 3.14, as well as the design, manufacturing, and installation of the Grist Mill Bridge.

The 3D printed diffusor installed in Thorndike, ME under Project 2.11, improves asset performance by increasing the capacity of the culvert by about 40%, eliminating the need for the replacement of the existing pipe. Additionally, the diffusor's ease of installation allows maintenance staff to conduct the installation without creating a traffic disruption.

b. What is the impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

The work conducted on the G-Beams in the Grist Mill Bridge has resulted in design changes that are being implemented in another bridge in Hampden, ME. The new manufacturing process is he next step in the commercialization process of the G-Beams within the transportation industry.

c. What is the impact on the body of scientific knowledge?

TIDC researchers have contributed to the body of scientific knowledge by publishing journal articles and presenting findings at conferences to transportation professionals.

d. What is the impact on transportation workforce development?

TIDC research findings have impacted workforce development through trainings and updates offered to transportation professionals at the city and state department/agency of transportations and industry organizations. Additionally, TIDC issued certificate of attendance certificates to 31 out of the 116 2021 TIDC Annual Conference attendees.

VI. CHANGES/PROBLEMS

a. Changes in approach and reasons for change:

Project 2.3 at the University of Vermont was canceled due to the faculty member leaving the university, as was project 3.8 at the University of Massachusetts Lowell.

b. Actual or anticipated problems or delays and actions or plans to resolve them:

Nothing to report.

c. Changes that have a significant impact on expenditures:

Nothing to report.

d. Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards:

Nothing to report.

e. Change of primary performance site location from that originally proposed:

Nothing to report.

VII. SPECIAL REPORTING REQUIREMENTS

All TIDC projects are in compliance with Research Project Requirements (located in the Grant Deliverables and Reporting Requirements for 2016 and 2018 UTC Grants (Nov 2016, revised June 2018)) in regards to new research projects.