Awarding Federal Agency: University Transportation Centers Program, Office of The Assistant Secretary for Research and Technology, U.S. Department of Transportation

Federal Grant Number: 69A3551847101

Project Title: Transportation Infrastructure Durability Center (TIDC) at the University of Maine

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Submission Date: 04/28/2023

DUNS: 186875787

EIN: 016000769

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

Project/grant period: 10/01/2022 - 03/31/2023

Reporting Period end date: 03/31/2023

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 overarching research objective of 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. The 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 proposal(s). The TIDC administrative team (Center Director, Senior Program Manager, Grant and Fiscal Manage, Education &

Outreach Manager, and Advisory Board Chair) then reviews the recommendation(s) and makes the final selection of the successful proposal(s).

Funding is 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 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 underrepresented populations 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 STEAM education by sharing research with future members of the workforce in K-12 education settings. 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. TIDC will partner with industry members and non-profit education organizations like 4-H Cooperative Extensions and Jobs for Maine Grads (JMG), after-school programs, homeschooling cooperatives, and local libraries throughout New England to bridge transportation related activities into schools. TIDC will also create an online resource guide, portfolio, and transportation-related curriculum and activities for educators to utilize in their classrooms. TIDC will work with the College of Education and Engineering Colleges at the partner universities to create opportunities for professional development (continuing education requirements) for educators to create a better understanding of how to incorporate engineering activities into already existing curriculum at school districts.

TIDC will implement a series of webinars, workshops, conference sessions, and symposiums to provide opportunities for current transportation professionals to receive training on new technologies and outputs from TIDC funded research projects to help current professionals implement the findings into practice. Certificates of attendance will be offered to all attendees to be used toward professional development hours for all training opportunities.

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 presentations led by TIDC supported students; number of PDH certificate hours issues; number of K-12 students who participate in transportation-focused tours or activities at member institutions; and 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 and findings are outputted consistently and in a scheduled manner to effectively reach a steady audience.
- Ensure research developments have long-term value and significant impact to the transportation industry through collaboration with government and industry 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 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 demonstrated 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
Output: Post updates for technology transfer activities to TIDC virtual platforms	Number of posts to all TIDC platforms	350
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 delivered 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.

A crucial outlet by which TIDC research is disseminated is through the use of social media platforms, YouTube, and the TIDC website. This serves to accomplish TIDC's technology transfer objectives by reporting TIDC technological findings and advances primarily to those who would not normally have exposure to TIDC operations. Our primary goal is to reach and inform as many people as possible from various demographics.

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 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 provide 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 assess the status of 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 add 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 investments in 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 49 projects that were

active, 6 projects that concluded their work, 3 projects began work during the reporting period. See Table 3 for a list of the 49 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.)

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
1.12 – 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
1.18 - Vision-Based Detection of Bridge Damage Captured by Unmanned Aerial Vehicles*	University of Rhode Island	11/9/2022
C3.2018 – Condition Assessment of Corroded Prestressed Concrete Bridge Girders	University of Massachusetts Lowell & Western New England University	1/1/2019
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
2.4 – 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
2.18 – Recycling Large-Scale 3D-Printed Polymer Composite Precast Concrete Forms	University of Maine	1/1/2022
2.21 - Mineralogical Characterization of Pavement Aggregates in Maine*	University of Maine	11/14/2022
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		
3.5 – 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
3.11 – 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 – 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
3.15 – Nonstructural Approaches to Reduce Sediment and Pollutant Runoff from Transportation Infrastructure in Urbanized Areas	University of Rhode Island	9/1/2021
3.16 – CT Bridge Girder Sections with Precast Decks and FRP girder-deck Shear Connectors	University of Maine	1/1/2022
3.17 - Assessment of CT Girder Load Distribution and Web Buckling Through Field Load Testing and Finite-Element Analysis	University of Maine	6/1/2022
3.18 - Steel-free Concrete Bridge Decks	University of Maine	6/1/2022
3.19 - Detection and Monitoring of Material Aging and Structural Deterioration using Electromagnetic and Mechanical Sensors with Virtual Reality and Machine Learning Modeling	University of Massachusetts Lowell	6/1/2022
3.21 - GBeam Bridge Girder Pultrusion: Section Design and Optimization	University of Maine	6/1/2022
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
4.9 – Analysis of Covid-19 and Travel In Maine (ACTIME) – Validation Study	University of Maine	8/1/2020
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
4.13 - Development and Application of Cost-Benefit Tool for Quantifying External Social Impacts of Small to Mid-Size Transportation Projects	University of Vermont	06/01/2022
4.15 - Travel Demand Survey to Inform Infrastructure Investments*	University of Maine	3/1/2023

Projects 1.2, 2.4, 2.5, 3.21, 4.9 and C7.2018 completed work and submitted final reports during the reporting period.

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

- The URI Project 2.15 team analyzed data from the established right-of-way plots and determined that broadcasting seed over screened loam is the best way to establish large numbers of forbs, as opposed to drilling a mixture of grass and forb seeds which results in the grasses outcompeting the forbs. They also determined that Black-eyed Susan (*Rudbeckia Hirta*) is the most competitive insect-pollinated forb.
- The UML Project 1.5 team conducted a field test on the Grist Mill Bridge in Hampden, Maine in October 2022 and the results were found to agree with the data collected in 2020. This testing confirmed that the sensor is in good condition after two years and provided training to students in how to conduct field tests and solve unexpected problems on site.
- The UConn Project 1.16 team retrieved the wireless joint monitoring system from the field in order to set up cloud computing and be used in laboratory-scale testing before being re-deployed into the field to collect data.
- The UMaine project 2.9 team used thermogravimetric analysis (TGA) on carbonated samples that were subjected to freeze-thaw cycles and post freeze-thaw drying. This process helped to evaluate the durability of frost susceptible subgrade soils that were stabilized via carbonation. The direct quantification of calcium carbonate binder content at different protocols via TGA helped to understand the strength of carbonated soils, and possible continuation of carbonation in the long term.

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

TIDC has continued their work to increase their outreach effort to the K-12 audience in order to encourage students to consider transportation as a profession. As part of this effort, researchers and the TIDC Education and Outreach Manager in collaboration with undergraduate students and TIDC staff and Researchers attended numerous events throughout the reporting period. The University of Maine team conducted numerous K-12 activities, reaching over 1,000 students, teachers, and parents. Some examples of these activities include:

- The UMaine Project 2.9 research team attended events at Medway Middle School and Schenck High School attended by approximately 200 students and their teachers. During the event, Dr. Gallant and Grad Student Temitope Omokinde gave a demonstration of what Geotechnical Engineers do and used work from their Soil Carbonation project for the demonstration. Students and teachers were able to interact with the materials.
- On March 4th, the TIDC Education & Outreach Manager and team members attended the Maine Engineering Promotional Council's Engineering Expo at the University of Maine. Despite the significant snow event that happened that day, over 460 youth and parents attended. TIDC hosted a table that promoted engineering through the use of K'Nex Bridge building activities.

- The Maine Science Festival field trip day was held on March 23rd at the Cross Insurance Center in Bangor. The Outreach team engaged with 350+ students and teachers utilizing the K'Nex Bridge Building Activity. The Event resulted in making connections with 5 educators who want to collaborate with TIDC for their curriculum development in the Fall.
- On March 25th, the Maine Invention Convention (MIC) was held in conjunction with the Maine Science Festival. There were 30 inventions selected for the State Level competition. The TIDC Education & Outreach Manager collaborated with MIC to act as a judge. Additionally, during the event, she was able to connect with educators leading the local Invention Convention events to begin incorporating transportation related activities into their classrooms.

Researchers at the URI conducted K-12 outreach events. The research team on Project 3.15 Partnered with Guiding Education in Math and Science Network (GEMS-NET; https://web.uri.edu/gemsnet/) to develop a series of interactive videos that will be used in 4th-8th grade curriculum in several schools in RI. The team developed a "beta" version of the video (Water for the World Lab (Beta Version)) and presented it to a small group of teachers. Teachers provided the team with feedback. The feedback is being used to finalize the video for distribution. Additionally, on March 15th, the team for Project 1.18 hosted about 45-50 10th-12th graders for an indoor flight demonstration in the ICRobots Lab at URI using the UAV configured for their project. The students learned about different types of UAVs and flight modes. Additionally, they learned about the research efforts on UAV bridge inspections.

Researchers on projects 3.5 and C3.2018 at WNEU hosted K-12 Students and their families participated at Open House events held in October and November of 2022. The students visited the concrete and transportation labs. The research team conducted impact and comprehensive strength tests on Engineered Cementitious Material (ECM) samples. They learned about what fibers can do in concrete. Additionally, The WNEU research team gave presentations about the corrosion of reinforcements and ECMs, as well as, the project overviews at a February Open House event for about 30 Juniors/Seniors and their parents.

In the realm of higher education and workforce development, TIDC hosted their annual Student Poster Contest. 32 students participated. As part of the contest, students submit a poster with an abstract and a short video presentation to be judged by the TIDC Advisory Board. The top three posters and presentations are awarded recognition at the Student Recognition night held in November and on the TIDC social media and Website. The technical winners for 2022 were Jon Pink of UMaine for his poster, Development of Live Load Distribution Factors for CT Girder Bridges in third place. Second place was Felipe Saavedra of UMaine for his poster, Durability of Large-Scale 3D Printed Materials for Transportation Infrastructure. First place went to Andrew Pariseault and Pamela Franco of URI for their poster, Determining Layer Thickness and Understanding Moisture Related Damage of State-Owned Roads Using GPR and Capturing Such in GIS-Based Inventory. TIDC also hosted a "Fan Favorite" portion of the contest that allowed members of the public to vote on their favorite posters/presentations. We received 281 votes on our website form with a top four selected due to a tie in third place. The two third-place winners were Koosha Raisi of UML & Felipe Saavedra of UMaine; the second-place winner was Bolaji Oladipo of URI; and the first-place winner was Jhan Kevin Gil-Marin of UMaine. Additionally, researchers at UConn supported a group of four students from the Material Science department by providing material and technical assistance for their senior research project.

The TIDC New England Railroad Symposium was held in February and hosted 96 attendees. All participants have access to Certificates of Attendance for professional development hours. Workforce Development Opportunities were also offered for TIDC researchers and staff at the Maine Transportation Conference in December and the TRB Annual Meeting in January. Additionally, the TIDC Education & Outreach Manager participated in STEM Education White House Listening Sessions held this year.

Technology Transfer

TIDC research results have been disseminated through a variety of ways including the TIDC website and social media platforms. In December, TIDC launched a newly designed website aimed at engaging more users and providing a more streamlined method of technology transfer. The previous website is being maintained now solely to house the consistently growing catalog of our previous tech transfer events and provide information to the public on new tech

transfer opportunities as they arise. TIDC continues to employe their recently developed plan for social media operations and have developed internal management systems to facilitate schedule consistency and higher volume of output. Since the last report, TIDC social platforms have continued to promote findings and opportunities for collaboration directly to the public and have promoted market-ready technology transfer opportunities. TIDC platforms have seen steady increase in a number of analytical categories with the goal of more consistently reaching the general public. TIDC virtual platforms, links to which can be found in section II.e - Website(s) or other Internet site(s), have accumulated the following total results over the last semi-annual period:

- TIDC Website – 7,427 views, 3,179 sessions
- TIDC YouTube Channel - 4528 views, 273.6 hours of watch time, 30 new subscribers
- TIDC LinkedIn – 32,307 impressions, 1209 reactions, 706 views, 241 new followers
- TIDC Facebook - 4785 unique impressions, 150 reactions, 8 new followers
- TIDC Twitter - 4677 impressions, 96 reactions, 11 new followers
- TIDC Instagram - 1396 unique impressions, 189 reactions, 30 new followers

TIDC researchers gave 20 presentations at 7 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
2022 TIDC Student Poster Contest	Poster Contest	Virtual	11/30/2022
Rhode Island Peer Exchange on Road Infrastructure Resilience	Conference	University of Rhode Island	10/11/2022
SPIE Smart Structures/Nondestructive Evaluation Symposium	Symposium	Long Beach, CA	3/13/2022-3/15/2022
Trends in Coastal and Offshore Geotechnical Infrastructure	Seminar	Tufts University	1/28/2023
Transportation Research Board Annual Meeting	Conference	Washington D.C.	1/7/2023-1/11/2023
2023 TIDC New England Railroad Symposium	Conference	Virtual	2/16/2023
University of Connecticut School of Engineering Annual Poster Competition	Poster Contest	University of Connecticut	3/10/2023

Additionally, TIDC has published or submitted 13 journal papers/articles, 9 conference papers, and 2 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 executives, transportation professionals, and various stakeholders that assist in addressing the center goals. TIDC's researchers regularly hold meetings with their partners across these fields to provide project updates and receive feedback. On March 30, 2023, the research team of Project 1.13 (UConn) held their quarterly meeting with the project's technical champion and advisors, including representatives from ConnDOT, Metro-North Railroad Co., Amtrak, Genesee & Wyoming Railroad Co., and Polytech Inc.

TIDC researchers are actively working with industry partners during their research efforts to ensure their findings will be able to transition into practice more efficiently. For example, the research team for Project 1.5 (UML) worked with Saint Gobain this reporting period to have a technician trained to use Saint Gobain's technique of using an embroidery

machine to embed fiber optic sensors in sensing textiles to work on the sensing textile the team has developed for bridge monitoring.

Also, during this reporting period, the TIDC Management Team met each month, with the exception of January (due to the TRB Annual Meeting attendance and the semester gap), for a total of five meetings. All five meetings were held via Zoom. The Semi-Annual in person meeting was unable to happen in November due to the on-going COVID-19 restrictions. The Advisory Board met twice during the reporting period to discuss research goals and future endeavors. Adding to our collaboration efforts and goals, TIDC Administration also met with 10 other UTCs to discuss administrative best practices.

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 will 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. The following table identifies the 60 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
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
Jeff DeGraff, P.E., Hydraulics Project Engineer	Vermont Agency of Transportation
Paul DelSignore, Deputy Chief Engineer, Structures	Amtrak
Haresh Dholakia, Transportation Engineering Supervisor	Connecticut Department of Transportation
Anthony Diba, Engineer	AIT Bridges
Manesh Dodia, Transportation Engineer	Connecticut Department of Transportation
Todd Dragland, Vice President	Hayward Baker
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
Peggy Hagerty Duffy	ADSC-IAFD; Hagerty Engineering
Robert Haradon, Senior Technician	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
Mario Pineda, Territory Manager	Polytec, Inc.
William Pratt, Principal Engineer	Connecticut Department of Transportation
John Preiss, Bridge Engineer	Rhode Island 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
Rita 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
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
Craig Nazareth, Bridge Inspection and Load Ratings Database Information Manager *	Rhode Island Department of Transportation
Jonathan Ehrlich, Developer*	T2D2
Badri Hiriyur, Developer*	T2D2

The following table identifies the 41 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
Amtrak	Philadelphia, PA	In-kind, collaborative research, personnel
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
Genesee & Wyoming, Inc	Darien, CT	In-kind, collaborative research
Geophysical Survey Systems, Inc. (GSSI)	Lowell, MA	Collaborative research, personnel, in-kind, facilities
GMS	Pennsylvania	In-kind
Helix Mooring Systems, Inc.	Cumberland, ME	Financial, in-kind,
Hexagon PPM	Madison, AL	In-kind, personnel
Hubbell Power Systems, Inc.	Centralia, MO	Financial, in-kind, facilities, personnel
Jacobs Engineering	Herndon, VA	Personnel
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
New Hampshire Department of Transportation	Concord, NH	Personnel
Nucor	Pennsylvania	In-kind
Oak Ridge National Laboratory	Oak Ridge, TN	Financial, collaborative research
OCI	Pennsylvania	In-kind
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
Santec, Consulting Services, Inc.	South Burlington, VT	In-kind, personnel
T2D2	New York, NY	In-kind, collaborative research
The International Association of Foundation Drilling (ADSC-IAFD)	Pennsylvania	Financial
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 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://tidc.umaine.edu/research/project-search/. 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, the 2020, 2021, and 2022 Annual Conferences, and the 2021 and 2023 New England Railroad Symposium 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 achieve high impact, relevant, and innovative research projects, and the performance of current research projects will continue to be evaluated against the mission, goals, and objectives of TIDC. During the next reporting period, TIDC will begin preparing for the close of the grant program by working with researchers to set guidelines and expectations for completion of their active projects and to develop opportunities for high impact deployments. Additionally, TIDC will pursue further funding and collaborations in order to provide for new research opportunities.

Education & Workforce Development

During the next reporting period, the TIDC Education & Outreach Manager will continue to expand TIDC presence in K-12 classrooms by reaching out to educators to introduce the bridge building curriculum into classrooms throughout New England. This will be done in collaboration with researchers at member universities. Another big part of the outreach efforts will include updating the K-12 section of the TIDC Website to include an easily accessible, digital version of the bridge building curriculum. Additionally, the Education & Outreach Manager will work with the College of Education at the University of Maine, in addition to other stakeholders at the Department of Education, to create a micro-credential for Middle School Teachers. The micro-credential will be a certified continuing education credit course and will provide educators with an outline of how to incorporate teaching engineering throughout their curriculum and how to identify how they are already teaching engineering. Lastly, several K-12 events are planned throughout the reporting period including the Maine Summer Transportation Institute and 4-H summer programming.

In the realm of Higher Education and Workforce Development, the TIDC Annual Transportation Infrastructure Conference will be held August 8th-10th. A student poster session will be included with the conference to help foster communication and presentation skills among our Graduate and Undergraduate students. Additionally, Certificates of Attendance will be made available to attendees of the conference to be used for professional development hours (PDHs). The TIDC Outreach team, in collaboration with researchers, will also begin work on hosting a series of webinars as lunch and learns. This is in the very beginning state of thought right now, but a plan for implementation and at least one webinar will be held during the next reporting period. In addition to disseminating research outputs, the webinars would allow attendees to earn Certificates of Attendance to be used for PDHs. The Student Poster Contest will also be announced during the next reporting period.

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 2023 TIDC Annual Conference at the University of Maine, August 8-10, through early advertising and outreach activities in New England; (3) continued participation/presentation in regional/national transportation conferences and industry webinars; (4) The 2023 TIDC Student Poster Session taking place during the Annual Conference in August; (5)

involvement and planning in the 2023 Maine Summer Transportation Institute at the University of Maine, July 11-15 and July 18-22; and (6) promotion of all market-ready technology transfer opportunities through industry/trade publications, the TIDC website, and social media accounts.

TIDC will continue to output consistent technology transfer centered posts to virtual platforms. During the next reporting period, TIDC will organically increase total social media impressions by 20%, follower count by 5%, and reactions by 30%. TIDC will increase YouTube viewership, watch time, and subscribers all by 50%. Additionally, TIDC will increase website views by 50% and unique viewership by 50%

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 professional development hours (PDH), but it will allow TIDC research findings to be presented to the public.

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 an annual basis. Also, in a continued effort to help with the goal of expanding the next TIDC Annual Conference for more collaboration opportunities, TIDC is currently reaching out to industry partners to develop a varied and engaging selection of topics and presenters to participate in the conference.

II. PARTICIPANTS & COLLABORATING ORGANIZATIONS

a. What individuals have worked on the project?

In total, 63 principal investigators, faculty, administrators, and management team members and 91 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, Dr. Keith Berube, Dr. Sunil Bhandari, James R. Bryce, Amanda Collamore, Dr. Bill Davids, Dr. Wilhelm Friess, Dr. Aaron Gallant, Dr. Per Garder, Dr. Douglas Gardner, Dr. Andrew Goupee, Kathryn Grond, Hosain Haddad Kolour, Dr. Eric Landis, Dr. Linfei Li, Dr. Roberto Lopez-Anido, Genna O'Berin, Vu Phan, Dr. Jonathan Rubin, Brianne Sales, Aaron Schanck, Dr. Andrew Schanck and Dr. Ali Shirazi.	Arnav Acharya, George Akandinge*, Zahra Ameli, Jake Bear, Danilo Botero-Lopez, Sunil Bhandari, Sebastian Carvajal, Jacob Clark, Jhan Kevin Gil-Marin, SK Belal Hossen, Prabhat Khanal*, Izaak Krause*, Ennis Marshall, Sebastian Montoya, Temitope Omokinde, Maedeh Orouji*, Jon Pinkham, Felipe Saavedra, Katie Schweizer, and Emma White.
University of Connecticut	Dr. Lesley Frame, Dr. Alexandra Hain, Dr. Song Han, Dr. Shinae Jang, Dr. Ramesh Malla, Dr. Nalini Ravishanker, Dr. Jiong	Rahul Anand*, Sreeram Anantharaman , Prakash Bhandari*, Indrani Chattopadhyay, Nathan Comment, Celso De Oliviera, Santosh Dhakal, Pierredens Fils, Giovanna Fusco, Binit Gautam*,

	Tang, Dr. Kay Wille, Dr. Jin Zhu, and Dr. Wei Zhang	William Hughes, Harley Jeanty, Cameron Larkin, Steven Matile, Dominic Parciasepe, Bijaya Rai, Daisy Ren, Alok Sharma*, Rinchen Sherpa*, Sachin Tripathi, Jiachen Wang, Ting Wang, Peng Wu, Zelin Yun, and Yang Zhang.
University of Massachusetts Lowell	Dr. Susan Faraji, Dr. Xingwei Wang, Dr. Jianqiang Wei, and Dr. Tzuyang Yu	Sabrina Abedin, Ritham Batchu, Andres M. Biondi Vaccariello, Lidan Cao, GuoQiang Cui, Harsh Gandhi, Pouria Gharajalou*, Amirhossein Madadi*, Koosha Raisi, Eion Stack*, and Rui Wu.
University of Rhode Island	Dr. Christopher Baxter, Dr. Aaron Bradshaw, Dr. Rebecca Brown, Dr. Sumanta Das, Dr. Mayrai Gindy, Dr. Joseph Goodwill, Dr. Abdelttawab Hendawi, Dr. Stephen Licht, Nicole Martino, Dr. Vinka Oyanedel-Craver, and Dr. Paolo Stegagno	Logan Beattie, Eva Davet, Sami Doner, Pamela Franco, Chan Young Koh*, Hewenxuan Li, Katie Marcil, Bolaji Oladipo, Andrew Pariseault, Rakesh Paswam*, Andrew Sheerin, and Brandon Yeh*.
University of Vermont	Dr. Mandar Dewoolkar, Jeff Frolik, Dr. Ehsan Ghazanfari, Dr. Eric Hernandez, Dr. Dryver Huston, Dr. David Novak, Dr. Hamid Ossareh, Mitchell Robinson, Dr. Dana Rowangould, Dr. Gregory Rowangould, Dr. Matthew Scarborough, James Sullivan, and Tian Xia	Joshua Allen, Anna Casavant, Lane Feldeisen, Matt Kaplita, Ben Kopacki, Richard Laverty, Yi Liu, Fiona Nutbeam, Lauren Snow, Neha Subedi, Ryan van der Heijden and Bismark Yeboah
Western New England University	Dr. Moochul Shin and Dr. ChangHoon Lee	Simon Banas*, Evan Blake, Christa-Elizabeth Cicerone, Adam Garstka, Brian Leclair, Charles Maloy, Conner McLeod*, Keara Mooney*, Archer Parker, Thomas Schreiber*, and Christopher Spinazola.
Total	**63**	**91**

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 10 and Table 6 on page 11 for an overview of the collaborators on TIDC research projects and what they have contributed.

c. Have other collaborators or contacts been involved?

In addition to the collaborators and Technical Champions listed above, TIDC researchers have partnered with 60 individual transportation industry professionals over the reporting period.

III. OUTPUTS

a. Publications, conference papers, and presentations:

The following table includes a list of some of the 50 accepted, submitted, and published papers, reports, and presentations given during the reporting period. For the full list, see Appendix I Table I:

Table 8: Publications, Conference Papers, and Presentations

Type	Title	Citation	Date	Status
Poster Presentation	Analyzing the Effect of Ground Glass Pozzolan as a Supplementary Low-Carbon	Yeboah B, Cassavant A, Huston D, Dewoolker M, (2022) "Analyzing the Effect of Ground Glass Pozzolan as a	11/30/2022	Presented

	Cementitious Material in Concrete	Supplementary Low-Carbon Cementitious Material in Concrete." poster at TIDC Student Poster Contest, November 2022.		
Conference Paper	Structural Health Monitoring (SHM) of a Train Model under Traffic Loading	Ritham Batchu, Koosha Raisi, Tzuyang Yu, "Structural Health Monitoring (SHM) of a Train Model under Traffic Loading.", Presented at SPOE Smart Structures/NDE Symposium, March 12-15, Long Beach, CA.	03/15/2023	Published
Symposium Presentation	Development of High-Performance Concrete with Non-Metallic Prestressed Concrete Crossties	Shin, M., Lee, C.H., Blake, E., Cicerone, C., LeClair, B., Parker, A., and Doyle, D. " Development of High-Performance Concrete with Non-Metallic Prestressed Concrete Crossties," 2023 TIDC New England Railroad Symposium, February 16, 2023 (online).	02/16/2023	Presented
Poster Presentation	Displacements and Loading Frequencies of an Old Truss Railroad Bridge Under Service Trains using a Laser Doppler Vibrometer	de Olivera, C., Dhakal, S., and Malla, R.B., "Displacements and Loading Frequencies of an Old Truss Railroad Bridge Under Service Trains using a Laser Doppler Vibrometer.", Transportation Research Board2023 Annual Meeting, Washington D.C., January 08-12, 2023.	01/08-12/2023	Presented
Seminar	Lateral and Torsional Resistance of Helical Piles Using a Novel Collar Vane	Carvajal-Munoz, J.S., Gallant, A., Bradshaw, A., Berube, K. “Lateral and Torsional Resistance of Helical Piles Using a Novel Collar Vane.” Presented at Tufts University Trends in Coastal and Offshore Geotechnical Infrastructure Seminar. January, 28th, 2023.	1/28/2023	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
Probabilistic Risk Assessment of Bridge Vulnerability to Debris Accumulation and Scour near Bridges	Hughes, W., Santos, L., Lu, Q., Malla, R., Ravishanker, N. Zhang, W., (2023) "Probabilistic Risk Assessment of Bridge Vulnerability to Debris Accumulation and Scour near Bridges", Structure and Infrastructure Engineering	3/6/2023	Published
Full Scale Bridge Expansion Joint Monitoring Using 6TiSCH Network	Fils, P., Jang, S., Ren, D., Wang, J., Han, S., Malla, R. (2022) "Fulll Scale Bridge Expansion Joint Monitoring Using 6TiSCH Network." Structural Monitoring and Maintenance, vol. 9, No 4. https://doi.org/10.12989/smm.2022.9.4.000	2/2023	Published
Intelligent Design of Microencapsulated PCM-Incorporated Concrete Protective	Citation Pending	03/31/203	Under Review

Layer for Efficient Reduction of Freeze-Thaw Cycles in Concrete Structures			

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

The following table includes a list of TIDC publications in books or other non-periodical media during the reporting period and their status:

Table 10: Books and Non-periodical Publications

Title	Citation	Date	Status
Design and Manufacture of Precast Concrete Formworks Using Polymer Extrusion-Based Large-Scale Additive Manufacturing and Postprocessing	Bhandari, S.; Lopez-Anido, R. A.; Rojas, F.S.; LeBihan, A., "Design and Manufacture of Precast Concrete Formworks Using Polymer Extrusion-Based Large-Scale Additive Manufacturing and Postprocessing." 2022, 1-13. https://doi.org/10.1520/STP164420210120	12/12/2022	Published (Book Chapter)

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
News Article	UMaine TIDC recognizes students from member universities	UMaine TIDC recognizes students from member universities. 12.02.2022. https://umaine.edu/news/blog/2022/12/02/umaine-tidc-recognizes-students-from-member-universities/	12/02/2022	Published

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: https://tidc.umaine.edu/
YouTube: https://www.youtube.com/channel/UCimTO-44wrniqXx4_AXnLGA
Instagram: https://www.instagram.com/tidcatumaine/
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:

- UConn Project 1.16: developed a secure wireless communication protocol using the 6TiSCH network, which will enable convenient and secure long-term monitoring at remote locations at affordable costs.
- UMaine Project 3.18: developed five concrete mix designs based on the suggestions from Maine DOT. Five cylinders and four beams were prepared and cast for each mix for testing of compressive strength and flexural strength/toughness.

- URI Project 3.15: developed an automated road prioritization model using GIS and Python with statewide compatibility to decide locations of priority sweeping events.
- UML Project 3.19 developed an alkali-silica reaction expansion data set of cement mortar bars.
- UConn Project 1.13 developed a detailed finite element model that details critical members and connections for three selected railroad bridges, which will predict the response of critical members and connections using more accurate stress distribution over critical members and connections under the service loading conditions.
- URI Project 2.16: developed a machine learning based design tool to evaluate the influence of PCM's on the freeze-thaw response of concrete bridge decks.
- UConn Project 1.15: developed a machine learning classification algorithm that is capable of automatically extracting features from impedance measurement data.
- UMaine Project 3.18 developed a standard bridge model by analyzing a series of steel girder bridges built in the state of Maine in the last 15 years under AASHTO HL93 loading.
- UMaine Project 4.11: Speeding models in Maine and Connecticut were finalized and initial crash models were developed. Results showed that the odds of speeding significantly increased during the pandemic in both states and that speeding continued to happen in both states for a year after the start of the pandemic.

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

Two projects are currently pursing patent opportunities:

- UMaine Project 2.9 is in the process of having a due diligence review completed.
- UMaine Project 2.11 has filed a provisional patent application No. 63/411,027 Culvert Rehabilitation Transition Structure, Co-inventors: Lopez-Anido, R., Bhandari, S., and Anderson, J.

IV. OUTCOMES

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

- The UMaine Project 2.10 team deployed full structural health monitoring on all six stays anchorage of the Penobscot-Narrows Bridge. Maine DOT has adopted the technology for utilization in providing 24/7 monitoring for assessment of Carbon Fiber Composite Strands long-term durability.

V. IMPACTS

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

As a result of the successful implementation of the structural health monitoring system at the Penobscot-Narrows Bridge, will improve the operation and safety of the bridge by identifying events that affect the response of the carbon fiber composite strands and the anchor system.

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?

Nothing to report.

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, webinars, seminars, and symposiums 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 has issued a total of 134 certificates of attendance totaling 615.75 Professional Development Hours to date.

VI. CHANGES/PROBLEMS

a. Changes in approach and reasons for change:

Nothing to report.

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.

Appendix I

Table 1: Full List of Publications, Conference Papers, and Presentations				
Type	**Title**	**Citation**	**Date**	**Status**
Poster Presentation	Wireless Joint Monitoring System for Safety of Highway Bridges	Fils, P., Ren, D., Wang, J. Yun, Z. (advisors: Jang, S., Han, S., Malla, R.) (2022). "Wireless Joint Monitoring System for Safety of Highway Bridges." TIDC Student Poster Contest	11/30/2022	Presented
Poster Presentation	Analyzing the Effect of Ground Glass Pozzolan as a Supplementary Low-Carbon Cementitious Material in Concrete	Yeboah B, Cassavant A, Huston D, Dewoolker M, (2022) "Analyzing the Effect of Ground Glass Pozzolan as a Supplementary Low-Carbon Cementitious Material in Concrete." poster at TIDC Student Poster Contest, November 2022.	11/30/2022	Presented
Poster Presentation	Development of Protocols for Determining Deleterious Material Content in Processed Glass Aggregate	Subedi, N., Scarborough, M., and Dewoolkar, M. (2022) "Development of Protocols for Determining Deleterious Material Content in Processed Glass Aggregate" Poster presented online at the 2022 TIDC Student Poster Contest.	11/30/2022	Presented
Poster Presentation	The Impact of the Abutment Wall Height, the Bridge Span Length Range, and the Roadway Profile Grade on the Moment Profile and Lateral Displacement Profile of HP or W Piles Under Thermal Expansion in Integral Abutment Bridges (IABs)	TIDC Annual Student Poster Contest, Nov. 30, 2022(virtual).	11/30/2022	Presented
Poster Presentation	Lateral and Torsional Resistance of Modified Helical Piles Using a Novel Collar Vane	TIDC Annual Student Poster Contest, Nov. 30, 2022(virtual).	11/30/2022	Presented
Poster Presentation	Clustering of Bridges for Vulnerability Assessment from Combined Debris and Scour	W. Hughes, S. Anantharaman, S. Matile, I. Cahttopadhyay, W. Zhangm N. Ravishanker, R. Malla "Clustering of Bridges for Vulnerability Assessment from Combined Debris and Scour" TIDC Annual Student Poster Contest, Nov. 30, 2022(virtual).	11/30/2022	Presented
Poster Presentation	Flexural Strength of Micropile Threaded Connections	TIDC Annual Student Poster Contest, Nov. 30, 2022(virtual).	11/30/2022	Presented
Poster Presentation	Development of Live Load Distribution Factors for CT Girder Bridges	TIDC Annual Student Poster Contest, Nov. 30, 2022(virtual).	11/30/2022	Presented

Conference Presentation	Denoising of GPR B-Scan Images using Discrete Wavelt Transform	SPIE Smart Structure & Nondestructive Evaluation Symposium	3/13/2023	Presented
Conference Presentation	Detection of Steel Rebar Corrosion in Bridge Piers Using 1.6GHz Ground Penetrating Radar	SPIE Smart Structure & Nondestructive Evaluation Symposium	3/15/2023	Presented
Conference Presentation	Remote Detection of Chloride Ion Content Using SAR	SPIE Smart Structure & Nondestructive Evaluation Symposium	3/15/2023	Presented
Conference Presentation	Real Time Traffic Monitoring of Pedestrian Bridge Using Distributed Fiber Optic Sensing Textile	SPIE Smart Structure & Nondestructive Evaluation Symposium	3/13/2023	Presented
Conference Presentation	Distributed Optic Fiber Sensing Textile Installation on a Novel Composite Girder Bridge	SPIE Smart Structure & Nondestructive Evaluation Symposium	3/13/2023	Presented
Conference Presentation	Experimental Validation of Wireless Expansion Joint Sensors for an In-Service Bridge	Transportation Research Board Annual Meeting	1/11/2023	Presented
Conference Presentation	Development of High-Performance Concrete with Non-Metallic Prestressed Concrete Crossties	2023 New England Rail Symposium	2/16/2023	Presented
Conference Presentation	Investigating the Use of Xanthan Gum in Roadway Subbase Stabilization	Transportation Research Board Annual Meeting	1/10/2023	Presented
Conference Presentation	Lateral and Torsional Resistance of Helical Piles Using a Novel Collar Vane	Tufts University Trends in Coastal and Offshore Geotechnical Infrastructure Seminar	1/28/2023	Presented
Conference Presentation	Displacements and Loading Frequencies of an Old Truss Railroad Bridge Under Service Trains using a Laser Doppler Vibrometer	Transportation Research Board Annual Meeting	01/08-12/2023	Presented
Conference Presentation	Modeling the Impact of the Covid-19 Pandemic on Speeding at Rural Facilities in Maine Using Short-term Speed and Traffic Count Data	Shahlaeegilan, A., Shirazi, M., Marshall, E., Ivan, J.N. "Modeling the Impact of the Covid-19 Pandemic on Speeding at Rural Facilities in Maine Using Short-term Speed and Traffic Count Data" presented at TRB. (2022)	1/10/2023	Presented
Conference Presentation	Leveraging Probe Data to Model Speeding on Urban Limited Access Highway Segments During the COVID-19 Pandemic	Shahlaeegilan, A., Shirazi, M., Marshall, E., Ivan, J.N. "Leveraging Probe Data to Model Speeding on Urban Limited Access Highway Segments During the COVID-19 Pandemic" presented at TRB. (2022)	1/10/2023	Presented

News Article	UMaine TIDC recognizes students from member universities	UMaine TIDC recognizes students from member universities. 12.02.2022. https://umaine.edu/news/blog/2022/12/02/umaine-tidc-recognizes-students-from-member-universities/	12/02/2022	Published
Peer Reviewed Journal Article	Modeling the impact of the COVID-19 Pandemic on Speeding at Rural Facilities in Maine using Short-Term Speed and Traffic Count Data.	Shahlaee, A., Shirazi, M., Marshall, E., Ivan, J.N. (2022), Accident Analysis and Prevention.	11/2022	Published
Journal Publication	Probabilistic Risk Assessment of Bridge Vulnerability to Debris Accumulation and Scour near Bridges	Hughes, W., Santos, L., Lu, Q., Malla, R., Ravishanker, N. Zhang, W., (2023) "Probabilistic Risk Assessment of Bridge Vulnerability to Debris Accumulation and Scour near Bridges", Structure and Infrastructure Engineering	12/31/2022	Accepted
Conference Paper	Denoising of GPR B-Scan Images using Discrete Wavelt Transform	SPIE Smart Structure & Nondestructive Evaluation Symposium	3/13/2023	Published
Conference Paper	Detection of Steel Rebar Corrosion in Bridge Piers Using 1.6GHz Ground Penetrating Radar	SPIE Smart Structure & Nondestructive Evaluation Symposium	3/15/2023	Published
Conference Paper	Remote Detection of Chloride Ion Content Using SAR	SPIE Smart Structure & Nondestructive Evaluation Symposium	03/15/2023	Published
Journal Article	Pipeline Monitoring Using Fiber Optic Textile for Structural Health Monitoring	Biondi, A., Zhou, J., Guo, X., Wu, R., Tang, Q., Gandhi, H., Yu, T., Gopalan, B., Hanna, T., Ivey, J.,& Wang, X. (2022). Pipeline Structural Health Monitoring Using Distributed Fiber Optic Sensing Textile. Optical Fiber Technology, 70, 102876. https://doi.org/10.1016/j.yofte.2022.102876	03/26/2023	Published
Journal Article	Structural Health Monitoring Using a New Type of Distributed Fiber Optic Smart Textiles in Combination with Optical Frequency Domain Reflectometry (OFDR): Taking a Pedestrian Bridge as Case Study	Abedin, S., Biondi, A.M., Wu. R., Coa, L., Wang, X. (2023). Structural Health Monitoring Using a New Type of Distributed Fiber Optic Smart Textiles in Combination with Optical Frequency Domain Reflectometry (OFDR): Taking a Pedestrian Bridge as Case Study. Sensors, 232 1591. https://doi.org/10.3390/s23031591	2/01/2023	Published
Journal Article	Full Scale Bridge Expansion Joint Monitoring Using 6TiSCH Network	Fils, P., Jang, S., Ren, D., Wang, J., Han, S., Malla, R. (2022) "Full Scale Bridge Expansion Joint Monitoring Using 6TiSCH Network." Structural Monitoring and Maintenance, vol. 9, No 4.	2/2023	Published

		https://doi.org/10.12989/smm.2022.9.4.000		
Conference Paper	Experimental Validation of Wireless Expansion Joint Sensors for an In-Service Bridge	Ren, D., Fils, P., and Jang, s. (2023) "Experimental Validation of Wireless Expansion Joint Sensors for an In-Service Bridge." Transportation Research Board Annual Meeting, Paper no. TRBAM-23-04067	1/12/2023	Published
Peer-Reviewed Journal Article	Machine Learning Guided Designed of Microencapsulated Phase Change Materials Incorporated Concretes for Enhanced Freeze-Thaw Durability	Citation Pending	3/31/2023	Under Review
Peer-Reviewed Journal Article	Integrating Experiments, Finite Element Analysis, and Interpretable Machine Learning to Evaluate the Auxetic Response of 3D Printed Reentrant Metamaterials	Citation Pending	3/26/2023	Under Review
Conference Paper	Structural Health Monitoring (SHM) of a Train Model under Traffic Loading	Ritham Batchu, Koosha Raisi, Tzuyang Yu, "Structural Health Monitoring (SHM) of a Train Model under Traffic Loading.", Presented at SPOE Smart Structures/NDE Symposium, March 12-15, Long Beach, CA.	3/15/2023	Accepted
Conference Paper	Functionalization of Metakaolin with Non-Ionic Surfactants: Swelling and Pozzolanic Reactivity	Dayou Luo, Jianqiang Wei. "Functionalization of Metakaolin with Non-Ionic Surfactants: Swelling and Pozzolanic Reactivity.", The 16th International Congress on the Chemistry of Cement 2023 (ICCC 2023), September 18-22, 2023, Bangkok, Thailand.	3/16/2023	Submitted